

E. Appendages

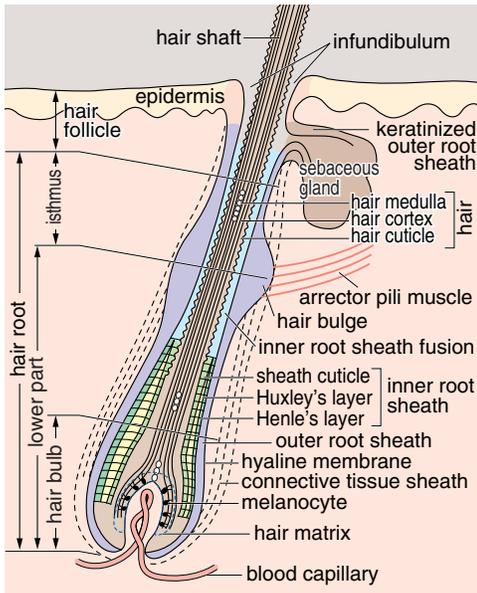


Fig. 1.37 Longitudinal section of the hair follicle.

a. Hair apparatus

The hair apparatus plays a role subsidiary to that of the sensory nerves in protecting the scalp from external forces and light, and in moderating heat in the head. Eyelids protect the eyes from dirt, and armpit hair and pubic hair absorb mechanical friction. The number of hairs on a person's head averages 100,000. The hair apparatus is found throughout the skin except on the lips of the mouth. It consists of hair and hair follicles that enclose the hair.

1. Hair follicle



The layer of tissue that encloses a hair is called a hair follicle. It is aligned obliquely to the skin surface. Part of the hair follicle is slightly enlarged to form a hair bulge to which the base of the arrector pili muscle is connected (Figs. 1.37, 1.38-1 and 1.38-2). Dermal stem cells reside in the hair bulge. Sebaceous glands are seen above the bulge stem cells, and apocrine glands open further above. The bottom of the hair root during the growth stage bulges out spherically; it is called a hair bulb and contains a hair group of cells known as the hair papilla. The hair follicle opens in a funnel shape (hair infundibulum).

The hair follicle is double-bounded with two layers, with an epithelial interior and connective tissue component on the exterior.

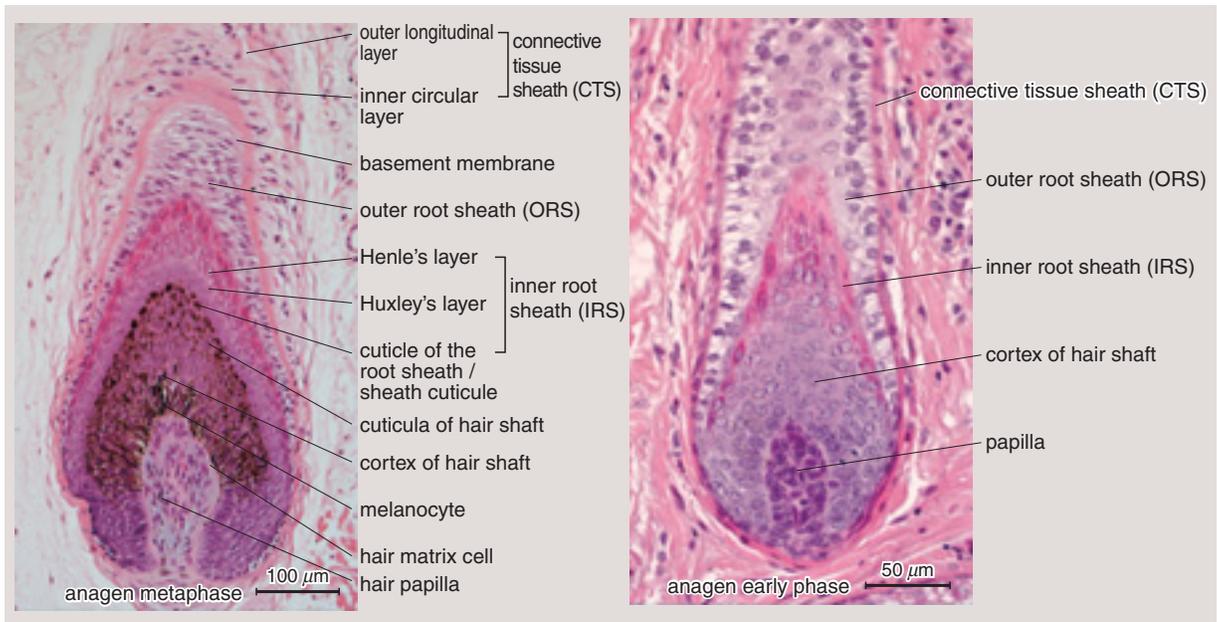


Fig. 1.38-1 Structure of the hair follicle (longitudinal section).

The epithelial components are the inner and outer root sheaths. The connective tissue component is called the connective tissue sheath.

1) Connective tissue sheath (CTS)

The connective tissue sheath (CTS) covers the outside of the hair follicle and is a layer connected with the dermis. Collagen fibers run circularly inside the connective tissue sheath and longitudinally outside of it. Several elastic fibers can be found among these collagen fibers.

2) Outer root sheath (ORS)

The outer root sheath (ORS) is the outermost part of the hair infundibulum (inner two layers). It is keratinized and comprises keratinocytes that contain a light cytoplasm without keratohyaline granules. The outside of the outer root sheath meets the connective tissue sheath at the basal membrane. The inside of the outer root sheath is connected by desmosomes with the Henle's layer, the outermost layer of the inner root sheath.

3) Inner root sheath (IRS)

The inner root sheath (IRS), found inside the outer root sheath, consists of capsular layers, Huxley's layer (a double layer of cells), and Henle's layer (a single layer of cells). The capsular cuticles anchor and entangle each other, with the differently directed apical tips functioning as hooks to stabilize the hair. The Henle's layer is connected with the outer root sheath by desmosomes.

Keratinization occurs in the inner root sheath close to the inter-follicular epidermis. IRS has the appearance of trichohyalin granules. These granules, often found in Henle's layer and Huxley's layer, stain eosinophilically. Keratinization finishes at the height of the sebaceous gland opening, and it is followed by exfoliation.

4) Hair bulb

The hair bulb is the bulge of the hair follicle, with a dermal hair papilla at its center. The keratinocyte follicle enclosing and covering the dermal hair papilla semi-spherically is the hair matrix layer, where hair and inner root sheath cells grow and extend upward. The outer root sheath forms the outermost layer of the hair bulb. Melanocytes that provide hairs with melanins are also found in the hair matrix.

2. Hair shaft



The hair shaft is composed of a three-layered structure. From innermost to outermost, the layers are the medulla, cortex and

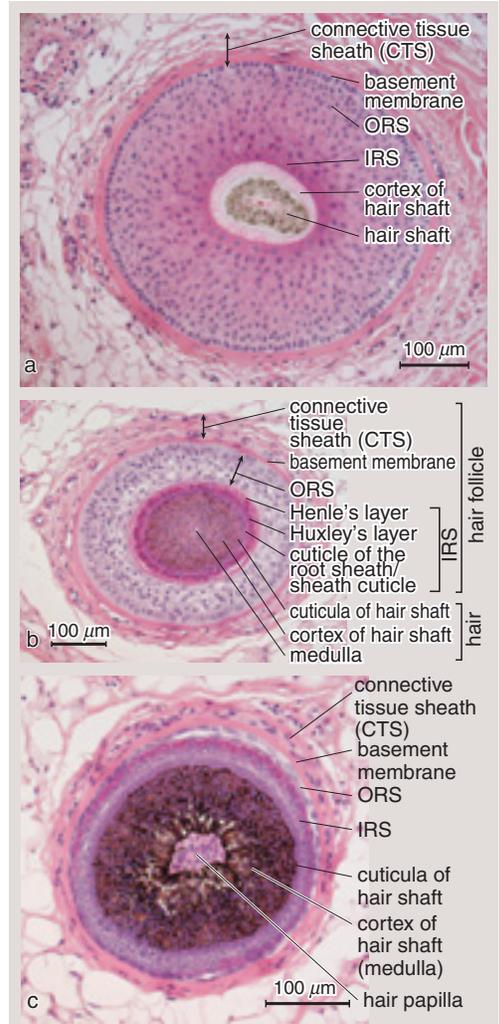


Fig. 1.38-2 Structure of the hair follicle (cross section).

a: Hair follicular isthmus. b: Lower part of a hair follicle. c: Hair bulb (see Fig. 1.37 for the cross-section position).

Unusual keratinization of the outer root sheath



When cells in the outer root sheath denude and keratinize without passing through the granular layer or becoming flat, it is called trichilemmal keratinization.

cuticula.

Tonofilaments align in the direction of the axis in the cortex, and a pattern similar to that observed for keratin by electron microscopy is observed at the tips of the tonofilaments. That is, keratinization is seen in the cortex; however, unlike in the epidermis and inner root sheath, no formation of keratohyaline granules or trichohyaline granules is seen. Unlike the keratins found in other epithelial cells, the keratins that are produced in hair cortex are rich in cystines, glycines and tyrosines. Such specific keratins are called hard keratins, a general term, and they are also found at other sites, including the nails.

In the hair cuticle, the cortex is covered by flat cells in a scale-like pattern, and they are attached to the capsular cuticles of the inner root sheath. This connection becomes the outermost layer of the hair shaft, protecting the shaft. The cuticles may be injured and the natural glow of hair lost if there is excessive physical damage to hair, such as over-brushing, or excessive use of chemicals such as hair dyes or permanent solutions.

Hair color differs according to the size and number of melanosomes: Large and/or multiple melanosomes are seen in dark hair, and red hair contains large amount of pheomelanins.

3. Hair cycle ★

The hair has a regular period of growth (anagen), transition (catagen), and rest phase (telogen) (**Fig. 1.39**). Head hair grows for several years after it sprouts (anagen: about 80% of all head hair), after which its growth rate slows for 2 to 3 weeks (catagen: about 1% to 2%) and then stops. The hair remains for several months after it stops growing (telogen: about 15%). As a new hair is produced, hair within the same follicle in the telogen phase falls out. Hair in the catagen period grows 0.3 mm to 0.5 mm per day.

When hair follicles in the anagen phase repeat cell division and transition to the catagen phase, they begin to contract and cell division stops. The hair follicle cells lose their ability to divide in the telogen phase and ascend to the elevated part of the hair. The hair root presents a stick-like shape called club hair. In the telogen phase, macrophages phagocytose melanin pigments and cell fragments in the hair papilla.

As the anagen phase comes around again, cell division begins at the surface of the hair follicle. A hair papilla forms and a new hair grows in the hair matrix. It pushes out the club hair, which exfoliates.

Only the part of the hair with stem cells below the hair bulge expands and contracts in the hair cycle. That area is called the fluctuation area, and the upper area is called the fixation area. The human hair cycle differs for each hair; however, the overall quantity of hair remains roughly constant.

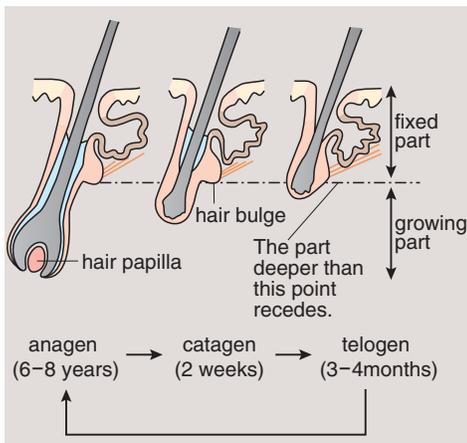


Fig. 1.39 Hair cycle.

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 sebaceous zone is very densely distributed with sebaceous glands (400/cm² to 900/cm²). Sebaceous glands open directly to the skin surface at hairless sites, which are distributed in the lips of mouth, buccal mucosa, areola

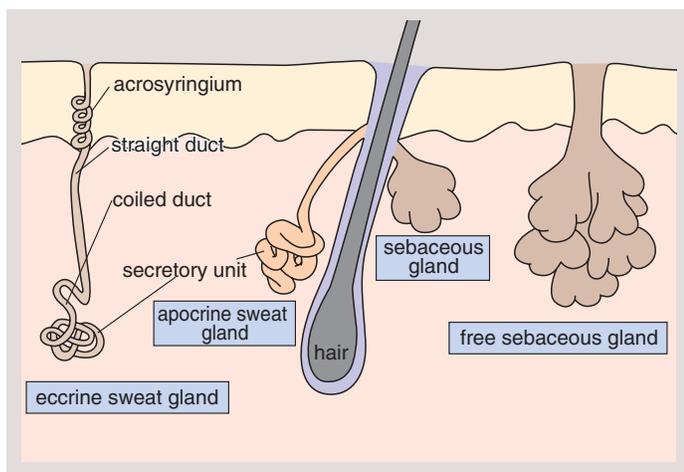


Fig. 1.40 Sweat glands, hair follicles and sebaceous glands.