

THE INTEGUMENT

The skin of mammals and other vertebrates is composed of two layers, the dermis and epidermis (Fig. 4.1). In the **epidermis**, only the cells in the two lowest layers, the deepest **stratum basale** (or **stratum germinativum**) and the cells in the layer immediately above, the **stratum spinosum**, are living and dividing (Sokolov 1982). Progressing toward the surface, successive layers of epithelial cells become more flattened and cornified, or keratinized. This surface layer of dead cells, the **stratum corneum**, receives the brunt of environmental wear and tear and continually flakes off the skin and is replaced by growth from below. Thickened portions of this keratinized epithelium form the **tori** (or **pads**) on the feet (Fig. 4.2A) of most mammals and form the **friction ridges** (Fig. 4.2B) on the digits, palms, soles, and naked prehensile-tail pads of primates. A fingerprint is an impression of such ridges. **Calluses**, which form where the skin is subjected to constant friction, are further thickenings of this cornified layer. Epidermal scales, hair, horn, and claws are all modifications of cornified epithelial cells.

The **dermis** lies below the epidermis and is a thick layer of fibrous connective tissue with associated skin glands, specialized muscles, nerves, and sensory structures. Most blood vessels and all specialized sensory receptors associated with the skin are in the dermal layer. Some reptiles (turtles, crocodylians, and many lizards), and some mammals (armadillos) also have bone present in the dermis for armor. Below the dermis, in the deepest layer of the integument, lies the **hypodermis**, which consists of adipose or fat tissue.

4-A Examine a slide of mammal skin under the compound microscope. Differentiate between epider-

mis, dermis, and hypodermis. Note the change in shape and degree of cornification of epithelial cells from base to surface. In the dermis and hypodermis, differentiate between connective, vascular, muscular, nervous, and adipose tissues.

4-B Examine the tip of your finger under a binocular microscope. Compare the friction ridges of humans with the pads on the foot of a rodent, a carnivore, or both, and with the ischial callosities on the buttocks of a nonhuman primate.

SCALES

Dermal bone is true bone formed within the dermal layer of the integument. This bone formed the protective shells of ancient jawless, fishlike vertebrates, and in modern animals occurs in the scales of elasmobranch fishes (e.g., sharks), the shells of turtles, and the skins of many lizards and all crocodylians. Dermal bones contribute portions of the skulls of bony fishes and tetrapods, including mammals (e.g., the frontals and parietals are dermal bones), and teeth are believed to be derivatives of dermal denticles. In many "lower" vertebrates, dermal bones compose much of the pectoral girdle, but in mammals, only the interclavicle (found only in Monotremata) and the clavicle are of dermal origin. Except for these elements, dermal bone is absent in the integument of all living mammals except the armadillos.

Epidermal scales are modifications of the cornified epithelium and are never bony, although they may be intimately associated with underlying dermal bone. Reptiles are usually completely covered with epidermal

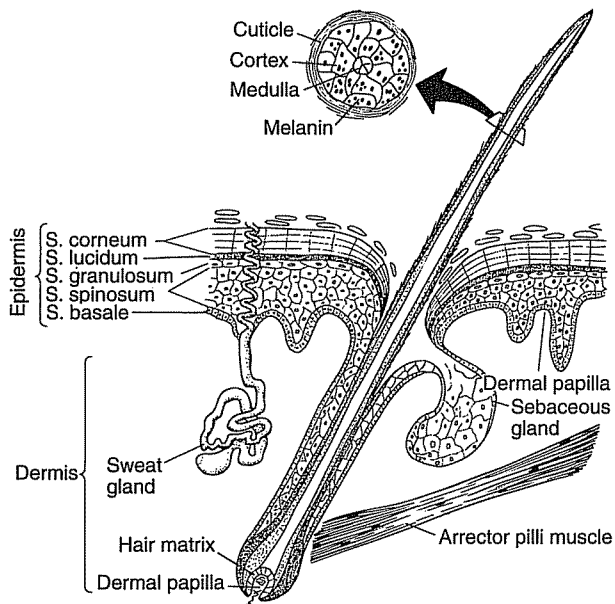


Figure 4.1 Sectional view of skin showing hair and various structures in epidermis and dermis.
(After Kardong 1998:211)

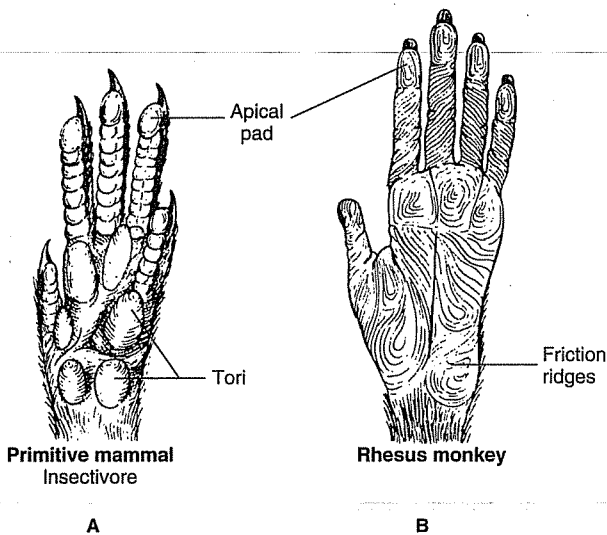


Figure 4.2 (A), Tori on the feet of an insectivore; (B), friction ridges on a primate.
(After Kent and Miller 1997:114)

scales. Birds have epidermal scales on their legs, and their bodies are covered with modified epidermal scales termed feathers. Various species of mammals retain epidermal scales on the tail, feet, or both (e.g. Rodentia: Anomaluridae, Castoridae). However, only two groups of mammals, the armadillos (order Xenarthra) and pangolins (order Pholidota), have a major portion of the body covered with scales of epidermal derivation.

The armadillos (Xenarthra, Dasypodidae) bear bony dermal scales embedded in the skin over the top of the head, the back, and (usually) the sides of the body. Also,

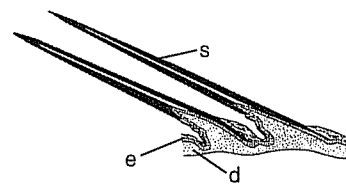


Figure 4.3 Diagram of a section through two scales of a pangolin showing the scales (s), epidermis (e), and dermis (d).
(After Feldhamer et al. 1999:253)

most species have rings of dermal scales encircling the tail. Overlying these dermal scales are thin horny epidermal scales that usually abut one another but do not overlap (except on the movable overlapping bands).

The pangolins (Pholidota) lack dermal scales but have most of the body covered with large, leaf-shaped, imbricate (overlapping) keratinized scales (Figs. 4.3, 18.1 and 18.2) of epidermal origin.

- 4-C Examine a piece of armadillo shell and an armadillo skin. Note the arrangement of dermal bone and epidermal scales. How do the sizes and shapes of the units of the two layers compare? How are the sutures of the bony shell positioned relative to the lines of contact between the epidermal scales? How is the shell constructed to allow for flexibility?
- 4-D Examine a pangolin and note the arrangement of scales over the body. What is the function of the scales in pangolins?
- 4-E Examine the scaly tail of a beaver or rat and note the placement of hairs in relation to the placement of scales. Compare this to the arrangement of hair follicles on the inner surface of a pigskin and the back of your hand on the "little" finger (digit V) side. How do these arrangements support the belief that hair is not a derivative of epidermal scales but is of separate origin?

HAIR ANATOMY

Though hairlike structures may be found on birds, insects, and even plants, true epidermal hair is unique to mammals. In most mammals, it is conspicuous; in others, it is sparse (the naked mole rat, *Heterocephalus glaber*; mysticete whales; and freshwater dolphins) or absent in most adult odontocete whales (in odontocete whales, vibrissae may be present in the embryo but disappear later in development) (Sokolov 1982:289).

A hair first develops as an epidermal thickening that pushes into the dermis to form a **follicle** (see Fig. 4.1). Directly under the follicle is a tiny invagination of blood

vessels and connective tissue, the **papilla**. The papilla is richly supplied with blood vessels that nourish the growing hair. The epidermal cells at the base of the follicle proliferate to form a column of dead, keratinized cells (the **hair**), which pushes out through the neck of the follicle. An outgrowth of epidermal cells from the side of the follicle forms a **sebaceous** (oil) **gland**, the secretions of which keep the hair from becoming brittle, and render a degree of water-proofing (see the "Integumentary Glands" section).

The hair follicle and shaft are oriented obliquely in the skin. Associated with each follicle are bundles of smooth muscle fibers of the **arrector pili muscle** (Sokolov 1982:34). Contraction of this muscle erects the hair. In humans, this brings about "goosebumps." In other mammals, it raises the hair, thereby increasing insulating properties or serving as a threat. Echidnas, marsupials, colugos, pinnipeds, and sirenians lack these muscles (Sokolov 1982).

4-F On a slide of mammal skin, locate a follicle. Identify the papilla, hair, sebaceous gland, and arrector pili muscle.

4-G The arrector pili muscle raises the hair to increase insulation or to make the animal seem larger in threat postures. In humans, "goosebumps" are usually produced by cold or fear. Is this consistent with what occurs in other mammals?

Each hair normally consists of a central core and two well-defined outer layers (see Fig. 4.1). The central **medulla**, present in all but the smallest hairs, may be continuous or may be interrupted by regularly or irregularly spaced air cavities. In some mammals, the medulla is absent, leaving a continuous central air column. The **cortex** immediately surrounds the medulla and makes up the bulk of a hair. The **cuticle** is a thin outer layer of **cuticular scales** covering the cortex. The scales may form a relatively smooth surface or may overlap in various distinctive patterns (Fig. 4.4). Pigment granules may be located in the medulla, the cortex, or both but are never found in the cuticle, although colored substances produced by skin glands may coat or adhere in flakes to the cuticle. In cross section, a hair may be circular or flattened. Flattened hairs are often curly, and cylindrical hairs are usually straight.

Certain combinations of hair structure characteristics are distinctive for various mammalian groups (Bruner and Coman 1974; Hess et al. 1985). Short (1978) used SEM microscopy to examine hair samples from 7 orders, 18 families, and 48 genera of mammals and found that cuticular scale patterns were less useful than color, size, and shape of the medulla in identifying hair to a particular taxonomic group. Keys can be constructed to aid in identifying mammals to species (e.g., Haffner and Ziswiller 1989, for species of vespertilionid bats) or to

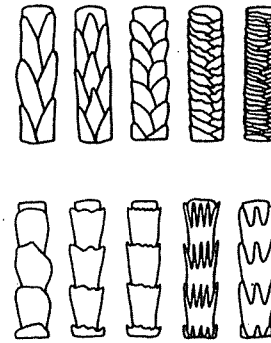


Figure 4.4 The basic types of cuticular scales found on mammalian hair.

(Nason 1948)

identify hairs found in dens, fecal material, owl pellets, etc. (e.g., Benedict 1957; Day 1966; Mayer 1952; Miles 1965). Hair size, the character of the medulla, the amount and distribution of pigments, and the type of cuticular scale patterns are all considered in writing these keys.

4-H Remove a hair from your head and from at least three other species of mammals. Mount each hair in a drop of water on a clean microscope slide and cover with a coverslip. With a compound microscope, compare the structure of the medulla and the location and relative abundance of pigment granules in each of the hairs.

4-I Place a sample of each of the kinds of hair used above on a separate microscope slide. Cover the hairs with plastic coverslips and then pass each slide through a flame until the coverslip has melted somewhat. Allow it to cool before removing hairs. Remove the hairs from the impressions made, mount the coverslips on microscope slides, and examine the impressions of the cuticular scale patterns under the compound microscope. See Chapter 34 for additional references on making slide preparations of hair.

CLASSIFICATION OF HAIR

On the basis of growth, hair may be classified as either **definitive** or **angora**. Hair with definitive growth reaches a certain length characteristic for the species and body location, and then growth ceases. These hairs are shed and replaced periodically, as with human eyelashes. Angora hair grows almost continuously and reaches a considerable length before being shed. Some angora hairs, such as a domestic horse's mane, are never shed but continue to grow through the life of the animal. Growth patterns and hair morphology and functions are combined to classify hair into the various types recognized on mammals. Although Sokolov (1982:33–34)

divided hair into five basic types, most reference sources divide hair into three main types: vibrissae, guard hairs, and underhairs. The latter two types are often further classified into subgroups.

Vibrissae

Vibrissae are usually long (short in colugos, cetaceans, and, with environmental wear, walruses) stiff hairs with well-innervated bases surrounded by many blood vessels. They primarily serve as tactile receptors. The best known vibrissae are the “whiskers” on a mammal’s face (Fig. 4.5), but vibrissae may also be located on the ankles and elsewhere on the body.

Guard Hairs

Guard hairs (or **overhairs**) are the most conspicuous hairs on most mammals. They serve primarily for protection. The three major types of guard hair recognized are spines, bristles, and awns, although intermediates between these conditions are known. **Spines** are greatly enlarged, stiff guard hairs with definitive growth. They serve primarily as defense from predators. The New World porcupines, Erethizontidae, and the tenrec genus *Hemicentetes* (Eisenberg and Gould 1970:49), have **barbs** on the tips of the spines (Fig. 4.6). Once imbedded in a predator’s skin, such a spine cannot be easily removed, and the victim’s muscular action will actually

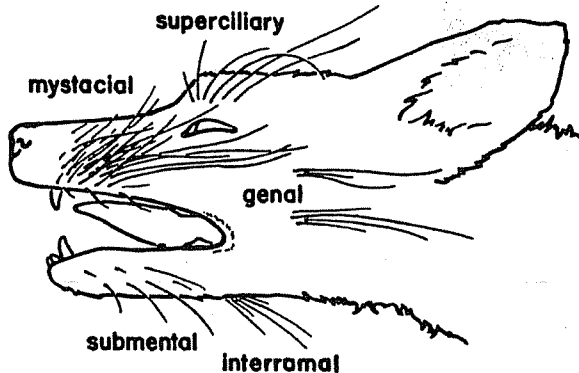


Figure 4.5 Locations of vibrissae on the head of a gray fox (*Urocyon cinereoargenteus*). (Hildebrand 1952:422)

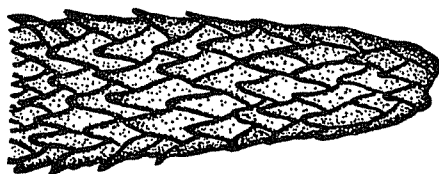


Figure 4.6 Enlarged view of a quill tip of a New World porcupine (*Erethizon dorsatum*). Note presence of barbs. (Shadle and Chedley 1949:172)

cause the spine to embed more deeply. Spines of other groups of mammals (e.g., Old World porcupines, Hystricidae; hedgehogs, Erinaceidae; and echidnas, Tachyglossidae) do not have barbs. **Bristles** are long, firm hairs with angora growth (e.g., horse and lion manes). **Awns** are hairs with definitive growth that have a firm, expanded distal portion and a smaller, weaker base. Awns are the most noticeable hairs on most mammals.

Underhairs

Underhairs function primarily for insulation. Three major types are generally recognized, but intermediate types do occur. **Wool** is angora (that is, evergrowing) underhair and is usually long, soft, and curly. **Fur** is fine, relatively short hair with definitive growth that grows densely over the body. **Velli** (or down, fuzz) are very fine, short hairs that are velvety in appearance. The embryonic hair or **lanugo** of humans is a type of vellus.

- 4-J Note the location of vibrissae on a variety of mammals. Explain these locations considering the habits and/or habitat of each species. Observe the action of the vibrissae in a live mammal.
- 4-K Under a binocular microscope compare the spines of a New World porcupine with those of an Old World porcupine, hedgehog, or other mammal with spines. How do they differ? Under what circumstances may a porcupine be said to “throw its quills”?
- 4-L Examine a variety of mammals. What types of hair are found on each? What is the function of each type of hair?

HAIR REPLACEMENT

Angora hairs grow continuously for the life of the mammal and are continuously worn away at the tips. Most hair, however, is shed and replaced periodically in a process termed **molting**.

Molts may occur continuously with at least some hairs being replaced at all times, (e.g., human eyelashes). But most mammals, particularly those living in temperate or polar climates, have an **annual molt** during which all hairs are replaced in a short period of time. Such molts usually begin in a specific region or regions of the body and spread in orderly sequential fashion until all hairs have been replaced. The **molt pattern** varies with the species and occasionally with the age of an individual (Fig. 4.7). Some mammals have **seasonal molts** with more than one molt per year. This is most conspicuous in species that change from a brown summer **pelage** (the hair covering of a mammal) to a white winter pelage. In northern populations of the long-tailed weasel, *Mustela frenata*, for example, the

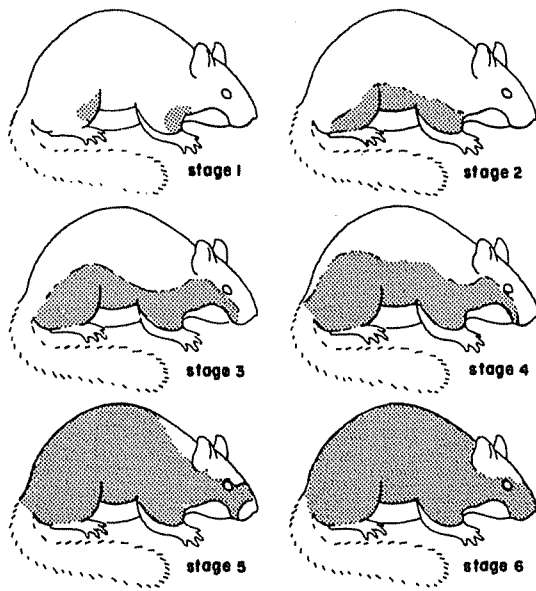


Figure 4.7 Postjuvenile molt pattern in the wood rat, *Neotoma cinerea*. Stippled areas represent appearance of new pelage as the molt progresses. (Egoscue 1962:335)

spring molt begins along the dorsal surface, and brown hairs replace the white winter hairs over the dorsal parts of the animal. In the fall, the molt pattern is reversed with replacement of brown hairs by white ones progressing dorsally from the perpetually white venter. In the southern parts of the range of this species, the molts occur but do not result in a color change, and the weasel has a brown dorsal pelage throughout the year. The change from winter to summer pelage is influenced by hormones, photoperiod, and temperature.

A distinctly **juvenile pelage** is recognizable in many mammals. This is usually grayer and duller than typical **adult pelage**. The juvenile pelage can also be variously striped or spotted, whereas the adult is more or less uniformly colored. In some groups, a distinctive **subadult pelage** occurs between the juvenile and the adult pelages.

- 4-M Examine series of skins of several species collected while the animals were in the process of molting. How does the molt pattern differ among the species examined?
- 4-N Compare winter and summer pelts of northern populations of *Mustela frenata*, *Lepus americanus*, or some other species that has seasonal alteration of colors. Compare the pelages of specimens collected in spring and fall.
- 4-O Examine a large series of deer mice (*Peromyscus*) and identify juvenile individuals on the basis of pelage. Compare pelages of juvenile and adult specimens of other species of mammals.

COLOR

The color of an individual hair is affected by numerous factors. Differences in kind, amount, and distribution of pigment granules in a hair produce different effects. In addition, hair surface texture, the thickness of the hair, and the amount of air space in the medulla can all alter the way in which light is reflected by the hair and, therefore, change the apparent color.

The overall coloration of a mammal is determined by the coloring of individual hairs and the relationships among these hairs in the pelage. An animal may, therefore, be red- and brown-speckled because each hair has red and brown color bands or because the pelage has a mixture of red hairs and brown hairs.

There are two main types of pigment in mammalian hair. **Eumelanin** in various concentrations produces blacks and browns. **Pheomelanin** in various concentrations produces reds and yellows. White is the complete lack of pigment. Each hair usually has a series of color bands. An **agouti** hair has a black tip followed by successive bands of pheomelanin and eumelanin.

Some unmolted pelage may show obvious changes of color over time. This can be caused by simple wear or by bleaching owing to sunlight or powerful artificial light. Old study skins may show **foxing**, chemical changes in pigments that lead toward dull reddish brown. Some opossum study skins show various marked color changes over time, apparently owing to breakdown of derivatives of the amino acid tryptophan.

- 4-P Examine individual hairs from a cottontail rabbit (*Sylvilagus*) or other animal with agouti hair, and note the sequence of color bands.
- 4-Q Examine the color banding on hairs of at least 10 species of mammals that could be described as brown. How do these compare in number, width, sequence, and hue of the bands? Do all of the hairs in a given body region exhibit the same banding?
- 4-R Examine a series of skins or study skins from the same general area (e.g., same county) but collected over a number of years (20+). Assess differences that may be due to age, sex, or season. Then, within samples of these subcategories, try to determine if any of the specimens show evidence of "foxing." Which years of collection show the most evidence of foxing in the skins? Which years the least? Would foxing be a factor that a taxonomist must consider in assessing geographic and interspecific differences in mammals?

Mammalian hair coloration and skin coloration serve several functions. Among these are concealment, communication, and protection from ultraviolet (UV) radiation (see Timm and Kermott 1982 for discussion and

references). Many predators and many prey have **concealing** or **cryptic coloration** that allows them to blend with their habitat to avoid detection. The primitive agouti pattern provides a coloration that is usually very similar to the color of the earth and dead vegetation. Mammals such as the tigers and okapis are strikingly marked with sharply defined light and dark colors. In these animals' normal habitats, however, these examples of **disruptive coloration** obscure the body contours and cause the animal to blend into the patterns of light and shadow caused by sunlight penetrating the vegetation. Facial stripes, present in many mammals, are also disruptive coloration, usually intended to conceal the eye. Most mammals have a ventral surface that is paler than the dorsum—an arrangement termed **countershading**. It conceals the usual pattern of contour-revealing highlights and shadow, thus making the animal more difficult to distinguish.

Coloration is also important for intra- and interspecific communication. The color pattern typical of a certain species may serve to elicit appropriate intraspecific behavior. In several species, display of distinctive color regions, such as the red genital area of some baboons, is an important part of the courtship ritual. Conspicuously colored **flags**, such as the white underside of the tail in many rabbits and certain deer, may alert others of a group to dangerous conditions. **Warning coloration** is present in some species that have special means of defense. The striking black and white patterns of skunks and the convergently patterned (Fig. 4.8) African zorilla, *Ictonyx striatus*, are examples.

- 4-S Examine skins of all of the mammal species known from your state or province. Which exhibit concealing coloration? Do any areas of the body have disruptive coloration patterns? Which exhibit countershading? Which are equipped with white flags or other color signals? Do any exhibit warning coloration?



Figure 4.8 Warning coloration in the zorilla, *Ictonyx striatus*, an African mustelid that has a pelage similar to that found in North American striped skunks of the genus *Mephitis* and *Spilogale*.

(After Feldhamer et al. 1999:264)

- 4-T Do any mammals other than skunks and zorillas exhibit warning coloration? Examine illustrations in Nowak (1999), Burt and Grossenheider (1964), van den Brink (1967), Dorst and Dandelot (1970), etc.
- 4-U Which mammals other than the tiger and okapi mentioned above exhibit a marked degree of disruptive coloration? Check the same sources listed in 4-T above.

Prolonged exposure to UV radiation from the sun can cause burns and in other ways be deleterious to an animal's health. The melanin pigments in hair and skin are known to filter this harmful UV radiation from sunlight (see references in Timm and Kermott 1982).

Terrestrial vertebrates inhabiting arid regions are usually paler in coloration than closely related forms inhabiting more humid regions. This phenomenon is known as **Gloger's Rule**. Although the rule links color and aridity, the influencing factor is most likely background color of the habitat. As the habitat becomes more arid, vegetation becomes more sparse, and soil color becomes generally lighter. Thus light-colored pelages are adaptations for concealment. In desert areas where there are large expanses of black volcanic rock, the small mammals are usually black like the rock rather than pale as Gloger's Rule would dictate.

- 4-V Examine a number of rabbits (*Sylvilagus*) or woodrats (*Neotoma*) including specimens collected in the eastern deciduous forests, the Great Plains, and the southwestern deserts. Do differences in color correlate with annual precipitation? If possible, compare these with specimens collected from an arid lava field.

Albinism, the complete lack of integumentary pigments, is a genetic trait that has been observed in many species of mammals. Because albinos are not well adapted for camouflage, communication, or UV radiation protection, they generally do not become established as an appreciable portion of a wild population. But geographically localized populations containing numerous albinos have become established in several species. True **albinos**, which lack pigments in the irises and thus are pink-eyed (due to the red blood visible through the transparent, colorless tissues of the eye), have been propagated in captivity, and albino rats and rabbits, in particular, are common domestic animals. **Piebald** individuals, having patches of white on the body, are not as radically different from normal and are, therefore, better able to survive in the wild. The white patches are often caused by somatic mutations and thus cannot be passed on to the offspring.

Melanism, a tendency toward completely black coloration, is also a genetic trait sometimes encountered in wild populations. Although melanistic individuals may

differ from the normal members of their species with respect to concealment and communication, they do have ample protection against UV radiation. In some species, melanistic individuals are common. Examples of these are the silver and cross varieties of the red fox, *Vulpes vulpes*; black fox squirrels, *Sciurus niger*; black gray squirrels, *Sciurus carolinensis*; and black leopards ("black panthers"), *Panthera pardus*.

- 4-W Examine a live albino animal (e.g., laboratory mouse, *Mus musculus*). Note color of hair, skin, and eyes. Compare the color of an individual hair with one from a normally colored individual of the same species. Is the albino really white?
- 4-X Examine mammal skins exhibiting unpigmented areas. (Such irregular white patches are common in the eastern mole, *Scalopus aquaticus*, and the Mexican freetailed bat, *Tadarida brasiliensis*.)
- 4-Y Examine a number of squirrel or fox skins showing the typical color for the species and others showing a variety of melanistic shades. Compare several hairs from the melanistic specimens with one from a normally colored individual of the same species. Does each hair have fewer or smaller red bands? Is each hair completely black? Are all the hairs black?

A few species of mammals have coloration that does not result from pigmentation. Sloths, for example, have coarse overhair with numerous external grooves. Algae grow in these grooves and often give the animals a greenish color that allows them to better blend in with their forest environment. Some mammals, (e.g., golden moles, Chrysochloridae) show iridescence of the pelage, caused by structural characteristics rather than by pigment.

- 4-Z Prepare a temporary wet mount of a sloth hair and examine under the microscope. Are grooves evident? Are algae visible?
- 4-AA Examine a specimen of a mole of the genus *Talpa* or *Scalopus* (Talpidae) and a golden mole (Chrysochloridae). Alternately move each of these specimens in different directions under an intense source of light (sunlight or illuminator). Do the colors of the specimens change under the light source as they are moved about? Which specimen exhibits iridescence? Why does one of the specimens not show dramatic color changes as it is moved under the light source?

INTEGUMENTARY GLANDS

There are two basic types of glands in the skin of mammals, sweat glands and sebaceous glands. All other

integumentary glands are considered to be—or hypothesized to be—modifications of one of these two types.

Sweat glands are found only in mammals, although several kinds of mammals—echidnas, megachiropteran bats, sirenians, elephants, lagomorphs, and rodents—have none. Sweat glands consist of two basic types, sudoriferous and eccrine. **Sudoriferous (=apocrine sweat) glands** are highly coiled and empty their secretions into the cavity of the hair follicle (Sokolov 1982). Sudoriferous glands produce the odorous component of perspiration. In humans, apocrine sweat glands are concentrated in the axillae, navel, anogenital areas, nipples, and ears. **Eccrine sweat glands** are also highly coiled (see Fig. 4.1) but open directly onto the skin surface, independent of the hair follicles. Eccrine sweat glands are responsible for most of the fluid portion of sweat and also excrete some metabolic wastes and salts. Evaporation of sweat from the surface of the skin is a cooling mechanism for the body, and perspiration can also improve tactile sensitivity and grip when secreted onto the palms and soles. The wax-producing glands of the external auditory meatus, the **glands of Moll**, are modified apocrine sweat glands that protect the tympanic membrane from becoming dry and losing flexibility.

Sebaceous glands (see Fig. 4.1), which are usually associated with hair follicles, serve primarily to keep the hair from becoming too dry and brittle. These glands are absent in elephants and sirenians (Sokolov 1982). In many mammals, they are also important in waterproofing the pelage. Sebaceous secretions in the hair of otters and fur seals, for instance, keep cold water from penetrating the fur and contacting the skin, thereby retarding heat loss. Some sebaceous glands, as in the upper lip, nose, and upper cheek areas of humans, open directly onto the skin surface rather than into hair follicles. Mammals' **Meibomian glands**, located on the eyelid, and **Hartner's glands**, located behind the eyeball, are modified sebaceous glands that lubricate the eyelid and nictitating membrane, respectively.

- 4-BB Examine prepared slides of mammal skin. Locate and compare the structures of a sebaceous gland and sweat gland. Where is the sebaceous gland situated with respect to the hair follicle? What portion of the skin (dermis or epidermis) houses the bulk of the eccrine sweat gland?

Scent glands (Fig. 4.9) are complex odor-producing glands of variable composition. They may be predominantly sebaceous or sudoriferous or divided about equally between these two types of glands. Although much remains to be learned about the function and significance of scent glands and their secretions (Doty 1976; Eisenberg and Kleiman 1972; Ralls 1971; Sokolov 1982), the functions can be divided into three general categories: defense, marking of territory, and other social interactions.

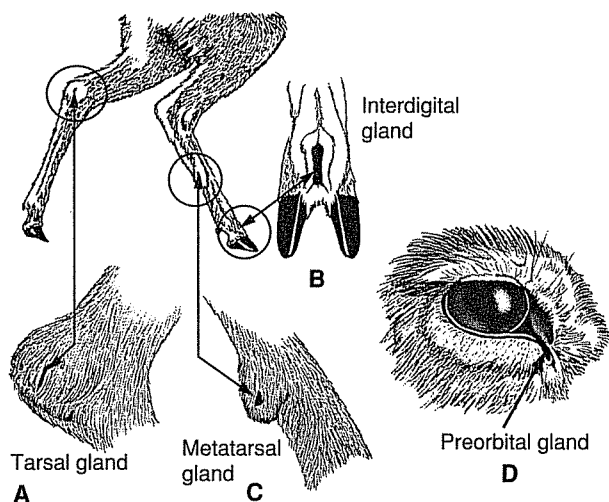


Figure 4.9 Scent glands in white-tailed deer, *Odocoileus virginianus*. (A) Tarsal gland; (B) interdigital gland; (C) metatarsal gland; (D) preorbital gland. (After Feldhamer et al. 1999:107)

In defense, skunks (*Mephitinae*) will discharge a mercaptan-based **musk** from anal glands. Wolverines (*Gulo*) and peccaries (*Tayassu*) are examples of other mammals that emit a musk when they are in danger.

Many mammals (e.g., canids and felids) establish scent trails in their territories to guide their travels. This process of labeling an area with scent is one kind of **marking**. An area marked may even be recognizable as a visible signpost (see Chapter 28). The interdigital glands of deer (*Cervidae* [e.g., *Odocoileus*]) and the anal musk glands of American badgers (*Taxidea*) apparently provide the scent for trail marking in these mammals. In rodents and some primates, urine and preputial gland secretions are important for marking territories.

A **pheromone** is an odor or musk (or odorless secretion) that has a behavioral or physiological effect on another individual or individuals of the same species. For example, pheromones in the urine of some rodents are known to influence the onset of estrus and other phenomena of the reproductive cycle. An **alarm pheromone** is released when an animal is in danger. The secretions of the metatarsal glands of deer are thought to be alarm pheromones.

The secretions of scent glands are sometimes utilized by humans in commercial enterprises. Some scent glands of mammals are removed by trappers and used to prepare scent baits or attractants (see Chapter 30). The musk, or **civet**, produced by the anal glands of certain civets (*Viverridae*, principally *Viverra*, *Viverricula*, and *Civettictis*) is utilized (as are glandular substances from other mammals) as a base in the manufacture of fine perfumes.

4-CC Examine preserved material of a variety of mammals. How many scent glands can you find? Where on the animals' bodies are these located?

4-DD Examine a demonstration dissection of the anal glands of a skunk (e.g., *Mephitis*). How are these animals able to propel their musk such great distances?

MAMMARY GLANDS

Mammary glands, unique to mammals, may be derived from sweat or sebaceous glands, although the precise origin is not clear. These glands develop from two ridges of tissue, termed **milk lines**, in the integument (Kent and Miller 1997). Mammary glands are present in both sexes in eutherians but normally only reach their full size and development in females. Secretions of **milk** from these glands nourish young during the early stages of their lives. In monotremes, there are two mammary glands that secrete milk into abdominal depressions. The monotreme hatchlings then suck milk (Griffiths 1968) from hairs associated with these mammary glands (Fig. 4.10A). All female (and many male) eutherian mammals have mammary glands that are equipped with either nipples or teats. **Nipples** are found in most mammals and have numerous small glandular ducts that exit from the tip of a small, fleshy projection (Fig. 4.10B). **Teats**, such as those found in artiodactyls, have ducts that lead from the glands into a common reservoir or **cistern** that in turn is connected to the exterior through a single duct (Fig. 4.10C).

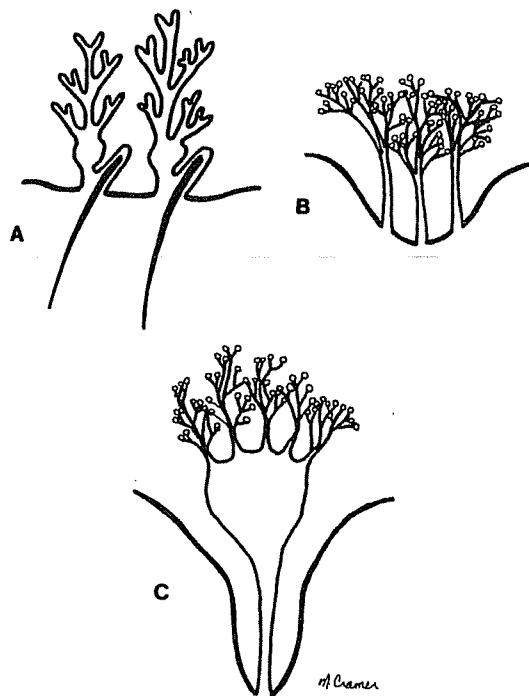


Figure 4.10 Lateral view (diagrammatic) of mammary gland of monotreme (A), and structure of nipple (B) and teat (C). (Mary Ann Cramer)

The number and placement of mammary glands vary greatly and are usually correlated with the typical litter size for a species. Marsupials frequently have a somewhat circular arrangement of nipples. The opossum *Didelphis virginiana*, for instance, has 13 nipples, 12 arranged in a large U shape and the thirteenth centrally located. Eutherian mammals usually have the nipples arranged in two longitudinal ventral rows (certain pouchless marsupials with many nipples—up to 27 in *Monodelphis sorex*—show a similar pattern). In species such as the hog, *Sus scrofa*, which has a relatively large litter size, each row extends from a point between the pectoral limbs to a point between the pelvic limbs. “Higher” primates, which usually have a single young at a time, have a single pectoral pair of mammae, whereas horses, which have the same litter size, have a single abdominal pair. Some rodents (e.g., species of *Mastomys*, which have an extremely large litter size) have the nipples extending out onto the backs of the thighs. Some

hystricomorph rodents (e.g., *Myocastor*) have the nipples located relatively high on the sides, apparently as an adaptation for nursing the large, precocial young of this group of mammals.

- 4-EE Examine a demonstration dissection or illustrations of the mammary tissue of the inner surface of skin that shows well-developed mammary tissue. How is the mammary tissue arranged? Are there differences in the arrangement of the mammary tissue in rodents, carnivores, and bovids?
- 4-FF Examine preparations of a teat and a nipple. How do these structures compare?

Horns and other integumental derivatives on the head and body are discussed in Chapter 5. Claws, nails, and hoofs, which are composed of keratinized epithelial cells, are discussed in Chapter 6.