gation. The duct here loses its membrana externa, which goes over into the tissue of the papilla, and also its cuticula, so that the lumen is bounded for a short distance in the stratum spinosum by the spiny cells alone. The cells which limit the lumen in its course through the epidermis, show granules of keratohyalin very early, and considerably below the level of the stratum granulosum; and it can further be seen that all the layers of the epidermis became interested and aid in forming the boundaries of this spiral canal in its course to the external surface. The views which are held by Unna, in regard to this portion of the duct, have so much in their favor as to claim general recognition. He does not consider that the spiral portion in the epidermis belongs entirely and alone to the duct of the sweat gland, of which it seems to be a continuation, but thinks that it is a canal which is also in connection with the system which conveys the juices throughout the epidermis. According to him, the sweat duct ends in the basic layer of the stratum spinosum, and he would, consequently, separate the two portions very sharply. He very rightly points out, in support of this, that we have no reason for concluding that the fluid which passes through it comes entirely from the same source, inasmuch as there are no grounds for asserting that the sweat is derived from the coils alone. All that we do know is, that it appears upon the external surface at the openings of these canals, but more than that has not been proved.

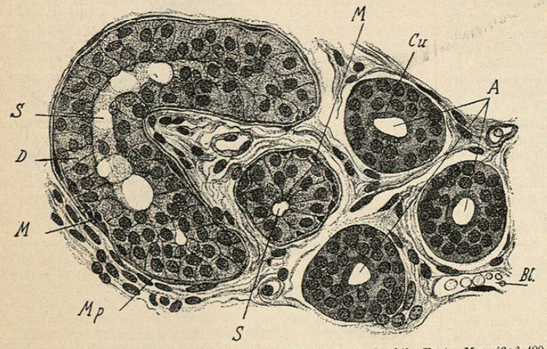

FIG. 5201.—Portion of a Sweat Gland from the Skin of the Back of the Foot. Magnified 400 diameters. (After Rabl.) *S*, Secreting portion of the coil; *D*, gland cells; *M*, smooth muscle fibres; *Mp*, membrana propria of the glandular tube; *A*, cross sections of the outlet portion of the gland; *Cu*, cuticula of the same; *Bl*, blood-vessel. Specimen hardened in a saturated aqueous solution of bichloride of mercury, and stained with hæmatoxylin and eosin.

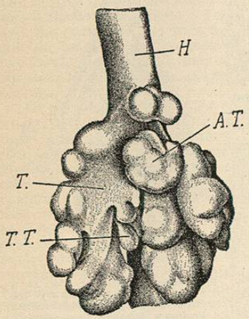

FIG. 5202.—Model of a Group of Sebaceous Glands Surrounding a Hair of the Scalp. (After Rabl, from K. Bauer.) *H*, Hair follicle; *T*, sebaceous gland; *T.T.*, tubular gland; *A.T.*, alveolar gland.

The histological anatomy of the larger sweat glands, as has been already mentioned, differs somewhat from that of those just described. The differences are shown both in the coils and in the duct, by a dilatation and a narrowing of the canal in places. Where the lumen is larger there is only a single layer of epithelial cells; but in the narrower portions there are several. It is also claimed that muscle fibres are present in the former situations, but they are always absent from the latter.

THE SEBACEOUS GLANDS.—*Embryology.*—The sebaceous glands of the skin make their appearance from the beginning of the fourth to the fifth month of pregnancy (Gegenbauer). Those glands which open directly upon the external surface of the skin, are formed from ingrowths of the rete Malpighii, which penetrate into the cutis. These epithelial prolongations are at first solid, but a canal soon forms in them by the fatty degeneration of the central cells. In its further development it is found that, by a process of cell proliferation, solid buds are given off from the original epithelial ingrowths, canals form in the axes of these, and the gland, finally consisting of several lobules, has become racemose. The origin of the sebaceous glands attached to the hairs is the same; except that the epithelial ingrowths proceed from the external root sheath of the hair. They appear very soon after the formation of the hair follicle by the prolongation of the rete into the cutis.

Distribution and Size.—The sebaceous glands are distributed very generally over the body, and are found everywhere in the skin, except upon the palms of the hands, the soles of the feet, and the last phalanges of the fingers and of the toes. They are particularly numerous upon the face and the scalp, where they are set very closely together. On the rest of the body they are found

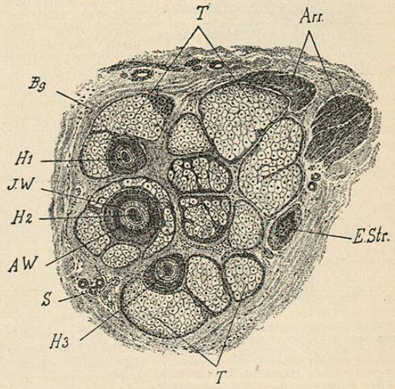

FIG. 5203.—Cross Section of a Hair and Neighboring Parts at the Level of the Sebaceous Glands. The specimen, which had been taken from the scalp of an adult, was first hardened in Mueller's fluid and then stained with hæmatoxylin and eosin. Magnified 50 diameters. (After Rabl.) H_1, H_2, H_3, Cross sections of three hairs; *E.Str.*, a column of epithelial cells, constituting the connecting link between those which surround the hair bulbs (belonging to the hairs shown in the picture) and those lying above the papilla of a fourth hair; *T*, sebaceous glands belonging to the hairs shown in the cut; *J.W.*, inner root sheath; *A.W.*, outer root sheath; *Arr.*, arrector pili; *Bg*, connective tissue; *S*, sweat gland.

to be fewer in number and more widely separated. The glands vary very greatly in size. Of those connected with the hairs, the smallest are the ones on the scalp, 0.1 mm. to 0.16 mm. in diameter, but larger ones are attached to the hairs of the beard and axilla, from 0.16 mm. to 0.24 mm.; but the largest are on the mons veneris, the labia majora, and the scrotum. The sebaceous glands which are in connection with the lanugo hairs are from 0.25 mm. to 1 mm. in diameter. The length of the glands is from 40 to 160 μ, but the large ones on the nose measure even as much as 1 mm.

In shape there is also considerable variation. The simplest ones resemble small pouches, but the glands are usually found to be racemose or acinous, that is, composed of several lobules which possess one duct in common.

These glandular bodies are situated for the most part in the upper portion of the corium, above the level of the coils of the sweat glands. Some extend, however, through almost the entire thickness of the cutis.

They are found either directly attached to the hair follicles, into which their ducts open, at a variable distance from the orifice on the cutaneous surface, and empty the fatty matter secreted by them; or the external opening of their ducts is situated on the surface of the skin. These latter are the glands with which the lanugo hairs are associated. Besides these two forms, there are others which are entirely unconnected with hairs, and which also open directly upon the outer surface of the skin.

The sebaceous glands which open into the cavity of the hair follicles are the most numerous. They are seen wherever fully developed hairs exist, as on the scalp, the beard, etc. There is sometimes only one gland, but more often there are two, situated on opposite sides of the follicles, of different sizes, and at different heights. Their excretory ducts are short and pass obliquely upward to enter the follicles, the larger glands opening more superficially, the smaller ones more deeply, but the common location is at the junction of the upper and middle thirds.

The sebaceous glands which are associated with the lanugo hairs, and which open directly upon the external surface, are distributed over the forehead, cheeks, sides of the nose, and areola especially. They occur also more or less scattered over the trunk, the extremities, and the genitals. These glands are the largest, and also the most complicated in their structure. The duct is usually broad, and its orifice dilated. The hair attached to it is really an appendage, and passes through the duct to reach the outer surface of the skin. It has no follicle of its own, except at its deepest portion.

The glands which are in no way associated with hairs, and which open directly upon the external surface, are certain ones situated in special localities. They have received distinguishing names, and are known as the Meibomian glands in the eyelids, and the glands of Tyson on the glans penis and prepuce. To this class also belong the large glands of the labia minora, and those of the vermilion border of the lip.

Histological Anatomy.—A sebaceous gland may be considered to be composed of an outer wall and an inner mass of cells. The wall is formed of connective tissue, which is derived from the external sheath of the hair follicles; but in those glands which are associated with the rudimentary or lanugo hairs, and in those unconnected in any way with hairs, the fibrous envelope is obtained from the corium. The wall acts as a support (Morel) for a basement or membrana propria, which bears upon its inner surface a layer of cylindrical epithelial cells, and it also contains the nerves, blood-vessels, and lymphatics supplied to the glands. The membrana propria is exceedingly thin and amorphous. The single row of cells which are in connection with it is a continuation of the basic layer of the epidermis, the spiny cells stopping at the neck of the glands. The cavity of the glands is filled with large oval and polyhedral cells having large nuclei, but in the central portions there is a semifluid homogeneous mass, the sebum. The source of the sebum seen in the sebaceous glands are the cells, which are found presenting all stages of fatty degeneration. The most external ones are granular, the succeeding ones contain small drops of fat, which gradually increase in size as the central portion of the cavity is reached, until there is no trace of protoplasm remaining, the cell being completely filled with fat.

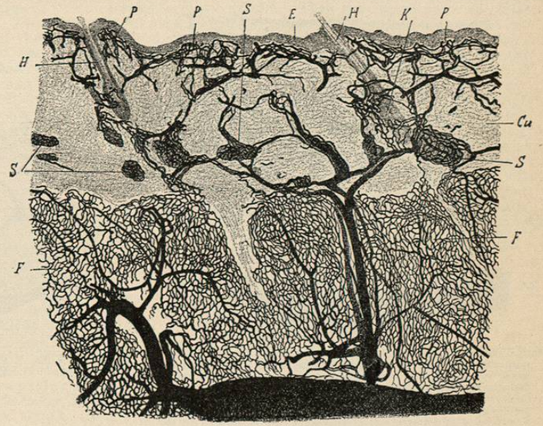

FIG. 5204.—Section of the Skin of the Shoulder of a Child. The blood-vessels have been completely filled with gelatin colored with carmine. Magnified 40 diameters. (After Rabl.) *E*, Epidermis; *P*, papillæ; *Cu*, corium; *F*, subcutaneous fat tissue; *H*, shaft of hair; *K*, bulb of hair; *S*, coil of sweat gland. The specimen therefore shows, besides the larger trunks of blood-vessels, the capillaries belonging to the papillary layer, the sweat glands, parts of blood-vessels that supply the hairs and also those vessels which belong to the fat tissue. The large trunk of a blood-vessel seen at the lower margin of the picture is situated in the horizontal plane of connective tissue which serves to separate the subcutaneous fat tissue into two superposed layers. In the picture only the upper half of the panniculus adiposus is visible.

THE BLOOD-VESSELS OF THE SKIN.—The vessels which supply the skin with blood are branches from the larger arteries which lie below the subcutaneous fatty tissue. They pass up through this latter and form at its junction with the corium a more or less horizontal network. From this network further branches are given off, some to supply certain portions of the skin, others to ascend obliquely and perpendicularly through the cutis, having only few branches, until they reach the subpapillary layer of the corium. Here they again form a more or less horizontal network, which also gives off many branches.

The plexus of arteries at the junction of the cutis and subcutaneous tissue is very rich. It supplies the papillæ of the hair, the coils of the sweat glands, and also sends off branches which break up into capillaries in the panniculus adiposus. The subpapillary network of arteries supplies vessels to the external root sheath of the hair, the sebaceous glands, the unstriped muscles, and the ducts of the sweat glands. In addition, this plexus gives off branches which break up into capillaries just

below the papillæ, and into each of these a tortuous arterial capillary ascends almost to its upper end, where it forms a loop and goes over into a venous capillary. These latter unite to form venules in the same plane as

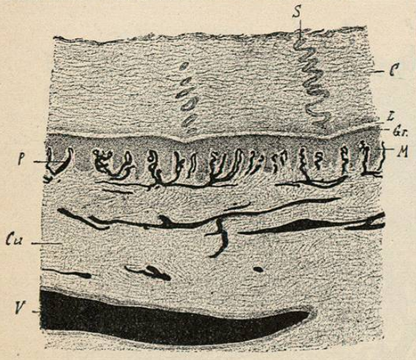

FIG. 5205.—Section of the Skin of the Palm of the Hand. The cutting was done in a direction parallel to the ridges. The blood-vessels have been filled with gelatin colored by carmine. Magnified 50 diameters. (After Rabl.) *C*, Stratum corneum; *L*, stratum lucidum; *Gr*, stratum granulosum; *M*, stratum Malpighii; *P*, papillæ; *Cu*, corium; *V*, vein at the lower border of the corium; *S*, orifice of a sweat gland. Portions of the cutaneous plexus of blood-vessels and of the capillaries belonging to the papillæ are also shown in the picture.

the arteries, and course along them. When they arrive at the subcutaneous layer they, together with the veins from the other portions of the cutis, unite to form large venous trunks in the same plane as the large arteries. Between the two horizontal plexuses of arteries there is a portion of the cutis which has a very poor blood supply, and here even the bundles of fibres which go to form the pars reticularis do not receive any vessels.

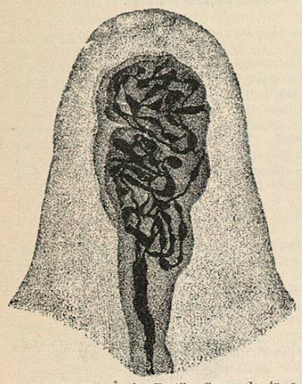

FIG. 5206.—Meissner's Tactile Corpuscle in a Papilla of the Tip of the Finger. The nerves have been stained by Fischer's gold method. (After Rabl, from Ruffini.) An afferent medullated nerve fibre enters the corpuscle from below and subdivides into a number of non-medullated varicose fibrillæ which traverse the corpuscle chiefly in a horizontal direction.

There are considerable differences in the distribution of the blood-vessels of the skin, and in the area supplied by any one branch. These areas are very small on the palms of the hands, the soles of the feet, and the face; also at the sulcus coronarius and the corona glandis, in which places each branch from the subpapillary arterial plexus, when it breaks up into capillaries, supplies only a few papillæ. The areas which are furnished with blood by one arterial branch are much larger in the greater part of the skin—the vessels breaking up into a number of capillaries—

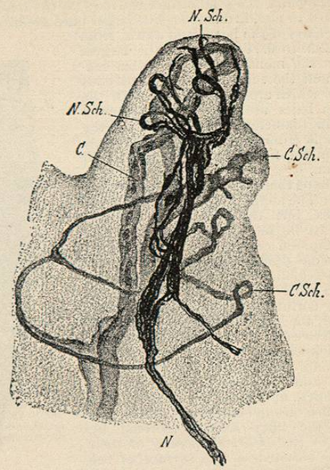

FIG. 5207.—Papilla from the Skin of the Tip of the Finger, showing Capillary Blood-vessels and Numerous Nerve Fibrillæ. Gold preparation. (From Rabl, after Ruffini.) *N*, Nerve trunk; *C.Sch.*, capillary loop; *N.Sch.*, nerve filaments surrounding the capillaries. (Greatly enlarged.)

and it is in general observed that they are more extensive on the extensor than on the flexor surfaces of the extremities.

Peculiar circulatory conditions are found in certain portions of the skin. On the ear, the alæ nasi, and in the region of the lips, large lacunæ are seen into which the venous capillaries empty from above, while from below the venules are given off. On the ends of the fingers there is likewise a special arrangement of the vessels. It has been found that here some branches of the digital arteries emptied directly into the large veins of the bed of the nails, without there being any intervening capillaries. Also it is observed that, after the vessels for the panniculus adiposus and sweat glands had been given off, but before the upper horizontal plexus for the supply of the papillæ had been formed, small arterial branches divided and broke up into many small coils. In the inner portion of these they emptied directly into venules.

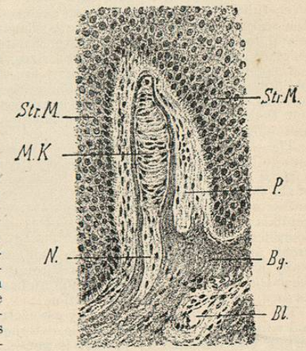

FIG. 5208.—Meissner's Tactile Corpuscle from the Skin of the Tip of an Adult Finger. Specimen hardened in alcohol and stained by means of hæmatoxylin and picrofuchsin. (After Rabl.) *MK*, Meissner's tactile corpuscle; *N*, afferent nerve fibres; *P*, papilla; *Str.M*, stratum Malpighii; *Bg*, connective tissue of the body of the papilla; *Bl*, blood-vessel.

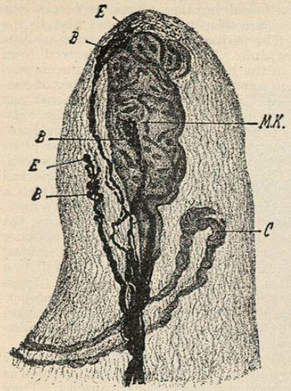

FIG. 5209.—Papilla of the Skin of the Finger. Staining by Fischer's gold method. (After Rabl, from Ruffini.) The papilla contains, at its extremity, a Meissner's tactile corpuscle (*MK.*); farther down, a capillary loop (*C*), and on the left three independent, fascicular terminal plexuses of nerve fibrillæ (*B*); *E*, small terminal knobs of the nerve fibrillæ.

The lumen of the arteries of the skin is narrow, but that of the veins is large and wide. Their coats are slightly marked in the cutis, and they show only near the subcutaneous connective tissue an adventitia and a media. But even there these are poorly developed. All the vessels of the papillary layer of the corium are capillary in character, that is, simple endothelial tubes.

THE LYMPHATICS.—There are in the integument of the body two forms of channels which contain the lymphatic fluid, and through which it flows, viz., the lymphatic vessels proper, those which possess an endothelial lining, and the numerous spaces which occur between the elements composing the various layers of the skin.

FIG. 5210.—Krause's Terminal Bulb from the Palpebral Conjunctiva. Nerves stained by means of methylene blue. (After Rabl, from Dogiel.) *M*, Afferent medullated nerve fibre: *N*, one of the non-medullated nerve fibrillæ resulting from the subdivision of the fibre *M*; *E*, terminal coil; *Bg*, connective-tissue capsule.

In regard to the latter, it has been proved that they are the origin of the lymphatic system of the skin, by the successful injection of the intercellular spaces in the spiny layer of the rete Malpighii from the lymphatics of the subcutaneous connective tissue (Retzius, Axel Key, et alii). Other lymph spaces exist between the membrana propria and the secreting cells of the coils of the sweat glands, and between the epithelial cells of the sweat ducts. The intercellular spaces in the stratum spinosum of the hair follicles and in the sebaceous glands are also points of origin for the lymphatics. The bundles of unstriped muscle fibres and the coils of the sweat glands and the bundles of connective-tissue fibres forming the cutis are sheathed by lymph spaces, as are also the fat clusters. According to Klein, very fine channels proceeding from these lymph sheaths penetrate into the latter and ramify betweeen all the fat cells of which they are composed.

The papillæ are also extensively traversed by lymph spaces, which empty into the lymphatic vessels proper. These vessels are lined with endothelium, and begin in the upper third of the papilla (the Hoggans) by means of a cul-de-sac. They course downward in the form of a plexus through the cutis, and at its junction with the subcutaneous connective tissue unite to form a few large vessels, which, according to Heming, have a muscular coat.

THE NERVES OF THE SKIN.—The nerves which are supplied to the skin are derived from branches of the cerebro-spinal system. They pass up through the subcutaneous connective tissue, in the same manner as the blood-vessels, from the larger trunks situated below. In the upper part of the panniculus adiposus the course of the nerves is a horizontal one, and they give off a large number of small branches for its innervation. They penetrate the cutis together with the arterial vessels, and accompany them more or less in their distribution. In their course they give off branches to supply the various constituent portions of the cutis. Those which supply the hair follicles pass to them in the neighborhood of the sebaceous glands, to which fibres are sent. They penetrate the hair sheath and are distributed between the cells of the root sheaths. The sweat glands

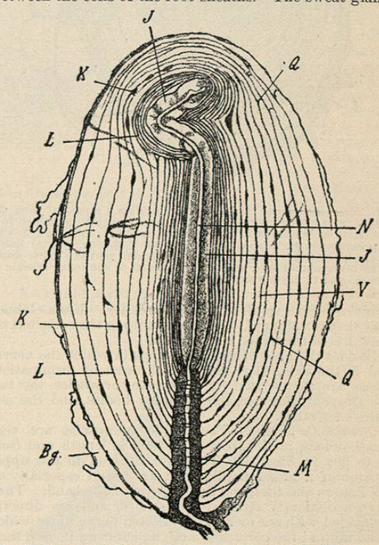

FIG. 5211.—Pacinian Corpuscle from an Amputated Foot. Magnified 70 diameters. (After Rabl, from Henle and Kölliker.) *M*, Medullated nerve fibre; *N*, non-medullated nerve fibre within the inner club-shaped sheath, *J*; *L*, lamellæ of the outer bulb-shaped envelope; *K*, nuclei of the connective-tissue cells; *V*, spot where two contiguous lamellæ unite, the lines of union forming an acute angle; *Q*, spot where the line of union runs transversely; *Bg*, connective tissue outside the corpuscle.

and their ducts are also furnished with nerves. Unna claims to have seen nerve endings between the secretory epithelial cells of the coils.

When the nerves arrive at the upper portion of the cutis they take a horizontal course and form a rich plexus just below the epidermis, which gives off a great number of branches. These break up into fine fibrillæ, and are distributed in every direction. These fibrillæ terminate either in the endothelium of the papillary blood-vessels, or free in the connective tissue of the papillary body, or penetrate into the interepithelial spaces of the stratum spinosum. Longer branches from this plexus ascend into the papillæ, and in certain portions of the integument end in the tactile corpuscles.

The nerve fibres which, it is claimed, have been traced between the cells of the epidermis are non-medullated.

They are said to be distributed generally throughout the rete Malpighii, as far up as the stratum granulosum, and to end in the intercellular spaces, either tapering to a

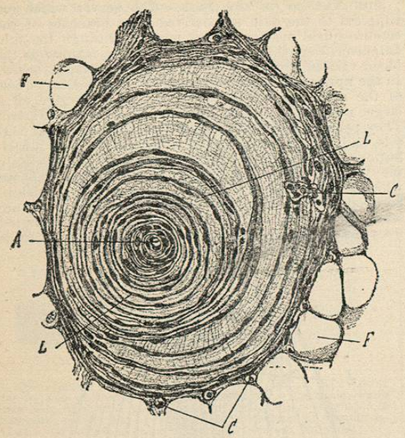

FIG. 5212.—Transverse Section of a Pacinian Corpuscle, from the Skin in the Neighborhood of the Anus. Specimen hardened in a solution of picrin and bichloride of mercury and stained with hæmatoxylin and eosin. Magnified 200 diameters. (After Rabl.) *A*, Axis cylinder lying in a narrow, circular, perfectly clear space, the inner club-shaped sheath; *L*, lamellæ of the outer capsule or envelope; *C*, capillaries; *F*, fat cells.

point or with a small rounded extremity. Unna claimed that they terminated in small discs upon the cells, but his view has not received recognition.

Besides the above-mentioned ways in which the nerves end in the skin, there are special forms of termination. These are represented by the tactile corpuscles, the tactile discs of Ranvier, the Pacinian bodies, and the end bulbs of Krause.

Tactile Corpuscles.—The tactile corpuscles are very small, oblong bodies from 40 to 200 μ in length, and from 30 to 60 μ in breadth. They are situated in the upper portion of a broad papilla, and are found especially on the fingers and toes, and in the palm of the hand. They have a distinctly striated appearance, and are directly connected with one or two medullated nerve fibres which wind around the corpuscle, and, on entering it, lose their medullary sheath, the perineurium becoming continuous with the capsule of the corpuscle. The nerves split up into branches, which end in flattened knobs between the connective-tissue cells of which the corpuscle is composed. They often consist of two or three sections lying close together, each one being supplied with a nerve.

Ranvier's Tactile Discs.—These discs are small cup-shaped bodies, the concave side of which is always directed toward the free surface of the epidermis. At several points on the convexity of the disc the termination of a non-medullated nerve fibre is seen. Ranvier claims that this nerve ends only on the surface of these discs, but according to others this takes place in the cell between the nucleus and the external membrane. This form of nerve ending has been found in the deeper portions of the epidermis, near the sweat duct, and in the corium just below the rete.

The Pacinian Bodies.—The Pacinian bodies were first thoroughly described by Pacinius, though they had already been mentioned by Vater over a hundred years ago. They are small, oval, transparent bodies from 2 to 3 mm. long and 1 to 2 mm. broad, and are situated in the subcutaneous connective tissue, almost exclusively upon the branches of the nerves which supply the skin of the palms of the hands and of the soles of the feet, but also upon the dorsal nerve of the penis and of the clitoris. They are likewise found in other places, as around the joints, where they are deeply situated, and also in the mesentery, etc. The major part of the Pacinian body is formed by the capsule. This capsule is derived from the perineurium of the nerve, which ends in the corpuscle, and is in reality composed of a large number of concentrically arranged laminæ, which are separated one from the other by a layer of flat endothelial cells. Between any two of these there is a more or less large quantity of an albuminous fluid, and connective-tissue fibres forming septa are also seen. This laminated and concentrically arranged capsule surrounds a narrow cylindrical space, which contains a granular substance in which a few cells are seen, and the termination of the nerve fibre. At its entrance into the cavity of the Pacinian body, the nerve loses its medullated character and the axis cylinder alone passes in. It appears as a pale, finely granular, narrow band, which ends in a single small knob or in a series of them. The nerve has also been observed to pass entirely through one of these bodies and end in another. A small artery penetrates the capsule of the Pacinian bodies along with the nerve, and forms a capillary plexus between the peripheral laminæ.

End Bulbs of Krause.—The end bulbs of Krause are minute oval or cylindrical bodies, which are regarded as being more or less related to the tactile corpuscles. They consist of a connective-tissue capsule containing a large number of cells which form a core. Between these, one or more nerve fibres end. They are found in the conjunctiva and the mucous membranes of the mouth, the glans penis, clitoris, and vagina, where they are termed genital corpuscles. The capsule of these end bulbs is derived from the perineurium, but the nature of the core which it contains is still a mooted point. The axis cylinder alone penetrates into this core, having lost its medulla, and it ends in the upper portions either free or as a small button-like protuberance.

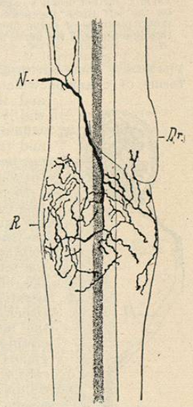

FIG. 5213.—Hair from the Lip of a Human Embryo 19.5 cm. long. (After Rabl, from G. Retzius.) *N*, Afferent nerve fibre, which first gives off a small forked branch in an upward direction, and then subdivides into a ring-like plexus (*R*) completely surrounding the outer sheath of the hair root which at this point is somewhat thickened. This plexus consists of a few nearly horizontal fibrillæ between which run numerous vertical ones; *Dr*, sebaceous gland.

The Appendages of the Skin.

The Nails.—*Embryology.*—The first steps in the development of the nails occur in the third month of fœtal life, and consist in the marking out of the nail bed and furrow. This is covered by the ordinary stratum corneum of that period of life, and it represents the eponychium of Unna. Underneath the eponychium the embryonic nail remains up to the fifth month. According to Kölliker, there appears in the fourth month, between the eponychium and the stratum mucosum, a layer of large, pale-colored, horny plates, which cover the bed of the nail and represent its primary form. The nail in its further growth increases in thickness quite rapidly, possesses a free border by the sixth month, and by the seventh month is fully formed. Kölliker also claims that the development of the nail takes place from

the entire nail bed, but Unna insists that he has observed the formation of a germinal spot in the matrix, from which the embryonic nail grows and pushes itself forward beneath the eponychium.

General Characteristics.—The nails of human beings are elastic structures of a horny texture situated upon

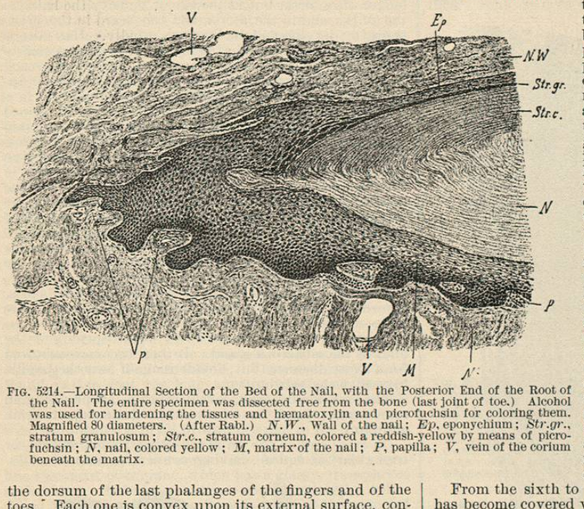

FIG. 5214.—Longitudinal Section of the Bed of the Nail, with the Posterior End of the Root of the Nail. The entire specimen was dissected free from the bone (last joint of toe.) Alcohol was used for hardening the tissues and hæmatoxylin and picrofuchsin for coloring them. Magnified 80 diameters. (After Rabl.) *N.W.*, Wall of the nail; *Ep*, eponychium; *Str.gr.*, stratum granulosum; *Str.c.*, stratum corneum, colored a reddish-yellow by means of picrofuchsin; *N*, nail, colored yellow; *M*, matrix of the nail; *P*, papilla; *V*, vein of the corium beneath the matrix.

the dorsum of the last phalanges of the fingers and of the toes. Each one is convex upon its external surface, concave upon its internal and moulded upon the cutis, to which it is firmly adherent. The exposed portion of the nail is called its body; the anterior extremity, the free edge; the semilunar portion posteriorly, which is of a white opaque color, the lunula. The portion of the cutis upon which the nail is situated is the nail bed. It is bounded laterally by two rolls of the skin, which are known as the walls of the nail. Around the nail bed is a groove which is covered by the nail wall, and in this lie the lateral edges of the nail, while the posterior portion, the nail root, is implanted in a similar though much deeper groove; this latter represents the matrix, and it is from here that the growth of the nail takes place.

Histological Anatomy.—The bed of the nail consists of the corium and the stratum mucosum. The connective-tissue bundles of the cutis run here partly longitudinally and parallel to the axis of the fingers, partly in a perpendicular direction from the periosteum to the external surface. The epithelium covering the corium is composed of cells identical with those in the stratum mucosum of the epidermis, and is sharply defined from the nail, except at the matrix.

The corium at the matrix of the nail shows a well-developed papillary body, and is very vascular, each papilla receiving a blood-vessel. In front of this and beneath the lunula the papillæ are very small, and still more so anteriorly; the cutis forming the nail bed has no papillæ but fine longitudinal ridges, in which run the blood-vessels, which give off capillary branches at regular intervals. These ridges of the corium are covered by the epithelial cells of the stratum mucosum, which also dips down between them.

The nail itself consists of horny lamellæ, which are closely bound together, and which are composed of cells similar to those of the epidermis, except that they contain nuclei.

In the formation of the nail the matrix plays the important part, and it is from this portion that regeneration of the nail is continually going on.

The Hairs.—*Embryology.*—The first steps in the development of the hairs occur at the end of the third or the beginning of the fourth month of fœtal life. They are shown by the formation of small, solid prolongations of the rete Malpighii, penetrating into the cutis and increasing in length by the proliferation of the cells composing them. Arriving in the deeper portion of the cutis, the lower end of the prolongations is very soon surrounded by an aggregation of round and spindle cells, which partly form the papilla of the hair and partly grow around the epithelial ingrowth in order to form the sheath of the hair follicle (Unna). During this time changes also take place in the epithelial column. In its inner portion a conical-shaped mass of cells, with its apex directed externally, becomes differentiated from the remainder, and this represents the primitive hair body. From it the hair and its inner root sheath are formed. The primitive hair body having grown around the newly formed papilla, it increases in length upward and keratofication begins and proceeds from above downward. The external root sheath is constituted by the portions of the epithelial ingrowth of the rete Malpighii which remain after the differentiation of the primitive hair body and surround the entire hair.

From the sixth to the eighth month of life the fœtus has become covered with hair, which, however, falls out

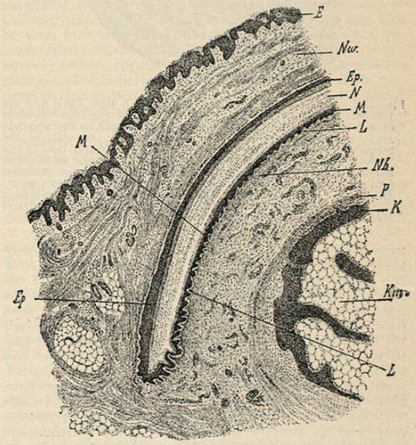

FIG. 5215.—Cross Section of the Basal Portion of the Nail of an Adult. Specimen hardened in Mueller's fluid and stained with hæmatoxylin and eosin. Magnified 25 diameters. (After Rabl.) *E*, Epidermis of the wall of the nail (*Nw.*); *Ep*, eponychium; *N*, nail; *M*, matrix of the nail; *L*, longitudinal border of the matrix; *Nb.*, bed of the nail; *P*, periosteum; *K*, bone; *Km.*, bone marrow.

and is replaced by new hair. This regeneration of the hair on the fœtus is continuous as in adults, but the

rapidity of the change ceases a few weeks after birth. The embryonic or lanugo hairs, which have a much shorter length of life than those which grow after birth, give place to more permanent ones, and on certain portions of the body acquire a much greater development than they do on others. The new hairs originate from the epithelium forming the external root sheath of the lanugo hairs, which sends out solid buds from which the hair develops in exactly the same way as has just been described, and grows up alongside of the embryonic hair to the external opening of the follicle. The old hair has, in the mean time, been separated from the papilla and become completely horny, owing to its loss of nourishment, and, being pushed upward by the new-formed hair, falls out when the external surface is reached. In this way the temporary hairs are replaced by the permanent ones, and an entirely similar procedure is furthermore constantly seen repeating itself, even in adults.

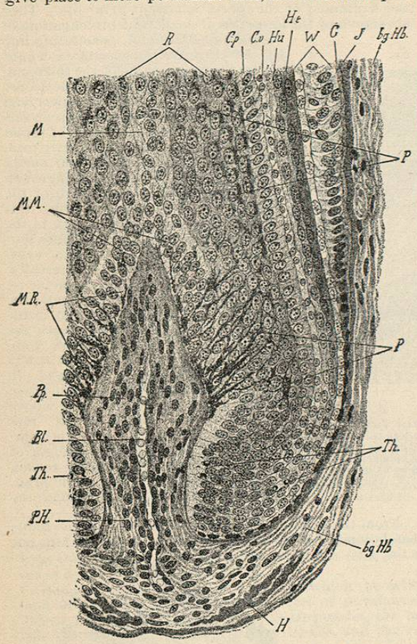

FIG. 5116.—Longitudinal Section of a Papilla, a Hair Bulb, and the Lowest Part of the Shaft of the Hair with its Sheaths, from the Scalp of an Adult. Magnified 300 diameters. (After Rabl.) *Pp.*, Papilla; *P.H.*, neck of the papilla; *Bl.*, blood-vessel; *M*, cells of the medulla of the hair; *R*, cortical cells; *MM.*, matrix cells of the medulla; *MR.*, matrix cells of the cortex; *Th.*, cells undergoing karyokinesis; *P*, pigment; *Cp*, membranous envelope of the hair; *Cr.*, membranous envelope of the root sheath; *Hu*, Huxley's layer; *He*, Henle's layer; *W*, outer root sheath; *G*, vitreous membrane; *J*, innermost layers of the connective-tissue hair follicle (*bg Hb.*); *H*, kollastin.

General Characteristics.—The hairs, which are modifications of the epidermis, are found in greater or less amount over the entire body, with the exception of the palms of the hands, the soles of the feet, the vermilion border of the lips, the glans penis, the labia minora, and inner surface of the labia majora. Over the majority of the surface they are short, rather colorless, having the character of the embryonic hairs, and hence are termed the lanugo hairs; but on the head, the eyebrows and the eyelids, in the axillæ, on the pubes, and in the male sex on the cheek and upper lip, they attain a much higher grade of development.

The hairs which are present upon the scalp, eyebrows, and eyelids become gradually more marked, thicker, and longer after birth, but at the age of puberty the hairs on the pubes and in the axilla, and the beard in the male, begin to develop and to increase rapidly. Hair also is found around the anus in the male. It is not unusual to see, in certain races, that in women, as they approach and pass the climacteric, a stronger growth of hair appears on the upper lip and face.

The hairs, both the lanugo and the fully developed ones, are for the most part placed obliquely in the skin and are situated in follicles termed the hair follicles. These latter are sometimes short, the papilla lying high up, or, again, of considerable length, and deep down in the subcutaneous connective tissue. The portion of the hair situated in the follicle is the root, that above the level of the skin, the shaft. At the lower extremity of the root there is a whitish, soft, bulbous enlargement, the hair bulb, which has a concave end that fits upon the conical vascular eminence already mentioned as being the hair papilla.

The hair follicle itself may be divided into three parts, according to its form. From its upper extremity, where it opens out upon the surface of the skin, it descends, shaped like a funnel, as far down as the opening of the duct of the sebaceous gland. It then becomes narrowed for a short distance, but broadens again near the papilla to receive the hair bulb.

The hair shaft varies considerably in shape, being in some cases round, in others much flattened, or again angular.

On cross section the hairs are either round, or oval, or triangular, or square, having convex or concave sides.

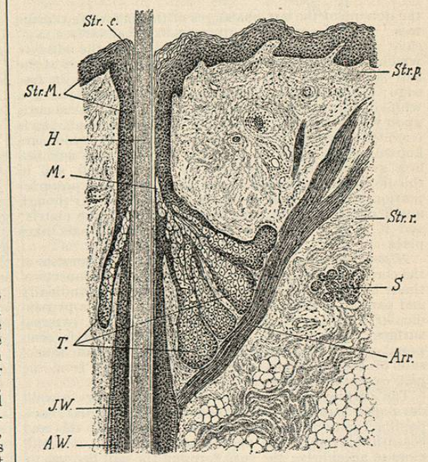

FIG. 5217.—Hair of an Adult at its Point of Emergence from the Scalp. Specimen hardened in Mueller's fluid and stained with hæmatoxylin and eosin. Magnified 50 diameters. (After Rabl.) *H*, Shaft of hair; *J.W.*, inner sheath of root of hair; *A.W.*, outer sheath of root; *T*, sebaceous gland; *M*, outlet of this gland; *Arr.*, arrector pili; *Str.c.*, stratum corneum; *Str.M.*, stratum Malpighii; *Str.p.*, stratum papillare corii; *S*, sweat gland.

The angular and flattened hairs are found in those localities where the hair is curly, the round ones where it is straight.

At its free external end the hair is pointed when in its natural state, but owing to the fact that it is continually subjected to mechanical influences, such as rubbing, etc., it is usually found to have a more or less rounded extremity.

Histology of the Hair and of its Follicle.—Hair Follicle.—The hair follicle is represented by a sac-shaped cavity composed of connective tissue. At its lower end, which is more or less deeply situated in the cutis, an eminence is seen, analogous to the papillæ in the upper portion of the corium, which is known as the hair papilla. This body, upon which the concave extremity of the hair root is accurately fitted, is oval in shape, and at its base is a distinctly marked constriction—the neck of the papilla. It is composed of connective tissue, similar to that of the cutis, of which it is a part, and contains blood-vessels. (See also Fig. 5203.)

The hair follicle envelops the lower two-thirds of the hair and of its sheaths, but above the openings of the ducts of the sebaceous follicles it is not demonstrable as a separate formation, becoming lost in the tissue composing the papillary body. It consists of three coats. The most external of these is a portion of the cutis proper, and is composed of connective-tissue fibres, which are closely bound together and run longitudinally in the axis of the hair, and is quite rich in connective-tissue cells. In it are distributed the blood-vessels and nerves supplied to the hair. The next innermost coat is composed of elements similar to those which are found in the most external, but they are arranged in a circular manner running around the hair follicle. There are many nuclei found in this coat, the long axes of which are directed parallel with the course of the fibres, and they resemble very strongly the nuclei seen in unstriped muscles; but this resemblance is in all probability due to the tension to which the fibres are subjected.

The innermost of the coats of the hair follicle is a hyaline basement membrane, which has a glassy, transparent appearance. It is in immediate contact with the cylindrical layer of epithelial cells belonging to the external root sheath of the hair. It is not always demonstrable, varying greatly in thickness, and is most clearly marked in the lower third of strongly developed hairs. In the lanugo hairs the connective-tissue envelope of the hair is absent, the root sheaths being derived from the epidermis forming the hair follicle.

The Hair Sheaths.—The root of the hair proper is in the greater portion of its extent covered by an envelope, which consists of several layers of cells very adherent to it. It constitutes the inner root sheath of the hair, and lies in contact with the external root sheath, by which it is separated from the connective-tissue envelope of the hair follicle.

The Hair Proper.—When a fully developed hair is examined under the microscope, it can be seen that it is composed of three tissues, which differ from each other in appearance. These three portions are termed the cuticula, the cortex, and the medulla. Each of these can be easily recognized in the shaft of the hair, but not so readily at the bulb. Still, if the hair is treated with picrocarmine, the cuticula can be traced here, and it can be seen that it starts from the neck of the hair papilla (Unna). By the same method, it is also found that the cortex develops from the lateral portions of the papilla, and the medulla from the apex.

The Cortex.—The most voluminous portion of the shaft of the hair is constituted by the cortex, a transparent fibrillar mass of varying color. In it are seen dark spots and longitudinal streaks, which are situated between the horny elements of the hair, and are caused by the presence of air. Pigment granules are also present in greater or lesser quantities.

When the hair is treated with sulphuric acid the cortex breaks up into the fibres of which it is composed, and, if the action of the acid has been long continued, it may even separate into long, narrow, spindle-shaped plates. In the centres of these latter an indistinct linear figure is oftentimes traceable. It represents the remains of the nucleus of the cell from which the plate was derived.

The development of the hair from cells is very distinctly seen at the papilla. The portion of the hair in immediate contact with this body is hollowed out or concave in shape, and it is composed of a row of cylindrical epithelial cells entirely similar to those forming the basic layer of the epidermis. This layer of cells is termed the matrix of the hair, and it is upon it that the growth of the hair depends. Starting from this point, it can also be seen how the cells and their nuclei grow longer, become finely fibrillated and granular, and finally, when entirely horny, appear as small plates. These successive changes should be studied on hairs which are little pigmented, for in them they can be seen much more easily than when the opposite is the case. The cells of which the cortex of the hair root is formed have been found by Waldeyer to be composed of small fibres. Each cell is united to the contiguous ones by short spines, in a manner analogous to the cells composing the epidermis.

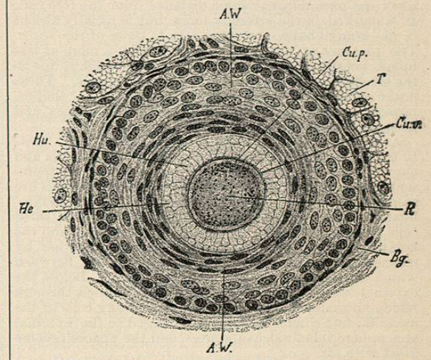

FIG. 5218.—Cross Section of a Hair and its Sheath, from the Scalp. Specimen hardened in Mueller's fluid and stained with hæmatoxylin and eosin. The cut was made at the level of the region in which lie the sebaceous glands. Magnified 250 diameters. (After Rabl.) *R*, Cortical portion of the hair shaft (the medullary substance is lacking in this specimen); *Cu.p.*, cuticula of the hair; *Cu.v.*, cuticula of the sheath of the root; *Hu.*, Huxley's layer; *He.* Henle's layer; *A.W.*, outer sheath of the root; *Bg.*, connective tissue; *T*, sebaceous glands.

The pigment which gives the hair its various shades of color is an important constituent of the cortex. It varies greatly in quantity, and in proportion to its abundance or comparative absence the hair is dark or light in color. It occurs both in a diffuse form and also in granules. The elements of the cortex are diffusely pigmented by the former, but the pigment granules are distributed here and there, and are situated in and between the cells composing the cortex (Waldeyer). This deposition of the pigment granules in the cells is most clearly seen in the root of the hair. The source of the pigment is not yet fully established, though Riehl and others more lately have thrown some light on the subject. In the tissue of the papilla of the hair irregular-shaped nucleated cells, the protoplasma of which contains a considerable amount of pigment, have been found. They were present as far up as the matrix of the hair, between the cells of which they sent long prolongations, and they could also be traced higher up as fine intercellular pigment deposits. Riehl also observed that the cells of this portion of the hair root, which were not yet horny, contained granules of pigment around their nuclei, and also that the cells of the matrix were quite closely connected with the prolongations of the wandering pigment cells of the hair papilla, from which their protoplasm took up pigment granules. In regard to the source of these

granules, Riehl argued that, inasmuch as wandering pigment cells were regularly met with in the papilla of the hair and following the course of the blood-vessels, the blood must be the source of the pigment, and this latter must be carried by the cells to the hair.

The Medulla.—The medulla is situated in the axis of the hair throughout almost its entire length, but it narrows and terminates at some distance from the free end. It is marked in the stronger hairs, but is usually absent in the lanugo hairs, and often also in those of the scalp. The presence of the medulla is shown by a more or less broad, longitudinal band of a dark color, which is due to the air situated between its composing elements. These latter are cells which are shrunken into irregular shapes, possess no nuclei, and are furnished with spines and prongs (Waldeyer).

At the bulb of the hair, the medulla differs very slightly from the cortex. Over the apex of the papilla and above the cylindrical cells situated there, which represent the matrix of the medulla, large nucleated cells are seen, and in their protoplasm are large drops of keratohyalin. In proportion as the shaft is ascended, these cells become shrunken, harder, lose their nuclei, and the keratohyalin disappears. They are bound together by means of the spines and prongs on their surface, between which are left spaces—intercellular spaces. Below the external surface these spaces serve as channels through which nourishment is furnished to the young cells of the medulla, but where the hair is exposed to the external atmosphere this fluid evaporates, and the spaces become filled with air.

The Cuticula.—The hair is also furnished with a cuticula, which surrounds the greater part of that portion of the hair which lies in the follicle. It is formed by a layer of horny plates, arranged like tiles on a roof, and they are closely bound together. The cuticula originates from the neck of the papilla of the hair, between the matrix of the cortex and that of the inner root sheath. At this point it consists of several rows of cylindrical nucleated cells, which divide soon after leaving the matrix into two layers. One of these goes to form the cuticula of the hair, the other the cuticula of the inner root sheath. The cells of the former are at the middle of the hair papilla, directed perpendicularly to the circumference of the hair, but gradually become more and more inclined toward it. At the upper portion of the hair follicle the cuticula is no longer distinguishable and becomes a constituent portion of the cortex. At the matrix the cells are epithelial in character, but they become transformed into solid transparent horn plates without nuclei.

The Root Sheaths.—The hair root is further enveloped by two coats—the root sheaths—which are closely adherent to it. They are known individually as the inner and the outer root sheath. The former is immediately around and in contact with the hair, and ends within the hair follicle; the latter, more external, passes up to the orifice of the follicle, where it becomes continuous with the spiny layer of the epidermis.

The Inner Root Sheath.—The inner root sheath is composed of three layers—the cuticula, the one nearest the hair, Henle's layer, the most external, and between these two Huxley's layer.

The cuticula of the inner root sheath arises from the same matrix at the neck of the hair papilla as the cuticula of the hair. The cells composing it are so arranged that their long axes are parallel to the circumference of the hair, that is, in an opposite direction to the cells forming the cuticula of the cortex. They undergo transformation in a manner entirely analogous to the one which has been already described for the cuticula of the cortex. The cuticula of the inner root sheath is lost sight of within the follicle, becoming a part of the sheath.

The Layers of Huxley and of Henle.—The portion of the inner root sheath which is situated between the cuticula just described and the external root sheath is composed of the two layers known as those of Huxley and of Henle. They also take their origin from the neck of the papilla, and at that point appear as a layer of three or more cylindrical epithelial cells. Drops of keratohyalin, however, appear very soon in these cells, and this substance increases rapidly in quantity. The change in their appearance due to the presence of the keratohyalin is very marked on a level with the apex of the papilla, and the cells are seen here to have attained a much larger size. The cells forming the layer of Henle—the most external—contain, however, a greater amount of keratohyalin, and undergo hornification much more rapidly than they do in the layer of Huxley. Consequently, Henle's layer is found represented by horny, polygonal, non-nucleated elements at a much lower level than Huxley's layer. This latter, the inner portion of the inner root sheath of the hair, is composed at the papilla of cells which contain a smaller amount of keratohyalin. Keratofication in them is not so rapid as in the cells of Henle's layer, the nuclei do not disappear so early, and the complete transformation of the elements of Huxley's layer into horny masses occurs at a higher level than is seen in the former one. The inner root sheath ends in the hair follicle.

The External Root Sheath.—In describing the embryology of the hair, it was stated that the first changes observed consisted in a proliferation and prolongation downward into the cutis of a portion of the cells forming the stratum spinosum of the epidermis. The further steps which occurred in the evolution of the hair, and which took place in the central portion alone of this prolongation, it has also been seen, resulted in the formation of the shaft of the hair, but the remaining portion also serves an important purpose. It represents the external root sheath, or envelope, of the hair, and is separated by it from the connective tissue composing the follicle.

The outer root sheath is not uniform throughout its entire extent, but is lined on the surface next to the hair shaft, and as far down as the opening of the duct of the sebaceous gland, by the stratum corneum and stratum granulosum. From here to the level of the hair papilla the stratum spinosum descends in its entirety, but then narrows, and at the neck of the papilla is reduced to a layer of two or three cylindrical cells. It lies at this point in close contact with the cells from which the inner root sheath is formed.

The appendages of the hairs are the sebaceous glands, and bundles of unstriped muscular fibres are also attached to them. They have been, however, already described.

George T. Elliot.

SNAILS.—A popular term applied to those forms of the gasteropod mollusks, belonging chiefly to the order *Pulmonata*, which are provided with a shell. They are divided into the land, fresh-water, and marine species, belonging respectively to the suborders *Geophila*, *Limnophila*, and *Thalassophila*. There are some few terrestrial species and a large number of fresh-water and marine forms, belonging to the order *Azygobranchia*, to which the term snail is also sometimes applied. The fresh-water and marine forms are perhaps more commonly known as periwinkles and whelks, while allied genera not provided with a shell are ordinarily spoken of as slugs.

The order *Pulmonata* is characterized by a lingual membrane provided with numerous teeth arranged in many uniform transverse rows; mouth usually supplied with one or more horny jaws, a respiratory organ in the form of a closed chamber lined with pulmonic vessels on the back of the animal and covered by the shell when present; the edge of the mantle being attached, and the entrance to the air chamber being through an opening in the side closed by a valve. The operculum is almost universally absent. The tentacles and eye peduncles are retractile or contractile. The shell varies in form, and is sometimes rudimentary or wanting. They are hermaphrodites, with reciprocal impregnation, generally oviparous, and all forms, whether terrestrial, fluviatile, or marine, respire free air.

The American species of terrestrial snails live mostly in the forest sheltered under the trunks of fallen trees,

layers of decayed leaves, stones, or in the soil itself. They are, as a rule, solitary in their habits; only exceptionally, as sometimes in the early days of spring, do they congregate in considerable numbers in warm and

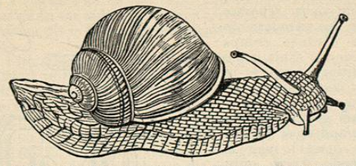

FIG. 5219.—Helix Pomatia Linn.; the European Vineyard Snail, the one most extensively eaten. (From Keferstein.)

sunny situations, but these assemblies do not last more than a few days; they then scatter and again resume for the rest of the year their solitary mode of living. They are rarely seen abroad except on damp dark days or at twilight, and, indeed, they almost disappear as the forests are cut down, and seem to flee the approach of man. The European species, on the other hand, follow in the track of cultivation and are common in gardens and fields, on walls and hedges, and other places exposed to the action of light. It is probably owing to this radical difference in their habits of life that the large majority of our species are so plain and uniformly dull-colored, while the European species are brightly colored. In size the snails vary from those minute species a quarter of an inch or less in length to the gigantic African species belonging to the genera Achatina and Balinus, which sometimes attain the length of eight inches.

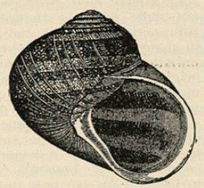

FIG. 5220.—Pomatia Aspersa. (From Binney.)

The eggs are laid in the early spring. Some few forms are viviparous. As soon as hatched, which takes place in from twenty to thirty days, the young snail devotes himself strictly to the business of eating. He first devours his own shell, and then, according as his instinct leads him, begins on either vegetable or animal food. The majority of them prefer vegetable food, though it is certain that some forms are also fond of animal food, and sometimes prey upon earthworms, their own eggs, or even upon each other. The amount they can eat is enormous, as can well be testified to by the gardener, who often finds a whole field of vegetables almost destroyed in a single night. As might be expected from this, their rate of growth is very rapid, and they frequently double in size within a week. At the first approach of frost they retire into secluded and sheltered spots under logs or stones, or partially burrow into the soil, withdraw into their shells, and dispose themselves for their annual sleep or hibernation, only to be awakened again in from four to six months by the warmth of spring.

They possess the power of secreting a mucus-like material from the general surface of the body at will. The slugs have this function developed to a much greater degree, and it is used by them as a means of defence. Whenever a foreign substance touches them they secrete a quantity of the mucus, which forms a kind of membrane interposed between themselves and the irritating substance. This mucoid material is a non-conductor of heat and impervious for a time to liquids, so that by its means they are enabled for a considerable time to withstand the action of corrosive gases, alcohol, and even boiling water. The fresh-water and marine forms live on the rocks and aquatic plants at the bottoms of ponds and rivers, and along the seashore, where they may be seen in immense numbers when at any time, as at ebb-tide, the rocks are exposed.

There are a large number of species of snails which have been used as food. Most of these belong to the genus Helix, of which more than twelve hundred species have been described. Few of the American forms have been so used, partly for the reason that it has never become the custom here, and partly, probably, from the curious fact, already mentioned, that the forms indigenous to this country are mostly solitary and do not collect in herds or communities. Many of the European species, on the contrary, herd together in immense numbers and so are very easy to collect and peculiarly adapted to colonization. The "edible snail," *Helix pomatia*, is the one most commonly eaten in Europe, but *H. aspersa* and *H. hortensis* are also very generally used. The first of these has, I believe, never been introduced into this country, but *aspersa* and *hortensis* both have been, and are now found in considerable numbers in certain localities. They retain their habits of congregation, and will no doubt in time be much more generally used as an article of diet than they are at present.

The ancient Greeks and Romans regarded snails as one of their greatest delicacies, and imported them from all parts of the then known world to be reared and fattened in their extensive snail ponds. In many parts of Africa the large species which are indigenous there are used as a daily food all the year round. At the present time in Austria, France, Switzerland, Spain, and Italy, the collection, rearing, and preparing them for market afford occupation to a large number of people. An idea of the extent of the industry may be gained from the fact that from Ulm alone some four million are annually exported, and about ninety thousand pounds are sold in the Paris markets every year.

The wild snails are collected and placed in small plots of land cleared of trees and covered with heaps of moss and pine-twigs, and separated from each other by moats, or trails of sawdust, for which snails have a natural antipathy. They are kept here and fed on fresh grass, cabbage leaves, mint, and other aromatic herbs. In the course of a week or ten days they have become quite obese and, besides, have attained a very delicate flavor; they are then starved for a few days to allow them to get rid of excrementitious matter, when they are ready for the market. To prepare them for the table they are well washed, then broiled, baked, or boiled, shell and all, when they are either extracted and served with various suitable sauces, or are placed on the table entire, to be removed at the time of eating by placing the shell to the mouth and drawing out the animal by sucking it.

The sea snails are not so extensively used as food, though in England the common periwinkle (*Littorina littorea*) is consumed in immense quantities by the poorer classes on the coasts as well as in London. About three thousand tons of them, valued at £15,000, are annually shipped to London alone.

There has been a number of cases of poisoning from eating snails which have been allowed to feed on hemlock and belladonna, so that now there has been an inspector appointed in Paris whose business it is to see that they are in fit condition for consumption.

FIG. 5221.—Tachea Hortensis. (From Binney.)

In some persons the ingestion of snails brings on marked attacks of urticaria—the same as is seen in certain cases after eating clams, oysters, and other shell fish. In these cases it will be understood that there is a more or less marked idiosyncrasy in the person.

An idea of the nutritive value of these mollusks may be gained from the following analysis of the "edible snail," made by Mr. Charles Mene:

Water	72.747
Nitrogeneous matter	17.652
Fatty substances	1.125
Non-nitrogeneous matter	6.300
Salts	2.176
Nitrogen	2.823