b. Arrector pili muscle ★

The arrector pili muscle is a smooth muscle bundle between the outer root sheath and the dermal upper layer. The hair stands vertically after contraction of the arrector pili muscles. This slightly elevates the peripheral hair follicles (causing goose bumps). Controlled by the adrenergic sympathetic nerves, the arrector pili muscle is contracted by cold stress and emotional stresses including fear and surprise. The formation of goose bumps may accompany shivering that occurs to raise the body temperature.

c. Sebaceous gland ★

The sebaceous gland produces sebum (**Fig. 1.40**) that mixes with moisture such as sweat and is emulsified on the skin surface to form fatty acids that coat the skin. The coat is an acidic bactericide with a pH of 4 to 6 (acid mantle). Sebum and sebaceous glands prevent invasion and infection by pathogens and toxic substances. Additionally, the sebaceous glands control water loss from the skin and maintain moisture in the horny cell layers.

The sebaceous glands are widely distributed throughout the skin, except in the palms and soles and some mucous membranes, but most of them open to the upper hair follicles at hair follicle sites. Sites where multiple individual sebaceous glands congregate are called sebaceous zones. They are seen in the scalp, face (the "T zone," which includes the forehead, regions of the glabella and the nasolabial groove), sternal regions, armpits, naval, and external genitals. The seborrheic zone is very densely distributed with sebaceous glands (400/cm^2 to 900/cm^2). Sebaceous glands open directly to the skin surface at hairless sites, which are distributed in the lips of mouth, buccal mucosa, areola

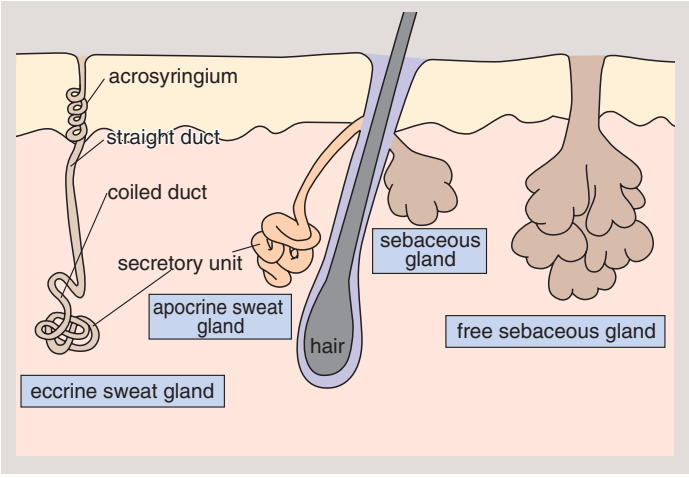

Fig. 1.40 Sweat glands, hair follicles and sebaceous glands.

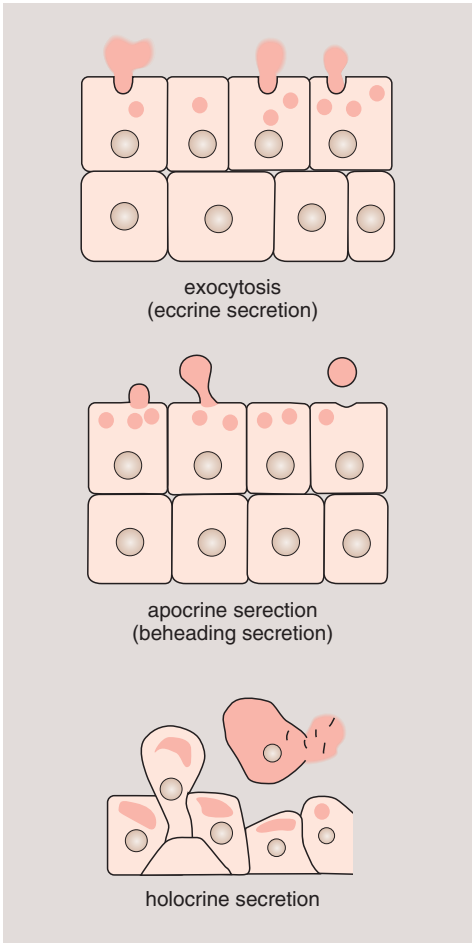

Fig. 1.41 Types of secretion.

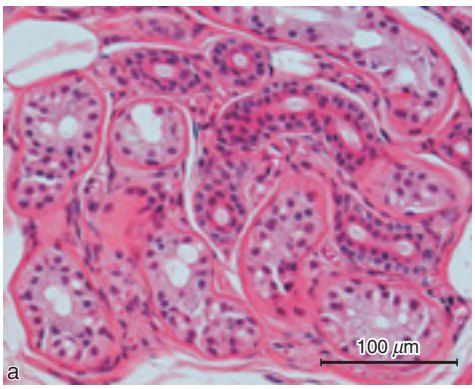

Fig. 1.42-1 Errcine sweat gland.
a: Cross section.

mammae, vagina, labia pudendis, glans penis and foreskin inner plate. These glands are called free sebaceous glands, because they are not attached to hair follicles. Meibom glands in the eyelids are a type of free sebaceous gland.

The sebaceous gland is composed of sebaceous lobules and a duct that carries sebum to the hair follicle. The daughter cell, produced by cell division, migrates into the lobule as it matures, to produce fat droplets. As they migrate, sebocytes are filled with fat droplets and the cells rapture, resulting in secretion of the cytoplasm and fat, which is called holocrine secretion (**Fig. 1.41**).

The amount of fat secretion changes with age. Large amounts of fat are produced in newborn infants, and small amounts in children. Production begins to increase again from puberty. The secretion of fat peaks in women in their second and third decades of life, and in men in their third and fourth decades of life, decreasing thereafter. The amount of fat secretion is controlled predominantly by sex hormones: testosterone in men, and adrenal androgens in women. Hormones derived from the mother are thought to be important in newborn infants.

d. Sweat glands

Human sweat glands are either eccrine, distributed throughout most of the body, or apocrine, found at specific sites of the body and producing and discharging sweat to the body surface. Both are hair follicle-associated glands consisting of a secretory part and a sweat duct. The secretory parts are coiled and surrounded by fat tissues in the deep dermal layer and subcutaneous tissue (**Fig. 1.40**).

1. Eccrine sweat glands ★

Eccrine sweat glands are found over the entire body, especially in the palms, soles, and armpits, at a density of 130/cm^2 to 600/cm^2. They are known to number approximately 3 million.

Perspiration is enhanced by thermal stimulation, which is associated with body temperature control, but it may be stimulated by mental strain or gustatory stimulus (gustatory sweating). The total amount of perspiration in a day is controlled by acetylcholines and is known to average 700 ml to 900 ml (in adults).

Two-layered secretory cells with a circular nucleus and peripheral flat myoepithelial cells are observed in the secretory area by light microscopy (**Fig. 1.42-1**). Cells on the basal-layer side contain few subcellular organelles and a large amount of glycogens. Since these cells secrete large amounts of serous sweat by eccrine secretion (**Fig. 1.41**), they are also called serous cells. Cells on the luminal side secrete mucus. The myoepithelial cell is a smooth muscle cell that pushes the accumulated sweat out of the lumens to the sweat ducts by contraction.

The sweat duct ascends perpendicularly in the dermis (straight duct) through the coiled duct that extends from the secretory area

(**Figs. 1.40** and **1.42-2**). The sweat duct contains two cell layers, consisting of intraluminal cells and peripheral cells, and it lacks myoepithelial cells. The sweat that is produced in secretory areas (as precursor sweat) is slightly hypertonic; therefore, sodium ions and chlorine ions are re-absorbed by intralluminal cells in the coiled ducts, and hypotonic sweat is finally secreted.

2. Apocrine sweat glands ★

Apocrine sweat glands, which number fewer than eccrine glands, are degenerated pheromone-producing mammary glands found in the armpits, external ear canals, areola mammae, external genitals and anus. They develop in conjunction with hair apparatuses, temporarily slow in development after birth, and accelerate with development again during puberty. Perspiration from these glands is considered to be adrenergic and is caused mostly by emotional stimulation. Mammary glands and Moll's glands are kinds of apocrine sweat glands. Although sweat is viscous and odorless, its components such as glycoproteins and fat are broken down by microbes resident on the skin surface, which produces odor. Glandular development is associated with sex hormones; the glands are thought to be involved with sexual function.

The secretory portion of the apocrine gland is larger than that of the eccrine gland. Secretory cells are aligned as a single-layer epithelium surrounded by myoepithelial cells (**Fig. 1.43**). The part of the cytoplasm that faces the lumen of the sweat duct bulges, blebs and separates from the cell (apocrine secretion; **Figs. 1.41** and **1.44**).

The sweat ducts do not open to the skin surface directly, but open on to the upper parts of the sebaceous glands (**Fig. 1.40**).

e. Nail

The nail is a portion of keratinized epithelial tissue and composed of the nail plate, nail matrix, nail folds and nail bed. Each of these parts comprises several more detailed structures (**Fig. 1.45**). The nail differentiates from the epidermis in the third month of fetal development. Recent studies have shown that the nail has characteristics of both dermis and hair. The fingernail grows 0.1 mm per day, and it takes about 6 months to re-grow an entire nail plate. The growth of nails is slower in the elderly, whose nails tend to be thick and brownish. Nails are important in protecting the digits and in assisting subtle sensation in the fingertips.

1. Nail plate ★

The nail plate is a rectangular horny plate on the dorsal tip of the digits consisting of top nail, middle nail and undernail. In the proximal area, the nail plate is ingrown and covered by the

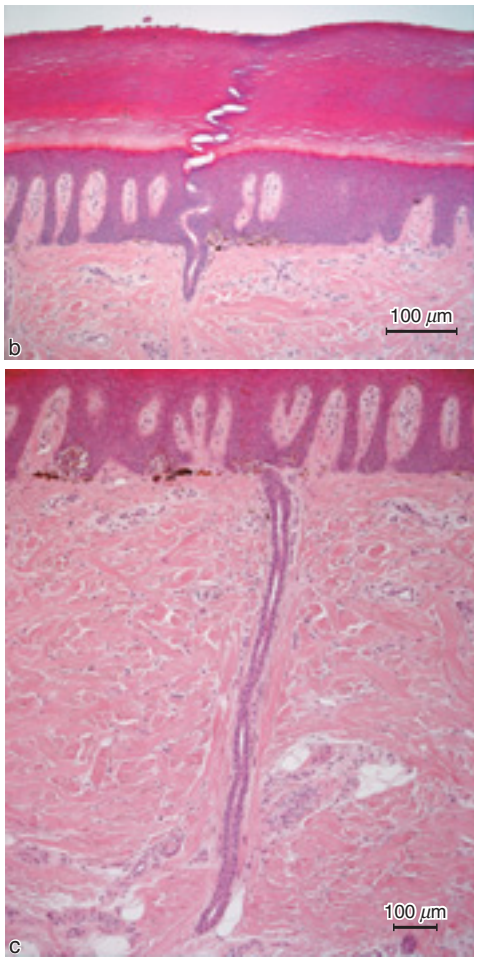

Fig. 1.42-2 Eccrine sweat gland.
b: Longitudinal section (epidermis). c: Longitudinal section (dermis).

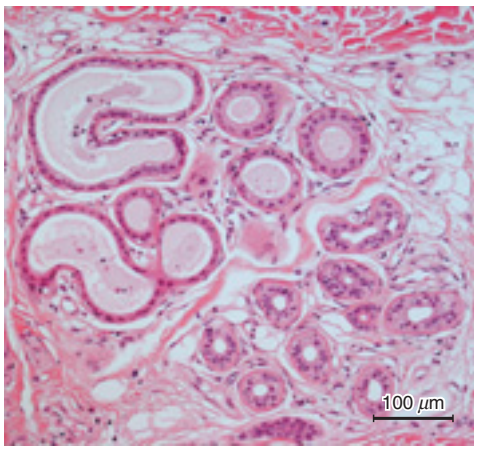

Fig. 1.43 Apocrine sweat gland (cross section).