The sweat is exhaled usually in the form of vapor, when it is known as insensible perspiration. When from any cause it collects on the surface, in the form of a liquid, it is called sensible perspiration.

The peculiar constituents of the sweat have been more carefully and successfully studied since the analyses of Favre. The neutral fats are probably derived in great part from the sebaceous glands, although certain fats, palmitine and stearine, have been found in the secretion of the palms of the hands, which contain no sebaceous glands. The volatile fatty acids are formic, butyric, caproic, capric, acetic etc., some of which exist also in milk. These give to the sweat its peculiar odor. Urea is always present in small quantity, and its proportion may be largely increased when there is a deficiency of elimination by the kidneys. It is a matter, also, of common as well as of scientific observation that the sweat is more abundant when the kidneys are comparatively inactive, and *vice versâ*. Generally, however, conditions operate to increase the quantity of sweat, and the quantity of urine is proportionally diminished. The skin is undoubtedly an important organ of excretion, and it may eliminate excrementitious matters of a character as yet unknown. The action of the skin as a respiratory organ has already been considered. With regard to the inorganic constituents of the sweat, there is no great interest attached to any but the sodium chloride, which exists in a proportion many times greater than that of all the other inorganic salts combined.

Peculiarities of the Sweat in Certain Parts.—In the axilla, the inguino-scrotal region in the male, and the inguino-vulvar region in the female, and between the toes, the sweat always has a peculiar odor, more or less marked, which in some persons is excessively disagreeable. Donné has shown that whenever the secretion has an odor of this kind its reaction is distinctly alkaline; and he is disposed to regard its peculiar characters as due to a mixture of the secretion of the other follicles found in these situations. Sometimes the sweat about the nose has an alkaline reaction. In the axillary region the secretion is rather less fluid than on the general surface and frequently has a yellowish color, so marked, sometimes, as to stain the clothing.

Physiological Anatomy of the Kidneys.

The kidneys are symmetrical organs, situated in the lumbar region, beneath the peritoneum, invested by a proper fibrous coat, and always surrounded by more or less adipose tissue. They usually extend from the eleventh or twelfth rib downward to near the crest of the ilium, and the right is always a little lower than the left. In shape the kidney is very appropriately compared to a bean; and the concavity, the deep, central portion of which is called the hilum, looks inward toward the spinal column. The weight of each kidney is four to six ounces (113 to 170 grammes), usually about half an ounce (14 grammes) less in the female than in the male The left kidney is nearly always a little heavier than the right.

Outside of the proper coat of the kidney, is a certain quantity of adipose tissue enclosed in a loose, fibrous structure. This is sometimes called the adipose capsule; but the proper coat consists of a close net-work of ordinary

fibrous tissue, interlaced with small elastic fibres. This coat is thin and smooth and may be readily removed from the surface of the organ, At the hilum it is continued inward to line the pelvis of the kidney, covering the calices and blood-vessels.

The kidney in a vertical section presents a cavity at the hilum, which is bounded internally by the dilated origin of the ureter. This is called the pelvis. It is lined by a smooth membrane, which is simply a continuation of the proper coat of the kidney, and which forms little cylinders, called calices, into which the apices of the pyramids are received. Some of the calices receive the apex of a single pyramid, while others are larger and receive two or three. The calices unite into three short, funnel-shaped tubes, called infundibula, corresponding respectively to the superior, middle and inferior portions of the kidney. These finally open into the common cavity, or pelvis. The substance of the kidney is composed of two distinctly marked portions, called the cortical substance, and the medullary, or pyramidal substance.

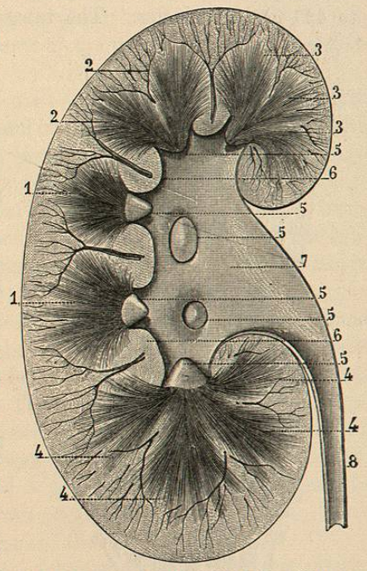

Fig. 113.—*Vertical section of the kidney* (Sappey). 1, 1, 2, 2, 3, 3, 3, 4, 4, 4, 4, pyramids of Malpighi; 5, 5, 5, 5, 5, 5, 5, apices of the pyramids, surrounded by the calices; 6, 6, columns of Bertin; 7, pelvis of the kidney; 8, upper extremity of the ureter.

The cortical substance is reddish and granular, rather softer than the pyramidal substance, and is about one-sixth of an inch (4·2 mm.) in thickness. This occupies the exterior of the kidney and sends little prolongations, called the columns of Bertin, between the pyramids. The surface of the kidney is marked by little, polygonal divisions, giving it a lobulated appearance. This, however, is mainly due to the arrangement of the superficial blood-vessels. The medullary substance is arranged in the form of pyramids, sometimes called the pyramids of Malpighi, twelve, fifteen or eighteen in number, their bases presenting toward the cortical substance, and their apices being received into the calices, at the pelvis. Ferrein subdivided the pyramids of Malpighi into smaller pyramids, called the pyramids of Ferrein, each formed by about one hundred tubes radiating from the openings at the summit of the pyramids, toward their bases. The tubes composing these pyramids pass into the cortical substance, forming corresponding pyramids of convoluted tubes, thus dividing this portion of the kidney into lobules, more or less distinct.

The medullary substance is firm, of a darker red color than the cortical substance, and is marked by tolerably distinct striæ, which take a nearly

straight course from the bases to the apices of the pyramids. As these striæ indicate the direction of the little tubes that constitute the greatest part of the medullary substance, this is sometimes called the tubular portion of the kidney.

From the arrangement of the secreting portion of the kidneys, these organs are classed among the tubular glands, presenting a system of tubes, or canals, some of which are supposed simply to carry off the urine, while others separate the excrementitious constituents of this fluid from the blood. It is difficult to determine precisely where the secreting tubes merge into the excretory ducts, but it is the common idea, which is probably correct, that the cortical substance is the active portion, while the tubes of the pyramidal portion simply carry off the excretion.

Pyramidal Substance.—Each papilla, as it projects into the pelvis of the kidney, presents ten to twenty-five little openings, $\frac{1}{300}$ to $\frac{1}{60}$ of an inch (85 to 425 μ) in diameter. The tubes leading from the pelvis immediately

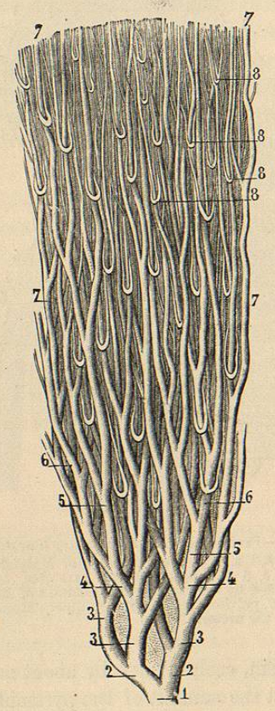

FIG. 114.—*Longitudinal section of the pyramidal substance of the kidney of the fœtus* (Sappey).

1, trunk of a large uriniferous tube; 2, 2, primary branches of this tube; 3, 3, 3, secondary branches; 4, 4, 5, 5, 6, 6, 7, 7, 7, 7, branches becoming smaller and smaller; 8, 8, 8, 8, loops of the tubes of Henle.

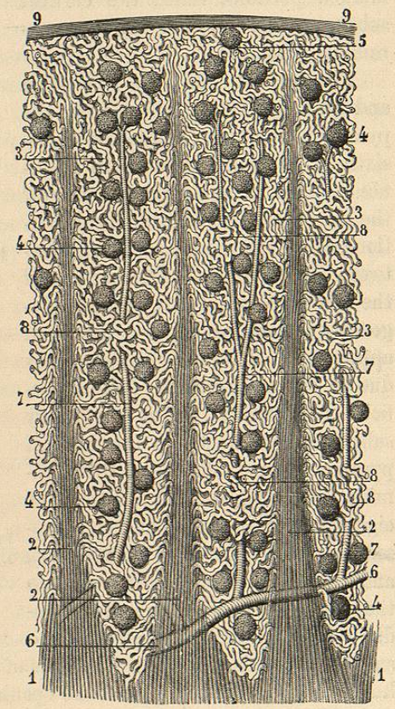

FIG. 115.—*Longitudinal section of the cortical substance of the same kidney* (Sappey).

1, 1, limit of the cortical substance and base of the pyramids; 2, 2, 2, tubes passing toward the surface of the kidney; 3, 3, 3, 8, 8, 8, convoluted tubes; 4, 4, 4, 4, 5, Malpighian bodies; 6, 6, artery, with its branches (7, 7, 7); 9, 9, fibrous covering of the kidney.

divide at very acute angles, generally dichotomously, until a bundle of tubes arises, as it were, from each opening. These bundles constitute the pyramids of Ferrein. In their course the tubes are slightly wavy and are nearly parallel to each other. These are called the straight tubes of the kidney, or the tubes of Bellini. They extend from the apices of the pyramids to their bases and pass then into the cortical substance. The pyramids contain, in addition to the straight tubes, a delicate, fibrous matrix and blood-vessels, which latter generally pass beyond the pyramids, to be finally distributed in the cortical substance. Small tubes, continuous with the convoluted tubes of the cortical substance, dip down into the pyramids, returning to the cortical substance in the form of loops. This arrangement will be fully described in connection with the cortical substance.

The tubes of the pyramidal substance are composed of a strong, structureless basement-membrane, lined with granular, nucleated cells. According to Bowman, the tubes measure $\frac{1}{300}$ to $\frac{1}{200}$ of an inch (85 to 127 μ), in diameter at the apices, and near the bases of the pyramids their diameter is about $\frac{1}{600}$ of an inch (42 μ).

The cells lining the straight tubes exist in a single layer applied to the basement-membrane. They are thick and irregularly polygonal in shape, with abundant albuminoid granules. They present one, and occasionally, though rarely, two granular nuclei, with one or two nucleoli. They readily undergo alteration and are seen in their normal condition only in a perfectly fresh, healthy kidney. Their diameter is about $\frac{1}{1500}$ of an inch (17 μ). The caliber of the tubes is reduced by the thickness of their lining epithelium to $\frac{1}{300}$ or $\frac{1}{800}$ of an inch (28 or 30 μ).

Cortical Substance.—In the cortical portion of the kidney, are found tubes, differing somewhat from the tubes of the pyramidal portion in their size and in the character of their epithelial lining, but presenting the most marked difference in their direction. These tubes are rather larger than the tubes of the pyramidal substance, and are very much convoluted, interlacing with each other in every direction. Scattered pretty uniformly throughout this portion of the kidney, are rounded or ovoid bodies, about four times the diameter of the convoluted tubes, known as the Malphigian bodies. These are simply flask-like, terminal dilatations of the tubes themselves.

The cortical portion of the kidney presents a delicate, fibrous matrix, which forms a support for the secreting portion and its blood-vessels. The tubes of the cortical substance present considerable variations in size, and three well defined varieties can be distinguished:

1. The ordinary convoluted tubes, directly connected with the Malpighian bodies. 2. Small tubes, continuous with the convoluted tubes, dipping down into the pyramids and returning to the cortical portion in the form of loops. 3. Communicating tubes, forming a plexus connecting the different varieties of tubes with each other and finally with the straight tubes of the pyramidal portion.

In tracing out the course of the tubes, it will be found most convenient to begin with a description of the Malpighian bodies and to follow the tubes

from these bodies to their connections with the straight tubes of the pyramidal substance.

Malpighian Bodies.—These are ovoid or rounded, terminal dilatations of the convoluted tubes, and are $\frac{1}{250}$ to $\frac{1}{100}$ of an inch (100 to 250 μ), in diameter. They are composed of a membrane, which is continuous with the external membrane of the convoluted tubes, and is of the same homogeneous character, but somewhat thicker. This sac, called the capsule of Müller or of Bowman, encloses a mass of convoluted blood-vessels and is lined with a layer of nucleated epithelial cells. In addition to the cells lining the capsule, there are other cells which are applied to the blood-vessels.

The cells attached to the capsule of Müller are smaller and more transparent than those lining the convoluted tubes. They are ovoid, nucleated and finely granular. The cells covering the vessels, however, are larger and more opaque, and they resemble the epithelium lining the tubes. They measure $\frac{1}{1400}$ to $\frac{1}{1000}$ of an inch (16 to 25 μ), in diameter, by about $\frac{1}{2500}$ of an inch (10 μ) in thickness.

Tubes of the Cortical Substance.—Passing from the Malpighian bodies, the tubes present first a short, constricted portion, called the neck of the capsule, which soon dilates to the diameter of about $\frac{1}{500}$ of an inch (50 μ), when their course becomes quite intricate and convoluted. These are what are known as the convoluted tubes of the kidney. The membrane of these tubes is transparent and homogeneous, but quite firm and resisting. It is lined throughout with a single layer of epithelial cells, $\frac{1}{1400}$ to $\frac{1}{1000}$ of an inch (16 to 25 μ) in diameter, somewhat larger, consequently, than the cells lining the straight tubes. The cells lining the convoluted tubes present two tolerably distinct portions. The inner portion or zone, which is next the lumen of the tube, is finely granular, with sometimes a few small oil-globules. The outer zone presents little fibrils or rods, which are perpendicular to the tubular membrane. These are called "rodded" cells, and a similar appearance is presented by some of the cells of the pancreas and of the salivary glands. The nucleus is usually situated between the granular and the rodded zones.

The researches of Heidenhain and others have shown that the greatest part of the solid excrementitious constituents of the urine, such as urea and the urates, is separated from the blood by the cells of the convoluted tubes of the cortical substance and perhaps by the dilated portions of the tubes of Henle, while the water and a certain portion of the inorganic salts of the urine transude through the blood-vessels in the Malpighian bodies. This view was first advanced by Bowman, in 1842.

Narrow Tubes of Henle.—The convoluted tubes above described, after a tortuous course in the cortical substance, become continuous, near the pyramids, with the tubes of much smaller diameter, which form loops extending to a greater or less depth into the pyramids. The loops formed by these canals (the narrow tubes of Henle), are nearly parallel with the tubes of Bellini and are much greater in number near the bases of the pyramids than toward the apices. The diameter of these tubes is very variable, and they

present enlargements at irregular intervals in their course. The narrow portions are about $\frac{1}{2000}$ of an inch (12 μ) in diameter, and the wide portions,

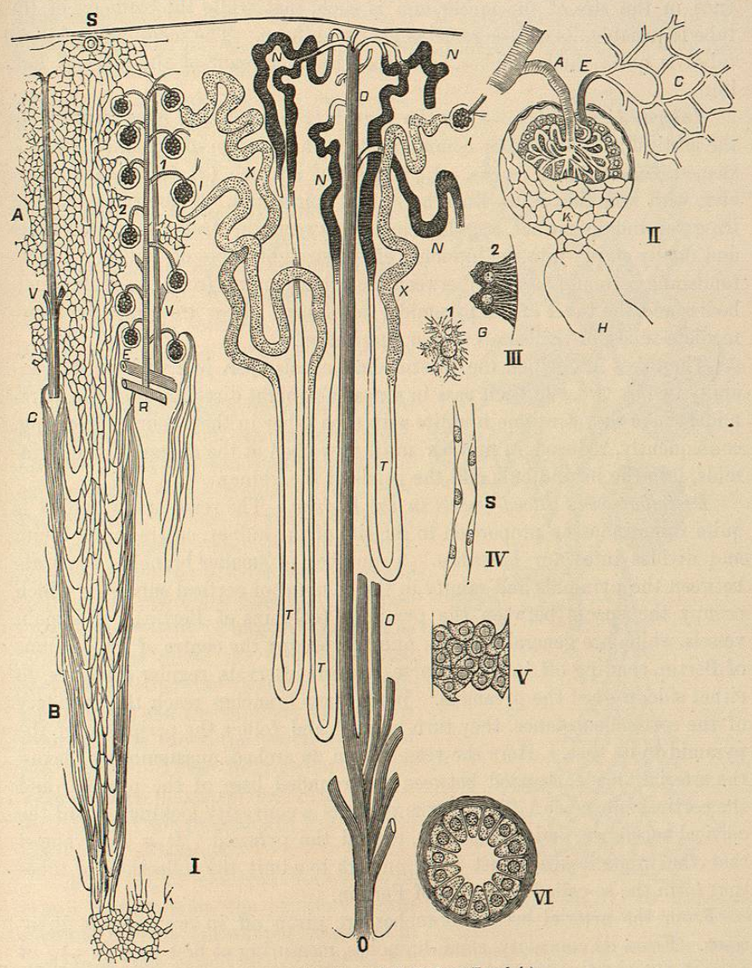

FIG. 116.—*Structure of the kidney* (Landois).

I, blood-vessels and tubes (semi-diagrammatic). A, capillaries of the cortical substance; B, capillaries of the medullary substance; 1, artery penetrating a Malpighian body; 2, vein emerging from a Malpighian body; R, arteriolæ rectæ; C, venæ rectæ; V, V, interlobular veins; S, stellate veins; I, I, capsules of Müller; X, X, convoluted tubes; T, T, T, tubes of Henle; N, N, N, N, communicating tubes; O, O, straight tubes; O, opening into the pelvis of the kidney.
II, Malpighian body. A, artery; E, vein; C, capillaries; K, epithelium of the capsule; H, beginning of a convoluted tube.
III, rodded cells from a convoluted tube. 1, view from the surface; 2, side view (G, granular zone).
IV, cells lining the tubes of Henle.
V, cells lining the communicating tubes.
VI, section of a straight tube.

about twice this size. The narrow portion is lined by small, clear cells with very prominent nuclei. The wider portions are lined by larger, gran-

ular cells. Near the bases of the pyramids the wide portion sometimes forms the loop, but near the apices the loop is always narrow. The difference in the size of the epithelium is such, that while the diameter of the tube is variable, its caliber remains nearly uniform. The membrane of these tubes is quite thick, thicker, even, than the membrane of the tubes of Bellini.

Intermediate Tubes.—After the narrow tubes of Henle have returned to the cortical substance, they communicate with a system of flattened, ribbon-shaped, anastomosing canals, $\frac{1}{1200}$ to $\frac{1}{1000}$ of an inch (21 to 25 μ) in diameter, with very thin walls, lined by rodded epithelium. These tubes take an irregular and somewhat angular course between the true convoluted tubes and finally empty into the branches of the straight tubes of Bellini, thus establishing a communication between the tubes coming from the Malpighian bodies and the tubes of the pyramidal substance. They are called the intermediate tubes, or the canals of communication.

The tubes into which the intermediate canals open join with others generally two by two, and then pass in a nearly straight direction into the pyramids, where they continue to unite with each other in their course, becoming, consequently, reduced in number until they open at the apices of the pyramids, into the infundibula and the pelvis of the kidney.

Distribution of Blood-vessels in the Kidney.—The renal artery, which is quite voluminous in proportion to the size of the kidney, enters at the hilum and divides into four branches. A number of smaller branches penetrate between the pyramids and ramify in the columns of cortical substance which occupy the spaces between the pyramids (columns of Bertin). The main vessels, which are generally two in number, occupy the centre of the columns of Bertin, sending off in their course, at short intervals, regular branches on either side, toward the pyramids. When these branches reach the boundary of the cortical substance, they turn upward and follow the periphery of the pyramid to its base. Here the vessels form an arched, anastomosing plexus, the arterial arcade, situated between the rounded base of the pyramid and the cortical substance. This plexus presents a convexity looking toward the cortical substance, and a concavity, toward the pyramid. It is so arranged that the interstices are just large enough to admit the collections of tubes that form the so-called pyramids of Ferrein.

From the arterial arcade, branches are given off in two opposite directions. From its concavity, small branches, measuring at first $\frac{1}{1200}$ to $\frac{1}{450}$ of an inch (21 to 34 μ) in diameter, pass downward toward the papillæ, giving off small ramifications at very acute angles, and becoming reduced in size to about $\frac{1}{2500}$ of an inch (10 μ). These vessels, called sometimes the arteriolæ rectæ, surround the straight tubes, and pass into capillaries in the substance of the pyramids and at their apices.

From the convex surface of the arterial arcade, branches are given off at nearly right angles. These pass into the cortical substance, breaking up into a large number of little arterial twigs, $\frac{1}{1500}$ to $\frac{1}{600}$ of an inch (17 to 40 μ) in diameter, each one of which penetrates a Malpighian body at a point opposite the neck of the capsule. Once within the capsule, the arteriole breaks up into five to eight branches, which then divide dichotomously into vessels measuring $\frac{1}{3000}$ to $\frac{1}{1500}$ of an inch (8 to 17 μ) in diameter, arranged in the form of coils and loops, constituting a dense, rounded mass (the Malpighian coil, or glomerulus), filling the capsule. These vessels break up into capillaries without anastomoses.

The blood is collected from the vessels of the Malpighian bodies by veins, sometimes one and frequently three or four, which pass out of the capsule and form a second capillary plexus surrounding the convoluted tubes. When there is but one vein, it generally emerges from the capsule near the point of penetration of the arteriole.

The efferent vessels, immediately after their emergence from the capsule, break up into a very fine and delicate plexus of capillaries, closely surrounding the convoluted tubes. These form a true plexus, the branches anastomosing freely in every direction; and the distribution of vessels in this part resembles essentially the vascular arrangement in most of the glands. Bowman has called the branches which connect together the vessels of the Malpighian tuft and the capillary plexus surrounding the tubes, the portal system of the kidney. These intermediate vessels form a coarse plexus surrounding the prolongations of the pyramids of Ferrein into the cortical substance.

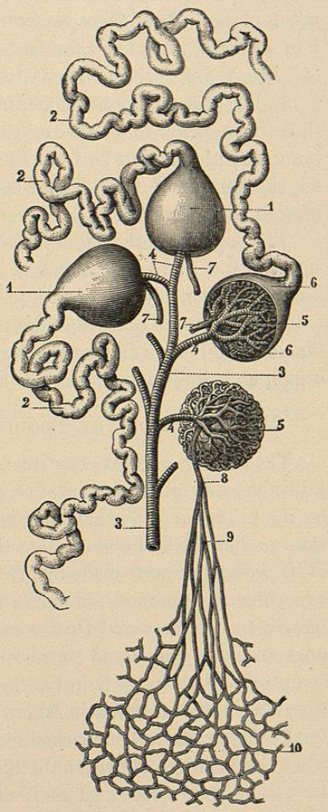

FIG. 117.—*Blood-vessels of the Malpighian bodies and convoluted tubes of the kidney* (Sappey).

1, 1, Malpighian bodies surrounded by the capsules of Müller; 2, 2, 2, convoluted tubes connected with the Malpighian bodies; 3, artery branching to go to the Malpighian bodies; 4, 4, 4, branches of the artery; 6, 6, Malpighian bodies from which a portion of the capsules has been removed; 7, 7, 7, vessels passing out of the Malpighian bodies; 8, vessel, the branches of which (9) pass to the capillary plexus (10).

The renal, or emulgent vein takes its origin in part from the capillary plexus surrounding the convoluted tubes and in part from the vessels distributed in the pyramidal substance. A few branches come from vessels in the envelopes of the kidney, but these are comparatively unimportant. The plexus surrounding the convoluted tubes empties into venous radicles which pass to the surface of the kidney, and these present a number of little radiating groups, each converging toward a central vessel. This arrangement gives to the vessels of the fibrous envelope of the kidney a peculiar, stellate appearance, forming what are sometimes called the stars of Verheyn. The