Others of the medullated branches are longer, pass upwards in the papillæ, and go towards the tactile corpuscles (of Meissner), which are here scattered throughout the entire skin. These bodies present, in contrast with the Pacinian corpuscles, a striking transverse striation. According to Ranvier, their development can be studied in the new-born child as follows: At the apices of some papilla a transverse striation is found, due

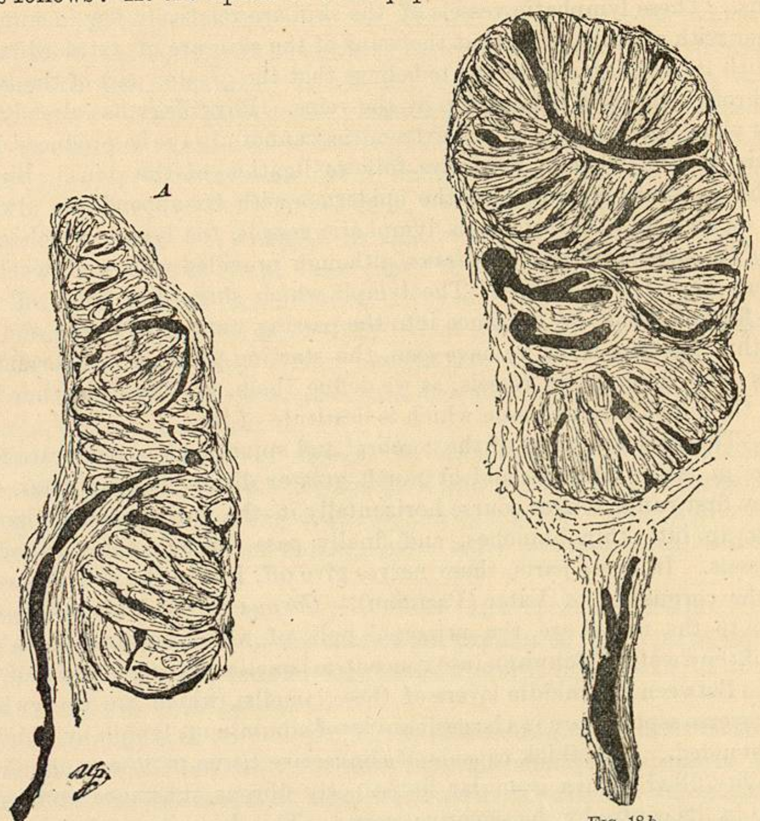

FIG. 18 *a*. FIG. 18 *b*.
Tactile Corpuscles.

to a horizontal bundle of fine terminal nerve-branches, and beneath it a little heap of cells of the mesoderm. While the nerve-branches are becoming larger and more numerous, this heap of cells pushes itself in between them, and in the sixth month forms one lobule of the tactile corpuscle. Beneath this is often found a second bushy branching bundle of nerves to which a new heap of cells applies itself from below. In the adult, therefore, we find tactile corpuscles with one, two, and three lobules, each supplied with a medullated nerve-branch. They seem closely pressed together, and consist of large flat connective-tissue cells, arranged like rolls of coin, with medullated nerve-fibres ramifying between them. The swollen lateral edges of the cells, which contain the nuclei, are alternately pressed against the outer border of the corpuscle, and this, together with the profile view of the medullated nerves which here and there run around the corpusle, gives the impression of a coarse transverse striation. The axis of the whole column of cells is usually vertical (see Fig. 18 *a*), but is often variously bent, especially when greatly developed (see Fig. 18 *b*). The final off-shoots from the nerves lose their medullary substance inside the corpuscles.

According to E. Fischer (Flemming), medullated spots alternate with non-medullated on the nerves which penetrate between the cells, and which after repeatedly dividing and subdividing, terminate finally in bulbous extremities (gold-specimens).

Nerves of the Epidermis.—The non-medullated branches of the sub-epidermic plexus ascend vertically between the cylindrical basal cells, and give off—after repeatedly dividing, and perhaps also uniting to form plexuses—fine terminal branches to all the prickle-cells as far as the granular-layer, which, coming from different nerves and various directions, enter each cell in pairs. They perforate the protoplasm of the cells, and apply themselves to the nucleus from without, terminating in minute bulbs. They often run half-way or entirely around the nucleus, but without penetrating it (see Figs. 19 and 5). Their typical manner of termination in the epidermis is, therefore, *a double, intracellular one.* Terminal bulbs are also found between the cells, but so irregularly and often in such numbers close together that it seems as if they had only lost their more advanced layers of epithelium. The non-medullated threads, which go to the capillary loops of the papillary layer behave exactly like these intra-epidermic nerves. They terminate in pairs, with bulbous extremities in the endothelial cells, in the vicinity of the nuclei.

Nerves of the Hair-Follicle.—I have also succeeded in demonstrating the terminations of the sensitive nerves in the prickle-layer of the hair-follicle; here also they end

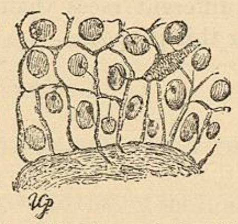

FIG. 19.—Termination of the Nerves in the Cells of the Epidermis.

inside the cells with two bulbs. The larger nerve-trunks may be everywhere followed as far as the constriction of the hair-follicle below the sebaceous glands. At this point, after passing through the follicle, they lose their medullary substance externally at the homogeneous membrane, which they perforate, and then give off filaments in the prickle-layer of the follicle. The hair-follicle is therefore supplied only from above.

Nerves of the Coil-Glands.—The ducts of the coil-glands also receive nerves from trunks which lie close to them just below the epidermis. According to Ranvier, tactile plates of the shape of an ivy-leaf are here met with, in which these nerves terminate, spreading themselves out on the corium. The nerves of the coils have been followed close up to them by Coyne and Herrmann, but these investigators failed to find their real terminations. Dr. Openchowsky (written communication) has followed, by the gold-method, non-medullated threads into the coils themselves. In good osmium preparations I have seen terminal nerve-bulbs in the secreting epithelial cells, as well as in the layers of transitional epithelium at the beginning of the duct (see Fig. 14), but I have not yet been able to form a positive opinion as to their constancy and double nature.

The statement of W. Krause, that all sensitive nerve-fibres finally terminate without medullary substance and in minute enlargements, therefore, seems justified. The larger part of these terminal bulbs is found in the epidermic cells themselves, as far up as the line of cornification. The peculiar tactile instruments, the corpuscles of Meissner and Vater, must, therefore, perform some special function, since they can no longer be regarded as instruments of general sensation.

Pigment of the Skin.—We conclude our study with an allusion to the pigment of the skin. Although of but little importance in the skin of the white race, we could associate it neither with the epidermis nor with the connective tissue alone, since it is formed in both germinal layers in a hitherto entirely unexplained manner, in the normal skin, mainly in the epidermis; in the pathological, principally in the corium. The physiological paradigm of the pathological pigments of the corium is found in the hair-change, in the connective-tissue cord of the old lower portion of the follicle, with atrophied and new-formed vessels. As far as I know, Waldeyer alone has demonstrated pigmented connective-tissue cells in the normal (?) corium of the eyelids. All the rest of the pigment of the European in the deeply-colored parts (scrotum, mammary areola), and over the whole body in the colored races, is found in the epidermis around the nuclei of the prickle-cells. In slight coloring, it is found only in the lowermost cells of the prickle-layer, and, therefore, the white color of the granular layer still asserts itself strongly. If the pigment ascends, as in the negro, as high up as the granular layer, the skin assumes a saturated dark color. The horny layer always remains free from granular pigment; at most, the horny membranes assume a darker horny-yellow color. As is well known, the colored races are unpigmented at birth, and a careful study of the manner and time of pigmentation on embryos and new-born children would doubtless throw more light on the relationship between different races than the futile attempts to utilize the hair and the coloring of adults for this purpose.

PHYSIOLOGY

BY

H. VON ZIEMSSEN.

TRANSLATED BY CHARLES L. DANA, M.D.

THE RESPIRATORY FUNCTION OF THE SKIN.

A RESPIRATORY process, analogous to that of the lungs, takes place in every part of the skin. The excretion of water and carbonic acid gas through the skin is undoubted; but the excretion of nitrogen and the absorption of oxygen are doubtful. According to A. Gerlach, the lungs absorb one hundred and thirty-seven times more oxygen than the skin.

The amount of CO_2 excreted, compared with that excreted by the lungs, is as 0.0089–0.0102 to 1, according to Scharling. Reinhard fixes the daily amount of CO_2 excreted by the skin at 2.23, and Aubert at 3.87 grammes.

This amount is increased by increased temperature of the air, by muscular exercise, and other conditions which augment the flow of blood to the skin and the excretion of sweat.

Water is usually eliminated by the skin in the form of vapor, and only when the flow is increased specially, does it appear on the surface in the form of drops. The amount of water excreted in twenty-four hours is about 600 grammes, or not far from double that thrown off by the lungs. In reality, however, the average cannot be determined, since the amount of water varies with the season, the place, individual, etc., to such a marked extent.

Among these factors is, first of all, the condition of distention of the blood-vessels of the skin. This in turn depends upon the clothing, the quality, quantity, and temperature of the food and drink, upon the bodily movements, and especially upon the temperature, moisture, etc., of the surrounding air.

If the water excretion increases to a too great extent, or if evaporation is prevented, the secretion of sweat makes its appearance.

THE SECRETORY FUNCTION OF THE SKIN.

The fluid secretions of the skin are the sweat and the sebum.

The solid substances thrown off from the skin consist of the cells of the epidermis, which are removed mechanically by rubbing, washing, etc., after the horny layer has been macerated by warm bathes, warm and moist applications, diaphoretic procedures, etc. The most superficial layer of the epidermis, by virtue of its hygroscopic properties, swells up, and it can then be rubbed off.

THE SECRETION OF SWEAT.

The sweat is chiefly secreted by the sudoriferous glands. That the sebaceous glands have some share cannot be denied or affirmed. It is not impossible that some sweat is secreted from the lymph-spaces directly through the sudoriferous ducts, and also that gases and watery vapor are thrown off in this way.

Krause endeavored to show that the surface of evaporation of the entire sudoriferous apparatus is only sufficient for the separation of one-eighth to two-ninth of the entire perspiration. The remainder must, therefore, pass through the epidermis itself.

Against this view it must be said that an accurate estimate of the superficial area of the sweat-glands and ducts is impossible; also that the evaporating surface is largely increased by the spreading-out of each drop of sweat upon the skin.

Erismann has shown that a much greater amount of water can be evaporated by the sweat-glands than Krause estimated. Furthermore, he has shown that the surface of the dead body excretes only one-sixth to one-fifth of the amount thrown off by the living body. In other words, at death the activity of a special organ ceases—an organ which in life has the power, on the one hand, constantly to deliver up water; on the other, to increase in a high degree its evaporating surface. As the epidermis is not changed at death, this organ must consist of the glandular organs of the skin, particularly the sweat-glands.

The sweat is a watery, almost colorless and clear fluid, of acid or alkaline reaction, salty taste, and a peculiar odor varying with the locality and the individual. The sweat contains volatile fatty acids (formic acid, acetic acid, butyric, propionic acids, etc.), and also neutral fats in small amount (palmitin and stearin), and cholesterin.

There can scarcely be a doubt that the sudoriferous glands have an active share in lubricating the epidermis, and that the secretion of the sebaceous glands is especially for the oleaginous needs of the hair.

According to the general view, the reaction of the fresh sweat is normally acid; if a profuse secretion is artificially induced by jaborandi, or other diaphoretics, and be kept up for some time, the reaction becomes neutral or even alkaline. The reaction also changes if the secreted sweat is allowed to stand a long time, in this case there being a decomposition of the nitrogenous constituents, especially urea, with the formation of ammoniacal salts.

Luchsinger and Trümpy found the reaction of the fresh sweat constantly alkaline when that part of the skin examined is first carefully cleansed of the sebum. The acid reaction of the sweat from the uncleaned skin depends, according to Luchsinger, upon the admixture of the uniformly acid sebum. The reaction of the sweat in the vola manus, where there are no sebaceous glands, is constantly alkaline.

It must not be forgotten, however, that Luchsinger and Trümpy examined only the sweat-secretion artificially increased and therefore not perfectly normal. Urea is a normal constituent of sweat and exists in the proportion of about 0.1–0.2 per cent. Whether variations take place under normal conditions remains still to be determined. Under pathological conditions, for example, in anuria in the course of nephritis scarlatinosa and cholerica, and nephritis suppurativa from nephrolithiasis, the excretion of urea may be so increased that upon evaporation of the sweat, crystals appear upon the surface of the skin.

The presence of other nitrogenous bodies as normal constituents of the sweat has not so far been uniformly observed.

Leube found in profuse sweat a small amount of albumin. Schottin found a rose-red pigment precipitated by alcohol, and turned bright-green by oxalic acid. Finally Favre found an acid containing nitrogen (hydrotic acid).

The inorganic salts in sweat exist, according to Funke, in the proportion of 0.099–0.629 per cent (average 0.329 per cent). The principal ones are the alkaline chlorides, especially chloride of sodium. In less amount are the alkaline and earthy phosphates and the oxide of iron.

The amount of water in sweat varies from 977.40 (Schottin) to 995.573 (Favre). These variations depend upon the amount and duration of the sweating, the food, the amount of water taken during the sweating, etc.

The process of secretion is periodic, being determined by certain causal conditions.

It is a true secretion dependent mainly upon nervous influence, and is analogous in many points to the secretion of saliva.

The centres for the sudoriferous nerves are situated in the spinal cord as far up as the medulla oblongata, which latter contains a general centre containing the spinal centres (Luchsinger).

The peripheral paths of the sweat-nerves follow the rami communicantes to the sympathetic, and then pass into the mixed nerves of the extremities. Some fibres pass directly to the extremities (Vulpian, Adamkiewicz), though this is denied by a competent observer (Nawrocki).

The terminations of the sweat nerves upon the sudoriferous glands have been demonstrated by Coyne by the gold method. Whether they pass into the cells and how is as yet unknown.

Irritation of the mixed nerves containing sweat fibres excites in animals secretion of sweat within the distribution of the nerve. Pilocarpine, muscarine, and other alkaloids stimulate secretion by acting upon the periphery. For example, they will excite sweating after section of the nerve trunk from its centre.

The secretion of sweat is increased through reflex and central stimulation by changes in the temperature and composition of the blood, especially by increase of its heat and by venosity, poisoning with strychnine, picrotoxine, camphor, ammonium aceticum.

The glandular activity is diminished or even entirely suspended by cooling the skin, cutting off the supply of arterial blood, separation of the glands from the central nervous system, finally by too long activity, and apparently also by too long rest.

Simple venous stasis without dyspnœic condition of the blood does not stimulate the sweat-glands; neither does active hyperæmia up to the point of inflammation. Similarly a simple increase in the arterial pressure is without effect, as, for example, when a large amount of water is taken into the system, unless the blood is heated by the imbibed fluid, or by a high temperature of the surrounding air, or by prevention of heat-radiation and water-evaporation from the skin, or by muscular activity. The secretion of sweat is so far independent of the blood-vessels and the vaso-motor nerves that it can