other chemicals which fluoresce under the action of the x-ray, the radiations from radium cause these substances to glow with a visible light; the properties of the radiations from radium in this respect being like those from the x-rays. A sufficient quantity of radium has never been obtained to allow of the practical use of the fluorescence so obtained in the way in which the fluoroscope is used with x-rays, but it is possible that with a sufficient quantity of radium a fluorescence equal to that of the x-rays could be produced.

Photochemical Effects.—When the rays from radium are directed upon a sensitized photographic plate from which all ordinary light is excluded by having the plate enclosed in a light-tight envelope, the silver salts are reduced, and an effect similar to that produced by the x-rays is obtained.

This photo-chemical effect appears to be identical with that produced by the x-rays, except that either from the radiations from radium being less powerful in photo-chemical effect or from a sufficient quantity of the substance not being used, the rays have not as great penetrating power. Exposures of long duration produce outlines of the human hand with but faint indications of the bones.

Like the fluorescent effects of radium the photochemical effects have not as yet been made of practical value. Practical results may, however, be possible, provided radium can be obtained in sufficient quantities and its action can be properly controlled.

Vitochemical Effects.—The effect produced by the radiations from radium on living tissue are most remarkable. These effects, in certain ways, resemble the effects produced by x-rays, but appear also to have peculiar properties which, so far, have not been found to be produced by x-rays. Radium rays, like x-rays, are capable of producing "burns." The discovery of this effect of radium was made by Professor Becquerel, who, when journeying from Paris to London, carried in his waistcoat pocket a small tube of radium. About a fortnight later the skin under the pocket began to redden and fall away, and finally a deep and painful sore formed which was several weeks in healing. Like the burns produced by the x-ray these pathologic effects of radium radiations do not appear until several days after the part has been exposed. Many other important vitochemical effects are produced by the peculiar force thrown out from this remarkable substance. Becquerel found that if seeds were exposed for a long time to the emanations from radium their germinating power was destroyed.

M. Banysz, in experiments in the Pasteur Institute, found that the emanations from radium produced remarkable effects upon rabbits, guinea-pigs, and other small animals. These experiments show that radium has the remarkable power of so interfering with organic processes as to inhibit growth and even destroy life. A small amount of radium suspended over a cage containing mice will, after a few days, cause loss of hair and blindness, followed later by death. The same experimenter reports that exposure to the radiations from radium will cause arrest of development in certain lower organic forms. He exposed the larvæ of Ephestia kuehniella in a glass flask to the emanations from radium for a few hours. After a few weeks it was found that most of the larvæ were killed, but that a few had escaped the destructive action of the rays by crawling into distant corners of the flask where they were still living, but living as larvæ; whereas in a control flask similar larvæ had changed into moths.

M. Bohn has shown that radium may so modify various lower forms of life as to produce "monsters," and he has caused remarkable deviations from the original type in tadpoles exposed to radium emanations.

The vitochemical effect of radium seems to be particularly expended upon the skin and subcutaneous tissues and the nervous system. Thus, Danysz reports that the application of a tube containing a salt of radium to the skin produces an ulcer in from eight to twenty days. A few moments' application produces congestion of the human skin. When applied to the skin of a rabbit destruction of the epidermis follows, but when applied under the skin there is only a feeble reaction on the epidermis. Danysz found that when tubes containing radium were introduced into the intestines and serous cavities of guinea-pigs very little effect was produced, but its action was noted upon the nerve centres of all animals subjected to experiment. This action, however, was comparatively feeble in those whose osseous tissues protected the nerve centres. Application of tubes containing the salt to the cranium caused paresis, ataxia, and convulsions, followed later by death.

Professor Curie introduced a few milligrams beneath the skin of a mouse over the vertebral column, causing death of the mouse in three hours.

The rays of radium have a direct effect upon the optic nerve. This was shown by Giesel, who found that when radium salts were brought near the closed eyes a sensation of light was produced. This is attributed by Hammer to phosphorescence of the humors of the eye and also to effect upon the nerves of the retina. Prof. M. Javal proposes a diagnostic use of this phenomenon, and suggests that blindness with alteration of the retina can be distinguished from that due to glaucoma or corneal opacity, because patients with the latter condition see rays from radium as well as those of sound vision, while patients who have alteration of the retina have no sensation of light when a salt of radium is placed near the eyes.

Therapeutic Uses.—The vitochemical action of radium is so like that of the x-rays that its use for the cure of conditions for which the x-rays have been used was at once suggested. Experiments seem to show that the vitochemical action of the rays of radium are much more powerful than those of x-rays. There seems every probability, when radium can be produced in sufficient quantity and its action properly controlled, that it will be a valuable therapeutic agent. So far, its use has been mainly confined to the treatment of lupus, epithelioma, and superficial skin diseases. Favorable reports of results of its use in these diseases have been given by a number of clinicians. Danlos reports a case of lupus of the face, exposed to the action of a salt of radium which had a radioactivity of 19,000 for from twenty to thirty-six hours, with the result of the disappearance of the disease and with the formation of a smooth, white cicatrix. Other clinicians have reported equally favorable results and have called attention to the good effect as shown by the smooth, soft, and white resulting scar.

For therapeutic use the radium compounds have in some cases advantages over the x-ray. In superficial diseases of the skin and mucous membrane these radium compounds, being enclosed in small hermetically sealed glass receptacles, can readily be employed as therapeutic agents. All that is necessary is to place the receptacles containing the compound in close apposition to the parts, so insuring a local action. Furthermore, radium compounds being permanent these glass receptacles can be used for an indefinite time in any number of cases, and this apparently with more surety of definite results, so far as tissue reactions are concerned, than can be obtained from the radiations from x-ray tubes.

William Cline Borden.

SKIN AND ITS APPENDAGES: ANATOMY.—The skin, or integumentum commune, of the body acts as a covering and a protection for the deeper portions, besides being an organ of secretion, of excretion, of special sense—the sense of touch,—of common sensation, and the conservator of animal heat. Embryologically, it is developed from those two primitive layers of the blastoderm, the ectoderm and the mesoderm, which are formed by the cellular division of the impregnated ovule. The epidermis, or most external layer of the skin, is formed from the ectoderm, while a superficial portion of the mesoderm furnishes the remaining constituent parts—the corium, or cutis vera, and the subcutaneous or fatty tissue.

General Characteristics.—When fully formed the skin can be regarded as a completely closed sac, which

models itself so closely upon the portions of the body which lie immediately below it, that it allows their shape and configuration to be more or less accurately distinguished. This, naturally and to a great extent, will depend upon the amount of intervening fatty tissue. When the latter is present in excessive amount, symmetry and roundness of form dependent upon its presence in moderate quantity is naturally lost.

The skin does not stop abruptly at the natural openings of the body. It is continuous at these points with the mucous membrane which clothes the cavities. At the nares, on the labia majora and minora, and on the external surface of the anus, the transition of the skin over to the mucous surface is gradual, not abrupt. At the mouth, however, on the eyelids, and at the meatus urinarius, the transition is abrupt.

The integument is very variable in thickness. In general, it varies between 0.5 and 4 mm. ($\frac{1}{50}$ to $\frac{1}{6}$ in.), exclusive of the subcutaneous tissue. It is thinnest on the eyelids, and thickest on those portions which are subjected more especially to pressure, as on the palms of the hand and soles of the feet, or which serve as points of insertion for muscles, as on the upper lip, alæ nasi, etc.

Density and Elasticity.—It has been found that the skin possesses considerable solidity and very perfect elasticity. Sappey concluded from his experiments that a strip of skin 3 mm. long and 10 mm. broad was able to support a maximum weight of 12 kgm. ($26\frac{1}{2}$ lb.). The solidity was also in direct ratio to the thickness of the piece of skin used in the experiment. As mentioned, the elasticity is very perfect, but slight; a considerable amount of stretching may result from the application of a small weight, and complete rectification takes place after its removal. The skin is not of uniform texture, but consists of bundles of connective-tissue fibres arranged like a net, between which are spaces of various sizes which are rhombic in shape. In these spaces there is found a cementing substance, and it is due to it and the enormous network of elastic fibres that the former are able to regain their natural shape after having been stretched.

Cleavage.—The cleavage lines of the skin were demonstrated by Langer. He pierced the skin with small, round awls in multiple places, and, after removal of the instruments, observed that the wounds which were made were linear. He then made series of them in rows and close together, and from uniformity in the direction of the long axes of a more or less greater number of them, he was able to conclude that the skin possessed complete linear cleavage over the greater part of the surface of the body. Not on all of it, however, for in some places, as on the forehead, on many points on the scalp, etc., the wound made was a triangular one, and he found that these occurred where two spaces met together which possessed linear cleavage in opposite directions.

The explanation of the fact that the skin is, to a great extent, cleavable linearly, is to be found in the arrangement of the spaces between the bundles of fibres. These spaces are of various sizes and shapes, and in many places are so stretched longitudinally and so narrowed that the fibre bundles run almost parallel to each other. The course of the cleavage lines of the skin can be well understood by consulting the accompanying figure (Fig. 5195).

Tension.—Except upon the scalp, the palms of the hands, and the soles of the feet, the skin is, more or less, in a state of tension. When a portion is excised, it will be seen that it diminishes in size to such an extent that it will no longer cover the surface which has been laid bare. This cannot be ascribed entirely to the retraction of the borders of the wound, but is also due to the diminution in size of the excised piece, which is then no longer subjected to its former tension. Where the skin possesses linear cleavage, the tension is in the direction of these lines; but where this condition does not exist, it occurs uniformly in every direction in the plane of the surface. The tension likewise depends upon the movements of the joints and muscles, the amount of fat deposited in the subcutaneous tissue, and also upon morbid conditions, such as œdema, or upon the existence of pregnancy. In this latter condition the degree of tension may be so great that a permanent change may result in the direction in which the bundles of fibres run.

Color.—The color of the skin differs according to the individual, the race, and the age, and it also varies upon different portions of the body. It cannot be ascribed in certain races to climatic influences alone, since in the same zones people of different color are found, as in Africa, negroes, and in a corresponding portion of America, the much lighter colored Indians. The difference in color depends entirely upon the amount of pigment present in the rete Malpighii, where, under the form of granules, it is found especially in its lower layer or stratum basale. This is easily demonstrable in the skin of the negro two or three days after death, and before decomposition has set in. If the skin is, under such conditions, sharply rubbed, the epidermis is detached and rolls up under the finger, and the corium or true skin is seen to be of a dull white color. In the white race the color changes, within certain limits, in the various seasons of the year. When the skin is exposed to the heat and the sun in summer, there is an increase in pigment deposit and it appears darker, but this disappears and the whiter color returns in winter.

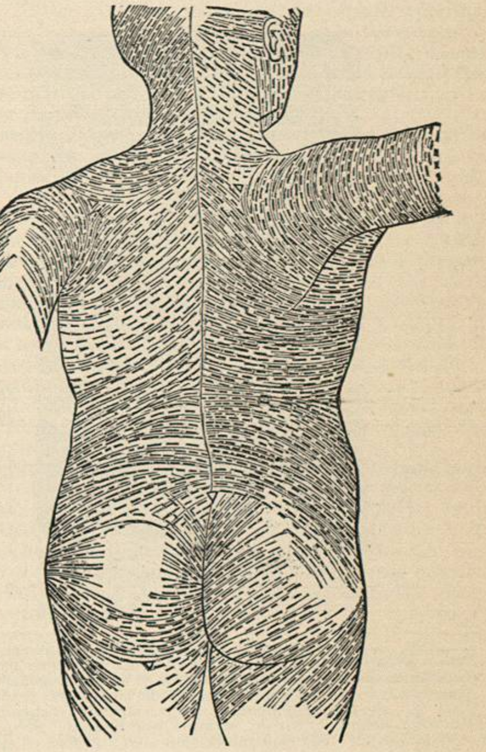

Fig. 5195.—Cleavage Lines of the Skin. (Langer.)

Under certain physiological conditions, such as pregnancy, there is likewise an increase in the amount of pigment in particular portions of the skin—the areola around the nipple, the linea alba, etc.—and this may in some instances be to an exaggerated extent. A large portion of this increase often disappears after the birth of the child, but a considerable amount usually remains. In the male the scrotum and penis, and in the female the vulva, are of a darker color than the rest of the skin. The pink or red color seen on certain portions of the body, as the cheeks, or induced by certain temporary causes, as those which produce flushing, is due to the blood in the vessels of the cutis. These latter becoming filled with blood its color is conveyed to the eye through the epidermic covering. When venous congestion is present the color is more or less of a bluish tinge. In old age the skin acquires a more or less yellow color, due to the atrophic changes that take place in it, and also to the lesser amount of blood supplied to it.

The Folds and the Furrows of the Skin.—Many furrows are seen on the skin. Some are long and deep, others are short and shallow. The former are present to a great extent from birth, and are seen running in a transverse direction across the extensor and flexor surfaces of joints.

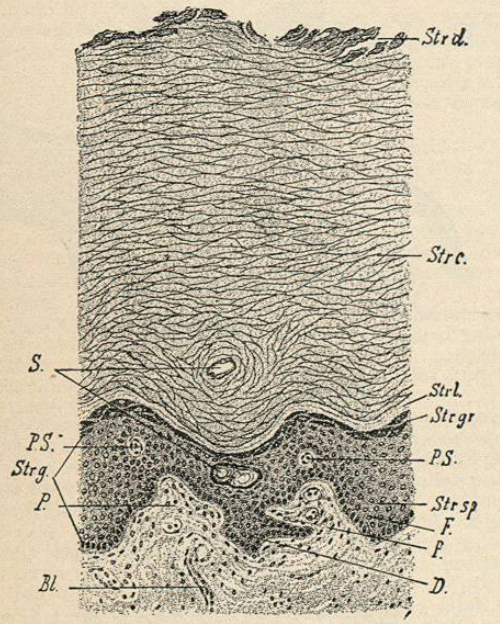

FIG. 5196.—Section of the Skin (epidermis and the papillary portion of the corium) on the Sole of an Adult Foot. Specimen hardened in a solution of picric acid and bichloride of mercury, and stained with hæmatoxylin and eosin. Magnified 90 diameters. (After Rabl.) *Str d.*, Stratum disjunctum: *Str c.*, stratum corneum; *Str l.*, stratum lucidum; *Str gr.*, stratum granulosum; *Str g.*, stratum germinativum; *Str sp*, stratum spinosum; *F*, fold of epithelium; *D*, glandular ridges; *S*, outlet channel of a sweat gland; *P*, papillæ; *Bl*, blood-vessel.

The latter are represented by the wrinkles on the face which develop with age. These latter are due partly to the diminished elasticity and turgescence of the skin, but they are induced more often by muscular contraction and stretching of the cutis.

The furrows around the joints are produced by the movements of flexion and extension. They are not able to overcome directly the tension of the bundles of fibres, which in this situation run transversely or obliquely across the joints; in consequence the fibre bundles are not stretched by the ordinary movements, but the rhomboidal spaces between them are. On one side of the joint their tension is in the direction of their breadth, while on the opposite side the fibre bundles are brought closer together. In this way the constant furrows around the joints are caused. Those which are due to muscular action, as the wrinkles on the forehead, etc., are produced in the same manner, the constant repetition of the movements finally effecting a permanent change in the arrangement of the fibre bundles and of the spaces between them.

The folds seen in very emaciated persons are likewise caused by the diminution in the size of the rhomboidal spaces. This is brought about by the loss of fat and the consequent change in the arrangement of the fibrous structure of the skin. Coarser furrows are also seen on the palms of the hands and on the soles of the feet, and in these places the skin is not movable. These furrows are always permanent, being caused by the firm union of the skin to the tissues below by means of short bundles of connective-tissue fibres. Dimples, where they occur, are due to the same cause; that is, the skin is at that point attached to the underlying tissues and does not move together with the rest of the skin of which it forms a portion.

THE STRUCTURE OF THE SKIN.—The integument of the body is composed of several layers. The most external of these consists of epithelium and is termed the epidermis. It clothes the outer surface of the corium, or cutis propria, the line of division between the two being very sharply defined and great morphological difference exists between the elements composing each. The corium is a closely knit tissue, consisting of connective tissue, elastic fibres, and unstriped muscle. It contains the glands of the skin and the hair, and is rich in blood-vessels and in nerves. It is not sharply limited on its under surface, but goes over here gradually into the subcutaneous or fatty layer of the skin. This layer, the panniculus adiposus, is in reality the deeper portion of the cutis, and consists of connective-tissue fibres loosely put together, which contain in their cells and in the spaces between them a more or less large amount of fat.

The epidermis and the corium are the most important portions of the skin, and vary in many particulars on different portions of the body. The various appendages of the skin—the hair, the nails, and the glands—are derived from or are attached to them.

EPIDERMIS.—*Embryology.*—The epidermis, the most external layer of the skin, is formed from the ectoderm, and in the first month of life and the beginning of the second consists of only a single, or in its thicker portions of two or three rows of polygonal cells. Below these is a layer of very small cells, which represent the origin of the stratum mucosum or rete Malpighii. This increases, in the course of development, to several rows of cells, the layer becoming more and more distinct and thicker. In the mean time the outermost cells have also become flatter, and represent the primitive horny layer, which, however, remains during fœtal life of a low grade. It is subjected to constant desquamation, and the scales from its surface are mixed with the secretions from the skin to form the vernix caseosa. As early as the eighth month (Unna), granular cells begin to appear between the horny and mucous layers, and the cornification of the epidermis cells becomes more marked. Nevertheless, and before this, the horny layer has become strong enough to oppose sufficient force to the epithelial growth and to the proliferation of its cells, so that the increase in thickness of the rete Malpighii can no longer take place in the direction of the external surface, but is compelled to proceed downward toward the cutis propria. It penetrates, in its further development, into the spaces between the rudimentary papillæ, springing from the surface of the cutis, and thus forms the interpapillary prolongations of the epidermis. It is by virtue of these ingrowths of the epidermis that, when fully formed, it lies upon the derma as an accurately fitting coat, which follows closely the outlines and inequalities of the true skin.

Thickness of the Epidermis.—The thickness of the epidermis, as a whole, varies from birth to old age, on different parts of the body, and is also influenced by external causes, as pressure, rubbing, etc. At birth it is from 0.15 mm. to 0.25 mm. in thickness, but in adult life from 0.75 mm. to 1.66 mm. The differences are due, for the most part, to the thickness of the horny layer, which in some situations, as on the palms and soles, or on any surface subjected to constant pressure, may attain a very considerable increase in thickness.

Layers of the Epidermis.—The epidermis is divided into two major layers, due to the different consistence of the cells constituting each. The most external and superficial one, consisting of horny cells, is firm and resistant, and termed the stratum corneum, while the one immediately below it, lying in contact with the derma, is called the stratum mucosum, or rete Malpighii. The latter consists of soft epithelial cells and is sharply defined from the stratum corneum. Both of these major layers are still further subdivided according to the appearance of its cells, or to the reaction of their various portions to certain coloring substances.

Rete Malpighii.—The most deeply situated cells of the stratum mucosum, those which are in immediate contact with the derma, are cylindrical in shape and form the basic layer or stratum basale of the rete. Its importance can be estimated from the fact that it represents the productive part of the stratum mucosum. In normal skin they are the only cells which show the karyokinetic cell figures and indirect division of the nucleus occurring in epithelial growths. Their long axes are directed perpendicularly to the corium, and if the layer is carefully examined, small basic cells, resulting from the cell division, are seen pushing their way in between the older ones.

The cylindrical cells send out into the corium more or less long prolongations, but the spines, which characterize the entire rete, are seen clearly only upon their upper contours. It is in these cells, especially, that a more or less large amount of pigment granules are deposited, which give the various shades of color to the skin of different individuals and races.

Above the basic layer, cells of various shapes and sizes are found. Over the papillæ, and in the interpapillary portions of the rete, round and cuboid and polygonal cells are seen. In the interpapillary prolongations, however, round cells predominate. As the external surface is approached the cells become larger, and have their long axes more parallel to the surface of the skin. The cells themselves have a body consisting of finely granulated protoplasm, which contains a clearly defined nucleus, in which are several nucleoli. According to the position of the cells in the rete, the shape of the nucleus varies. In the uppermost portions it is oval, in the middle, round, and in the cylindrical layer, rod-like, thus agreeing more or less accurately with the shape of the cell. The varying form of all of these cells is due in general to the degree of mechanical pressure to which they are subjected by the individual growth of each, and by other causes, such as atmospheric pressure. The cells composing this portion of the rete Malpighii do not lie in close contact with each other, but are held in apposition by protoplasmic prolongations from their surfaces, which are continuous with the protoplasm of the cell body. They have been termed spines. It is due to this characteristic that the entire layer has been named the stratum spinosum.

The spines, which characterize these epithelial cells, were first observed by Schrön, and the function of binding the cells together has been attributed to them. The manner in which this occurs has, however, always been a subject of controversy. Max Schultze was of the opinion that they were arranged as in a pinion and ratchet; Bizzozero, that their ends were united together; and Ranvier, that their ends were fused together, forming a peculiar elastic organ which allowed considerable movement. These spines can be studied best in rapidly proliferating growths of the rete, as in condylomata acuminata; but in the normal skin it is very difficult to form any opinion in regard to their natural arrangement. Whether the spines are active or passive in their nature is likewise a disputed point. Still, as Unna has pointed out, they are in all probability the result of active protoplasmic movement, since they are purely prolongations of the cell body and consist of the same protoplasm.

Intercellular Spaces.—The arrangement of the spines springing from the surface of the cells of the rete is such that small spaces are left between them. These, the intercellular spaces of the stratum mucosum, are of great importance, inasmuch as they serve as channels for the passage of the nutrient fluids from the corium to the epithelium. The communication existing between the blood and lymph vessels and spaces and these intercellular spaces was clearly demonstrated by Nalepa, who succeeded in injecting them from the subepithelial blood-vessels. The wandering cells coming from the vessels of the cutis and seen in the rete are also enabled to wander along by means of these spaces, and they are the source of the pigment sometimes seen in these situations.

Stratum Granulosum.—Situated above the stratum spinosum, but yet in close contact with it, is a layer of cells characterized by the possession of certain peculiarities. This layer consists of one or two rows of cells, seldom of more, upon whose surfaces shortened spines may still be seen, and they also contain granules of various sizes and shapes. It is owing to the presence of these that it has received the name of stratum granulosum. These granules react toward certain coloring substances in a marked manner, and stain very deeply. Unna, who has studied this layer very carefully, states that it makes its appearance in the epidermis toward the end of fœtal life, but that it can be seen much earlier in the inner root sheath of the embryonic hair.

The stratum granulosum is present over the entire skin, except on the vermilion border of the lips and in the nail bed. The granules appear white by direct light, and for this reason Unna asserts that they are the cause of the white color of the Caucasian race. Such an explanation is, however, scarcely a reasonable one, owing to the fact that this same stratum granulosum is present in the skin of the negro as well as in that of the other dark races; and besides, when it is found pathologically or even under natural conditions greatly increased in depth, it does not seem to cause the color of the portions where it is situated to be whiter than the remainder of the skin. The stratum granulosum is very marked in condylomata acuminata and on the palmar surface of the hands, and yet the former are far from being white in color, and the latter are not especially so.

The granules which are present in these cells have been the subject of so much discussion that they are worthy of extended consideration. They were observed long ago by Kölliker in the medulla of the hair, and by Aufhammer in the epidermis. Langerhans, however, was the first to describe them carefully, while Unna pointed out that they stood in constant relationship to the process of cornification, and he claimed that they represented the intermediate steps which occurred in this process, transforming the soft epithelial cells into horny tissue. Ranvier regarded them as drops of a fluid substance, which existed in a free state in the lowest layers of the stratum corneum, and to which he had given the name of eleïdin. Waldeyer, however, has furnished the most satisfactory and correct information in regard to them. He proved that they could not be drops of fluid, because they swelled up on the addition of alkalies and also changed their shape on pressure, but not in the manner that fluids do. They were likewise insoluble in ether, alcohol, or water, and possessed a very great affinity for the nuclei-staining dyes, as hæmatoxylon, picrocarmine, etc. The supposition that they were fatty in character was also excluded by their want of reaction to osmic acid. Waldeyer found, on the other hand, that they agreed chemically very closely with the hyalin of Recklinghausen, a product of degeneration, and for this reason he suggested the name of keratohyalin for the substance.

Keratohyalin, according to Unna, is found to a small extent around the nucleus of the cells in the middle portion of the stratum spinosum, but it exists to a considerable extent only in the stratum granulosum. The granules here are small, and though the cells are filled with them, yet a small peripheral zone always remains free from encroachment. The cells in this layer have atrophied nuclei, which, however, still stain well, and the intercellular spaces are narrowed to such an extent as to be almost entirely absent.

The significance of keratohyalin and its relation to the process of cornification have received much attention. The general opinion at present is in favor of regarding these granules, not as the cause of the cornification of the rete cells, but as a phenomenon accompanying that process, and as one which is produced by the act of cornification taking place in the periphery of the cells.

Stratum Corneum.—The layer of the epidermis lying above the stratum granulosum is the stratum corneum.

It is the one which is most external and is in contact with the air. It varies greatly in thickness on different portions of the body, being, however, usually most marked on the palms of the hands and on the soles of the feet, and also being always much increased on any portion of the skin which is subjected to constant pressure. On these surfaces especially, but not exclusively—that is, on the palms and the soles—it is noticeable that its lowest portion, that which is immediately next to the stratum granulosum, possesses great transparency. This stratum is narrow, sharply defined, and is known as the *stratum lucidum* of Oehl, but its existence has never been satisfactorily explained. The cells forming the stratum corneum are clear and transparent, showing neither granules nor nuclei. Unna claims to have found traces of the spines seen on the cells of the stratum spinosum even here, and asserts that the coherence of the cells forming the horny layer is due to their persistence.

By means of artificial digestion with pepsin and trypsin, it has also been found that the entire cell does not become cornified, but only the peripheral portions. After employment of this method it is clearly seen that it is the contents of the cells which are destroyed, while the peripheral portions remain and have the appearance of horny shells.

The reaction of the epidermis to certain staining materials allows furthermore a recognition of several layers constituting it, and shows successive changes not only in the cell substance, but also in the intercellular spaces. We owe to Unna the following table, showing the reaction of the several layers of the epidermis to various dyes:

tinct layer of the skin. The transformations which take place among the closely aggregated cells in the upper portion are shown by the penetration of fibres between them and by the deposition of collagenous material. The individual cells are thereby more and more widely separated from each other, and the corium attains a considerable degree of thickness. Gradually blood-vessels and nerves pass into it, and upon its superficial surface the papillæ begin to form. These latter appear about the sixth month of fœtal life as small eminences upon the surface of the cutis. They are formed by the growth of the epidermis, which pushes before it the weaker and more yielding portions of the cutis. They are first seen on the palms of the hands and the soles of the feet, but are quite general toward the end of fœtal life. The development of the papillæ is not fully completed until after birth.

Divisions of the Cutis.—The major part of the cutis consists of fibrous connective tissue, which is poor in cells and which is arranged in the form of bundles. The texture of the cutis is closely knit in that portion which is next to the epidermis, but is much looser in the parts below this. In this situation, the fibre bundles crossing each other form the rhombic spaces, which have been mentioned as the cause of the linear cleavage of the skin. On account of the difference in the texture of the cutis, it has been divided into two layers: the one in immediate contact with the epidermis being termed the pars papillaris, that below it, the pars reticularis.

Pars Reticularis.—The pars reticularis of the corium is composed of bundles of fibres of various sizes and lengths. They are continuous with the connective tissue of the

Layers of the epidermis.		Consistence.	Osmic Acid. Without removal of fatty matter.	Osmic Acid. After removal of fatty matter.	Picrocarmine.	Hæmatoxylon (glacial acetic acid).	Iodviolet (only slightly decolorized).	Salicylic acid—chloride of iron (H. Hebra).
A. Stratum corneum	1. Superficial	Firm	Black	Clear	Yellow	Bluish-white	Blue	Brown.
	2. Middle	Looser texture	Clear	Dark brown.	Red	Violet		Clear.
	3. Suprabasic	Firm	Black	Clear	Dark red	Bluish-white	Clear	Light brown.
	4a. Basic, stratum lucidum of Oehl.	Very firm			Yellow		Blue	Not constant.
	4b.	....	Clear	Dark brown.				
B. Stratum granulosum	....	Soft	Protoplasm		Granules colored dark red	Granules colored violet.		Brown.
C. Stratum spinosum	Rete Malpighii, stratum of Fleming.	....	Coloring (green).		Nuclei colored dark red.	Nuclei colored blue.	Nuclei colored blue.	Light brown.

The several layers which have just been described as entering into the formation of the epidermis should be carefully considered in the study of the anatomy of the skin. It is from the epidermis that the appendages of the skin, the hair, the nails, and the glands, originate and derive their most important parts. We shall refer to this again when describing these various constituent portions of the skin.

The Corium, Derma, or Cutis Propria.—*Embryology.*—The corium, or true skin, is that portion which lies between the epidermis and the subcutaneous or fatty layer. It is derived from a superficial portion of the mesoderm, consisting at first of only round cells. In the second month of fœtal life, however, spindle-shaped cells begin to appear, but only very little intercellular substance is present. Very shortly after this, it is noticed that the cells in the upper portion of this primitive corium become more closely aggregated together than in the lower portion, and at the same time the formation of fibrillated tissue begins in this latter. The fibres increase greatly in number, and by the fourth month the presence of fat is detected. It is in this way that the subcutaneous or fatty layer is developed, and it is to be considered, in reality, a part of the derma, since it has the same embryological source, and not a separate and dis-

inner portions of the body—the fasciæ, etc.—and pass upward perpendicularly, or slightly inclined to the surface of the skin, until they arrive at the cutis. Here they run obliquely, crossing each other at various angles, and serve as boundaries for spaces which are formed by their intersection. These spaces are, in general, rhomboidal in shape, but oftentimes polygonal, their regularity depending upon the length and uniformity of course of the fibre bundles forming them. The length of the fibre bundles and the absence of their firm adhesion to the underlying tissues are very important factors. It is owing to such an arrangement that the skin is freely movable over the greater portion of the body. On the scalp, the palms of the hands, and the soles of the feet, where these bundles of fibres are short and intimately united to the underlying fascia, the skin is only very slightly movable. These places of intimate union, however, serve as fixed points from which the skin is stretched over the body. The movability of the skin is also limited on the circumscribed portions, where it is in immediate contact with bone, cartilage, or tendons, as over the tibia, etc.

The bundles so frequently mentioned are composed of fibres, which correspond in structure to those of fibrous connective tissue. Under normal conditions they are in

a state of tension, and are for the most part straight, but under the microscope they are found presenting a wavy appearance. Chemical examination has shown that they consist to a great extent of collagenous material. The fibres themselves are bound together in bundles by an albuminous semifluid cementing substance, which Rollet has found to be similar to mucin. According to Fleming, this cementing substance not only exists between the fibres, but also surrounds the bundles, and Tomsa claims that it binds together all the constituents of the cutis.

The fibres possess cells, but they are numerous only in the vicinity of the large blood-vessels. These cells are the usual connective-tissue cells; they are large and contain nuclei and nucleoli. They lie upon the bundles in the same manner as endothelial cells do in the situations where these are found, and for this reason have at times been regarded as forming an endothelial lining for the rhombic spaces between the bundles. It has, however, been demonstrated that they differ from the cells of endothelium in that their edges do not lie in contact with each other, and they do not form a continuous covering for the bundles (Ranvier).

Elastic Tissue.—According to the latest investigations made in regard to the elastic fibres of the skin—a most thorough study of which has been made by Unna—they are exceedingly abundant in the reticular portion of the cutis. By the use of special methods of staining and of preparation, Unna found that, under the form of broad bundles, elastic fibres spring from the fascia below the skin, and, passing up between the fat masses, penetrate into the cutis. In their course they divide continually in a more or less forked manner. These bundles may be traced upward to just below the epidermis. The muscles of the cutis also serve as points of origin for bundles of elastic fibres, and Unna claims that they can be seen attached to the muscles at their points of origin and insertion, having a tendon-like appearance.

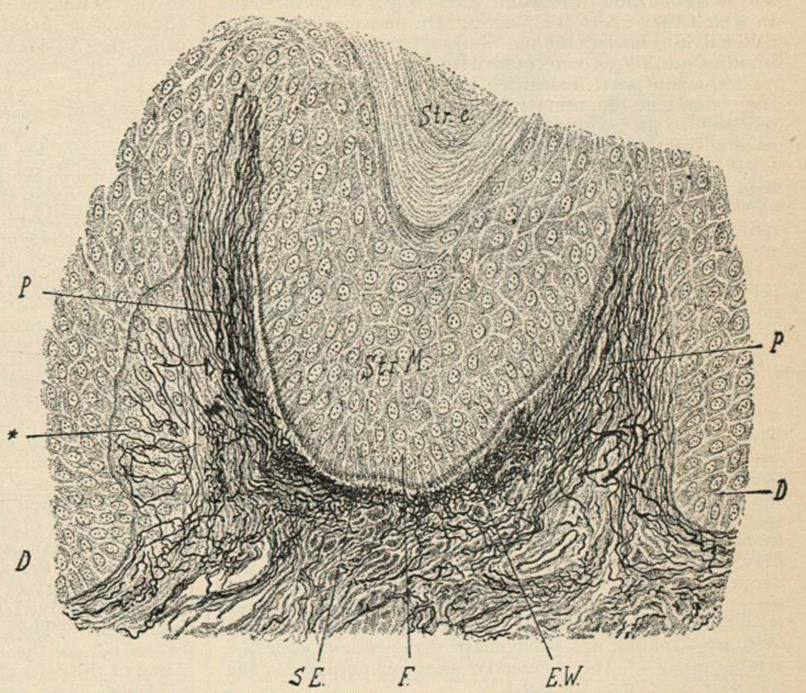

Fig. 5197.—Two Papillæ of the Skin of the End of the Toe. The elastic fibres which they contain have been rendered specially distinct by the use of Weigert's method of staining. This method, while causing the elastic fibres to assume a deep black color, makes all the surrounding tissues appear pale blue. The specimen was hardened in alcohol. *P*, Papilla; *F*, fold of the epithelial layer; *D*, glandular epithelial ridge; *Str.M.*, stratum Malpighii; *Str.c.*, stratum corneum; *S.E.*, subepithelial network of elastic fibres, which are especially abundant around the epithelial fold (*F*), whereas on the sides of the glandular ridge the network is looser, *i.e.*, it contains decidedly fewer elastic fibres; *E.W.*, basal epithelial cells which are distinguished from the others by their darker coloring.

Another relatively fixed point of the elastic basework of the cutis is seen in an extensive network of fibres, which follows with the greatest regularity the outline of the epidermis, where this latter is in contact with the corium. This network, which Unna terms the subepithelial elastic net, is situated just below the surface of the cutis, being separated from the epidermis by a narrow homogeneous strip of the derma, in which there are very few blood-vessels. From this network fine fibres are given off, which proceed upward perpendicularly and are lost sight of here and there between two of the basic epithelial cells of the epidermis.

There is, also, in the papillary portion of the skin, an extensive network of elastic fibres. It is formed by the repeated division of fibres which originate from the subepithelial network. All of these elastic fibres do not exist independently of the rest of the cutis, but are more or less closely connected with the fibre bundles of connective tissue which have already been treated of.

The relationship of these elastic networks to the appendages of the skin, such as the hairs and glands, has not yet been thoroughly studied. Still Unna claims that there is some special connection between them and the sweat ducts and glands. The elastic fibres are found to be entirely absent around the coils, but quite abundant about the ducts, along which they run in a parallel direction. He consequently is of the opinion that the contraction of the elastic network of the skin, acting with the fibre bundles with which it is in close union, produces a pressure on the ducts, and shortens them by diminishing the thickness of the skin. In this way the passage of the secretion of the glands through the ducts to the outer surface is favored.

Unstriped Muscle.—With the exception of the palms of the hands and the soles of the feet, the skin of the entire body contains a more or less large number of unstriped muscular fibres and bundles. They are found to attain their highest development in the skin of the scrotum, in the penis, and in the nipple and its areola. The vermicular movements of the scrotum are due to these involuntary muscles, as is also the erection of the nipple. They are situated in the cutis propria, and lie perpendicular to the plane of cleavage of the skin. On the penis they are arranged in a circular manner, and they follow a similar course in the nipple and in its areola.

Besides these, there are other muscles in the cutis which, owing to the connection existing between them and the hairs, are termed the arrectores pili. They are formed by the union of several small muscular bundles, which, originating in the pars papillaris, run an oblique course through the reticular portion of the cutis, and are attached to the hair follicle. The point of their attachment is not uniform—sometimes to the middle portion of the hair sheath, sometimes low down in the lower third. It will usually be observed that in their course to their point of attachment, they curve around the sebaceous gland attached to the hair follicle and are in quite intimate connection with it. According to Tomsa, the fixed point of the arrector muscles is the hair follicle, while the point of movement is the pars papillaris of the cutis.

The arrangement of the involuntary muscular fibres in many places in the derma, as in the cutis of the forehead, cheeks, back, is in the form of a network. This net originates in the pars papillaris and is distributed throughout the upper two-thirds of the pars reticularis. By the action of these muscles the skin is kept more or less in a condition of tension. According to the direction in which they exert their action, the muscles have been divided into horizontal and oblique tensors. The elastic bundles and fibres connected with the muscles play here an important part, inasmuch as Tomsa has shown that they stand in the same relationship to them as do the tendons to the voluntary muscles, and serve as fixed points from which the contraction of the cutis tensors takes place. The action of these muscles also regulates to a great extent the circulation of the lymph in the cutis, while the contraction of the arrectores elevates the hair, compresses the sebaceous glands, and facilitates the propulsion of their secretion into the hair follicle.

The Pars Papillaris Cutis.—The papillary portion of the true skin is constituted by a series of small eminences or papillæ, which spring from its upper or free surface. It is in direct contact with the epidermis, which, as has already been described, sends down prolongations of epithelial cells between the papillæ.

The papillæ of the skin are found most fully developed on the palms of the hands and on the soles of the feet. They are arranged here in long double rows, which form the curvilinear ridges seen in these situations. Between these rows there is a narrow path in which are the external orifices of the sweat ducts. On other portions of the body the papillæ are arranged more or less in groups or in short rows, and the surface of the cutis seems to be divided into rhomboidal spaces of various sizes by the deeper penetration of the interpapillary prolongations of the epidermis. The long diameters of these spaces agree with the line of cleavage of the portion of the skin where they are situated, and their shape is dependent upon the arrangement of the connective-tissue bundles in the reticular portion of the cutis.

The papillæ are more or less conical in shape, sometimes single, or again cleft into two or more points, forming a compound papilla. They differ greatly in shape, size, and distribution on the various portions of the body, and also vary according to the age of the person (Unna), becoming in old age almost flat. They are very numerous on the penis, the nipple, the labia minora, and the clitoris, appearing in these places as low hills. The largest papillæ are found in the cutis of the nipple and of the corona glandis. Those distributed generally over the surface of the body are very small, about 0.05 mm. in height. On the ends of the fingers, under the free borders of the nail, they attain a size of 0.5 mm.; but their height varies in general between 0.05 mm. and 0.2 mm.

The papillary portion of the cutis consists of a closely woven network of fibres, which are derived directly from those forming the pars reticularis. The papillæ are very rich in elastic fibres, and contain blood-vessels, lymphatics, nerves, and, in certain situations, tactile corpuscles. The manner in which the papillary body and the epidermis are joined together must be studied on specimens which have been macerated, and from which the epidermis has been removed *in toto*. When this has been done, it is seen that the entire surface of a papilla has a finely ribbed aspect. On sections made horizontally through them, they look as though their contour was toothed. The ribs have a slightly wavy course and are at times arranged in a concentric manner, having much the same appearance as may be observed on the palmar surfaces of the ends of the fingers. These ribs on the papillæ have been found to correspond to minute furrows on the cells forming the basic or cylindrical epithelial layer of the epidermis and to fit into them, each cell requiring usually three or four ribs. From the fibrillated appearance it might be thought that these ribs were connective-tissue fibres, but such has been found not to be the case. They consist in reality of a transparent homogeneous substance, which covers thinly the surface of the papillæ. The proof that it is a distinct membrane has never been satisfactorily made, and it seems better to accept Unna's view, that it stands in intimate connection with the cementing substance of the cutis in general, since it has been found that, when the cutis is subjected to the action of trypsin, this homogeneous substance covering the papillæ disappears in the same way as the cementing substance in other portions of the derma.

THE SUBCUTANEOUS CONNECTIVE TISSUE OR FATTY LAYER.—It was mentioned, in speaking of the embryological origin of the skin as a whole, that the subcutaneous or fatty tissue was derived from the mesoderm. It is that portion which attains its full development the earliest of all the layers of the skin, and in which the deposition of fat between the fibres constituting it takes place very early in fœtal life. The subcutaneous connective tissue, or panniculus adiposus, though in reality the lower portion of the corium, is regarded as forming the third layer of the skin, and it is characterized by the presence of a greater or less amount of fat included within its meshes.

It is composed of bundles of connective-tissue fibres, a network of elastic fibres, and of fat, and is very rich in large cells. These have long poles and are situated either in or between the fibre bundles, occurring in the form of spindle-shaped cells. According to Flemming, the masses of fat can be divided into three classes, each of which is characterized by its blood supply; the fat clusters with their own blood-vessels; the strands of fat which lie around the large vessels and receive only a meagre supply of blood from capillaries; and the fat islands which have no blood supply of their own. We have to thank the same investigator for our knowledge of the histology of fatty tissue. He found that the fat cells were derived from ordinary branching connective-tissue cells. They took up fat in small drops, and in proportion as the fat increased in quantity the protoplasm of the cells also increased, and they became round in shape. The protoplasm containing the nucleus is forced to the periphery by the accumulation of fat, and appears as a membrane; but these fat cells have no true enclosing membranes, except when they are old, and when the protoplasm has become thickened into a membrane-like covering. The contents of the cells do not consist of pure fat, but of a mixture of fat and of some product from the protoplasm. At the time of birth the panniculus adiposus is very greatly and uniformly developed over the entire body. As the child grows, however, it diminishes in quantity and remains of considerable extent only on certain portions. Its function is protection to the underlying tissues, and it serves to give roundness to the outline of the body. Those portions of the body which are firmly bound down to the fascia by short bundles of fibres, as the scalp, the skin of the palms and of the soles, etc., possess only a small fatty layer. Where great mobility is necessary, as in the eyelids, or where there is a great amount of muscular tissue, as in the scrotum, the panniculus adiposus is also absent. Over the joints, where the skin lies in close contact with the bones, and by their movements is continually subjected to pressure and tension, bursæ develop in the subcutaneous tissue after birth. In this layer the large arterial and nerve trunks going to the cutis are found, and also the veins and lymphatics which come from the derma and unite to form large efferent branches. In certain localities the Pacinian bodies are also present.

THE GLANDS OF THE SKIN.

There are two sets of glands which are found in the skin, the sweat glands and the sebaceous glands. They differ from each other to a most marked degree, and if considered from the standpoint of their relative importance the former claim priority and more extended study. We shall, therefore, begin with the sweat glands.

THE SWEAT GLANDS.—*Embryology.*—The primary evidences of the development of these glands of the skin

are seen in the fifth month of fœtal life. They appear first on the palms and on the soles, under the form of rows of epithelial prolongations from the inferior border of the epidermis into the cutis. At this stage they are solid, club-shaped, and surrounded by a homogeneous membrane. Their further development consists in the elongation of these epithelial ingrowths downward, and in the formation, by the seventh month, of a cavity along its axis, which is later further extended through the epidermis to the external surface. In the mean time, the gland tube at the end in the cutis has become coiled up, forming a ball, and the excretory duct in its course through the skin is twisted upon itself. The development of these glands is very rapid, and by the end of fœtal life they have already attained their full development. In certain situations, however, they enlarge even after birth, and in their structure differ somewhat from the ordinary and smaller ones distributed generally over the body. These larger glands are found in the axillæ, the inguinal regions, around the anus, the nipple, and in the auditory canal (ceruminous glands).

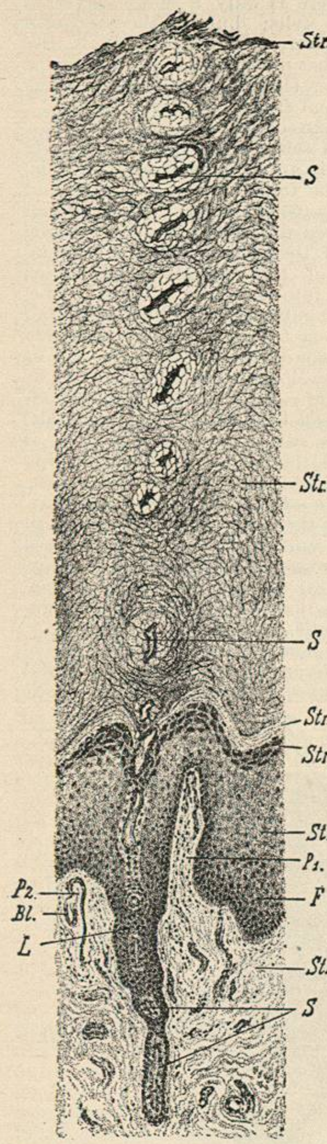

FIG. 5198.—Section of the Skin (epidermis and papillary layer of the corium) of the Sole of the Foot. Specimen hardened in Mueller's fluid; staining with hæmatoxylin and eosin. Magnified 60 diameters. (After Mracek.) *S*, Orifice and deeper tubular portion of a sweat gland; *Str.d.*, stratum disjunctum; *Str.c.*, stratum corneum; *Str.l.*, stratum lucidum; *Str.gr.*, stratum granulosum; *Str.M.*, stratum Malpighii; P_1, P_2, papillæ; *F*, fold of the epidermis; *L*, glandular portion of the epidermis; *Str.p.*, stratum papillare; *Bl.*, capillary loop in the papilla.

The sweat glands are present everywhere in the integument of the body, with the exception of the glans penis, the under surface of the prepuce, and the vermilion border of the lip. They are small bodies, consisting of a convoluted tube and an efferent duct which leads to the external surface, and they are situated in the corium or even in the subcutaneous connective tissue. They vary greatly in size. The coils of the large ones situated in the axilla are from 1 mm. to 2 mm. in diameter; the smaller ones on the general surface are from 0.2 mm. to 0.3 mm. They are most numerous on the palms of the hands, Krause estimating that there were twenty-eight hundred orifices in a square inch on those surfaces.

The sweat glands, as a whole, are composed of two distinct portions, a secretory and an excretory. The

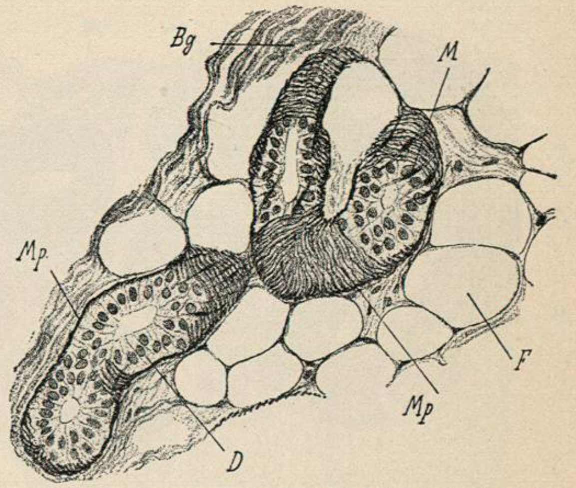

FIG. 5199.—Two Separate Portions of the Secreting Part of the Coil of a Sweat Gland, from the Skin of the Abdomen. Magnified 250 diameters. (After Mracek.) *D*, Gland cells; *Mp*, membrana propria, seen at one point in cross section, at the other as if spread out upon a flat surface; *M*, muscular fibres; *F*, flat cells: *Bg*, connective tissue. The specimen was hardened in alcohol and stained rapidly with orcein.

former is represented by the coils, the latter by the duct which leads to the external surface of the skin. The histological anatomy of the smaller glands differs somewhat from that of the larger ones, and will be considered first.

Histological Anatomy.—The coils, or secretory portions of the sweat glands, consist of a single layer of columnar epithelium, arranged around a rather irregularly shaped lumen. The cells are cloudy throughout, with the exception of a narrow portion along their free margin, which is clear. They are bounded externally by a layer of involuntary muscular fibres, which run spirally around the mass of cells, and which are so arranged that small spaces are left between them. The secreting cells send out processes into those spaces, and these form a union with the limiting membrane or membrana propria of the glands, which is composed of connective tissue. The excretory portion of the gland, or duct, consists of a connective-tissue coat, a structureless membrane, and bounding its lumen are two rows of epithelial cells, the free margins of which are covered by a cuticula. There are no muscle fibres in the coats of the sweat ducts. These latter begin in the inner portion of the coils, and rise to the surface in an oblique direction having a more or less spiral course, and they always reach the epidermis at an interpapillary prolon-

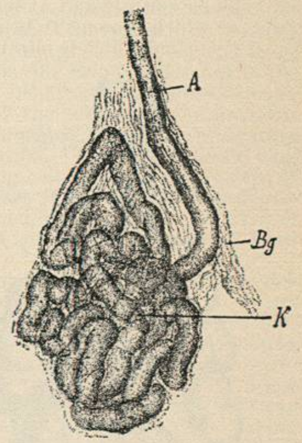

FIG. 5200.—Terminal Coil of a Sweat Gland, from the Skin of the Back of the Foot. Obtained by Professor Schaffer as a separate and complete specimen by maceration in diluted nitric acid. Magnified 80 diameters. (After Mracek.) *K*, Terminal coil; *Bg*, enveloping connective tissue; *A*, outlet of the gland.