



Virginia Master Naturalist

Basic Training Course

Mammalogy

John F. Pagels, professor emeritus of biology,
Virginia Commonwealth University

www.ext.vt.edu

Publication 465-314

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2013

Virginia Cooperative Extension programs and employment are open to all, regardless of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. An equal opportunity/affirmative action employer. Issued in furtherance of Cooperative Extension work, Virginia Polytechnic Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Edwin J. Jones, Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; Jewel E. Hairston, Administrator, 1890 Extension Program, Virginia State, Petersburg.

Virginia
Cooperative
Extension

 VirginiaTech
Invent the Future


V
S
U
VIRGINIA STATE
U
S
U

The Virginia Master Naturalist Program is jointly sponsored by:

Virginia Cooperative Extension



Mammalogy

Introduction

Wild mammals provided Native Americans with food and materials for clothing and shelter. Similarly, colonists relied on native mammals and the domestic forms they brought with them, such as dogs, cats, cattle, goats, horses, and swine. The beaver, because of the value of its pelt, played an important role in the westward movement of pioneers and the colonization of many portions of North America. Today, domestic and wild mammals play vital roles in the lives of Virginians. Our native mammals are economically, ecologically, and aesthetically important. The study of mammals can be exciting to everyone, and knowledge about mammals should be important to land managers and developers and others who often do not understand the importance of habitats and the species contained therein.

Classification of Mammals

Mammals are members of the phylum Chordata and subphylum Vertebrata, the vertebrates. The subphylum Vertebrata is comprised of:

- Class Agnatha: jawless forms such as the lamprey
- Class Chondrichthyes: cartilaginous fishes including sharks and rays
- Class Osteichthyes: bony fishes, the most diverse class of vertebrates
- Class Amphibia: including salamanders, frogs, and toads
- Class Reptilia: including crocodilians, snakes, lizards, and turtles (some biologists now place turtles in a separate class, Chelonia)
- Class Aves: all birds
- Class Mammalia: our primary subject

Table 1 provides a list of all native Virginia mammals, exclusive of truly aquatic forms

that may sometimes be spotted in our tidal rivers and along our shores. The list includes the orders that are represented and the common and scientific names of each species. Scientific names can be particularly useful when tracking down additional information on a species.

Mammalian Characteristics: What Is Unique About a Mammal?

Mammals share several characteristics with other vertebrates. For example, mammals possess a segmented “back bone” made up of numerous cartilaginous or bony segments known as vertebrae—hence the name “vertebrate.” Similar to birds, nearly all mammals maintain a constant, internal body temperature despite the outside ambient temperature; they are **homeotherms**. The heat necessary to maintain body temperature comes from within, through the metabolism of food consumed by the individual—**endothermy**, not from external sources such as soaking up solar radiation—**ectothermy**.

Members of the Class Mammalia display certain unique characteristics that separate them from other vertebrate classes, characteristics said to be **diagnostic characters**. One of the diagnostic characteristics of mammals is the presence of three bones in the middle ear: the incus (anvil), malleus (hammer), and stapes (stirrup). Birds and reptiles possess only the stapes. Other unique features include the lower jaw being made up of a single bone; the dentary (the left and right dentaries form the mandible); the presence of hair; and milk production for nourishment of young. Hair and milk characteristics will be discussed at greater length later in this chapter.

Diversity and Distribution of Mammals in Virginia

About 100 species of mammals are known to live in or frequent Virginia.

Objectives:

1. Understand the diversity and distribution of mammals in Virginia
2. Describe the role of mammals in Virginia ecosystems
3. Describe the natural history and basic biology of mammals
4. Describe the adaptations of mammals and how these relate to environmental factors
5. Describe the taxonomy of mammals
6. Describe the key characteristics used to identify mammals
7. Describe threats and/or issues relating to mammals in Virginia
8. Understand appropriate techniques and methods for studying mammals

Approximately 20 marine mammals—for example, manatees, sea lions, whales, and porpoises—are observed along Virginia’s shores or in its bays and tidal rivers, but many are rare visitors or vagrants from more northerly or southerly areas. The only seal regularly seen off Virginia’s coast is the harbor seal. The manatee, at home much farther to the south, has occasionally been observed during summer in Virginia’s waters over the past 20 years, including one recently seen in Richmond in the James River near the fall line. Among the whales, dolphins, and porpoises, the bottle-nosed dolphin is the species observed most frequently on Virginia’s coast; approximately 10 other species have been spotted at least six or more times, including the humpback whale, fin whale, long-finned pilot whale, striped dolphin, harbor porpoise, and the pygmy and dwarf sperm whales. Several other species are known, but largely from occasional strandings along the coast.



Including **extirpated** and introduced species, 84 species of land mammals have been recorded in Virginia within historic times. Extirpated species include the American bison, elk (wapiti), and gray wolf, which disappeared from Virginia in the late 1700s, mid-1800s, and early 1900s, respectively. The mountain lion, or cougar, is another extirpated species. Although sightings have been reported, there are no documented records of a wild form of the mountain lion here or in most of the eastern United States since the early 1900s. The snowshoe hare is on the list; however, that species has not been recorded in several years. The common porcupine is not on the list. The occasional records of porcupines over the years likely represent vagrant individuals of this sometimes widely wandering species. Museum or university specialists should be notified when sightings are made of any of these species or if physical specimens are found.

Among introduced species are the sika deer that live on Assateague Island. A native of Asia, the sika deer is more closely related to elk than to our white-tailed deer. The nutria—a large, semi-aquatic rodent that is native to South America—occurs in fresh and brackish water marshes in parts of eastern Virginia. This animal was brought to North America to be raised on farms for what was planned to be a valuable fur industry. When those aspirations did not pan out, many nutria purposefully were released or escaped; as a result, the nutria now inhabits many parts of the southeastern United States.

Introduced species that have the greatest economic significance, largely because of their pestilence and the money spent in controlling them, are the house mouse and Norway rat. The house mouse coexists with humans and is a common inhabitant not only of homes, but wherever food is available—especially at warehouses, farms, granaries, and horse- and cattle-feed establishments. The Norway rat is found in similar situations and is well known for the large numbers that can be present and the large quantities of food that may be destroyed. Millions of dollars are spent in attempts to eradicate these species. Interestingly, there is a good side! Albinistic and

other selected forms of the house mouse and Norway rat are bred in captivity and serve as laboratory mice and rats. Another introduced rat, the black or roof rat, is much less common than the Norway rat, has a longer tail, and, when present in buildings, is typically found on higher floors than is the Norway rat.

Seven mammal orders, containing 75 native land species (table 1), are represented in Virginia:

1. Didelphimorphia (Marsupialia): opossum
2. Insectivora: 10 shrews and three moles
3. Chiroptera: 17 species of bats
4. Lagomorpha: three species of rabbits and the snowshoe hare
5. Rodentia: seven squirrels, the beaver, 14 species of mice, voles, rats, and two jumping mice
6. Carnivora: one cat, three canids, bear, raccoon, four members of the weasel family, and two skunks
7. Artiodactyla: white-tailed deer

Two aquatic orders represented in Virginia are:

1. Sirenia: manatee
2. Cetacea: whales, dolphins, and porpoises

Exclusive of 17 bat species, about 50 percent of the 58 other native species have a statewide distribution, about 33 percent are restricted to western mountains of the state, and many of the remaining species occur predominantly in eastern, southern, or southeastern areas. A general characterization of the distribution of mammalian species in Virginia, such as “statewide distribution,” “mountains only,” or “south and southeastern portions of the state,” is provided in table 1. It should be noted that not all species occur at all elevations or in all habitats within a stated region; for example, some species labeled as having “statewide distribution” may occur only at the lower elevations of the mountains.

Similarly, certain species designated as “mountains only” may have very restricted ranges, limited to the highest elevations or small geographic areas within the mountains.

Because of Virginia’s location in the mid-Atlantic region and its broad range of physiographic regions, many northern (boreal) species approach the southern extent of their range in our mountains and, conversely, many southern (austral) species reach the northern extent of their range in southeastern Virginia. Appreciation of overall ranges of species can be determined by examination of range maps in field guides or in Internet searches of a species’ range.

Mammal Identification

Some Virginia mammals are well known, and many other species can be identified easily with the help of a field guide. However, because of subtle differences in morphology, the skills of a specialist at a museum or academic institution may be required to identify some species. Certain shrews and rodents are difficult to differentiate. Many of the characteristics described later in the chapter—for example: coloration or amount of bicoloration; body form; length of limbs, tail, and external ears; dentition; and prominent features of the skull—are used to identify species to at least the genus level. Because most small mammals are nocturnal or remain hidden in vegetation, few are seen, providing few opportunities to make measurements and distinguish subtle color patterns. Rephrasing and adopting an old bird phrase—a mammal in hand is worth two in the bush—is often an appropriate strategy whenever you want to make positive identifications. For example, when trying to identify unfamiliar mouse-sized or smaller rodent-like species, one often begins by examining for the presence or absence of the **diastema**, the wide space that separates incisors from cheek teeth in rodents, a critical diagnostic characteristic used to separate rodents from other species. When using field guides, it is essential to consult distribution maps.

How Do We Learn About Mammals? A Few Traps

If we want to know the kinds of mammals that live on our “back 40,” we probably would not be very successful in documenting those present by relying only on our observations and without using special collection techniques. Some species are difficult to identify, many are active only at night, some are active only in runways hidden under vegetation, some live underground, and still others rarely are seen because they are uncommon, secretive, or timid. In addition to visual observations, which include recording road-killed animals, mammalogists use various kinds of traps and other remote devices.

Live-capture traps, well recognized by both homeowners and professionals, are wire, cage-type traps available in various sizes and used to capture species ranging from chipmunks to foxes and even larger animals. When conducting studies of small mammals, large numbers (up to several hundred) of these “box” traps may be used simultaneously. A popular live-capture trap is the Sherman live trap, an aluminum trap that conveniently folds when not in use to facilitate transport to the field or reduce necessary storage space. Nest boxes for squirrels, box traps for rabbits, and mist nets for bats are examples of other live traps.

Live traps are not always effective for capturing certain species or may be impractical in certain settings; in these cases, kill traps are used. Although the common mouse- and rat-snap traps sold in hardware stores are very familiar to most homeowners, mammalogists use a slightly different model called the Museum Special snap trap. This trap is somewhat larger, more stout (durable), and more effective in capturing small mammals than the hardware-store version of the mouse trap.

A pitfall trap, which is an open-ended container buried upright in the ground so that the top is flush with the surface of the surrounding ground, captures animals that fall or are directed into the open device. Although these devices often are used as kill traps, they can function as a live trap if bedding material and food are placed in

the bottom of trap, and they are checked frequently throughout the time they are in operation. Pitfall traps are very effective for capturing shrews.

Motion- or infrared-triggered cameras placed strategically at baited stations currently are being used to document the presence and diversity of larger mammals.

Finally, many species, including less-common forms, can be identified on the basis of scats or tracks. Numerous field guides and Internet resources are available for aid in identification of mammal scats and tracks.

A Closer Look at Special Mammalian Features

Milk

A diagnostic characteristic of mammals is the production of milk by females for the nourishment of young. The name “mammal” is derived in large part from reference to the mammary gland and mammae—the milk-producing glands and nipples, respectively, from whence young obtain milk. Nipples, the small, outer protrusion of each mammary gland, are typically found in animals that bear young that require much parental investment and care early in their development (altricial young). Mammals of this type often raise their young in nests or other sheltered areas where mother and young are not easily seen and where nursing can proceed uninterrupted. The number of nipples found in a given species is a good indicator of the relative size of the litter (number of young born after a given pregnancy).

Unlike nipples, teats are elongated structures that extend from the area of the mammary glands. Teats are typical of mammals that bear young who developmentally are much farther along and require less parental care (precocial young). Teats are present within members of the Bovidae family, which includes cattle, bison, and the true antelopes; members of the Cervidae (deer) family; and selected other groups. These mammals often live in open areas and are characterized by long limbs and a running type of locomotion. Precocial young are not born in nests

or protected areas, they are covered with hair, and their eyes open immediately after birth—in some cases, the eyes may open before they have completely exited the mother. Importantly, these species are able to walk and follow the mother soon after birth. When feeding, young are able to obtain milk rapidly because milk flows into an enlarged cistern in the teat and the young obtain a relatively large amount of milk with each compression of the teat—just as we would if milking such an animal by hand or with a machine. Because these species represent prey to large predators, the ability to feed rapidly and flee quickly are highly adaptive survival traits.

Composition of Milk: Milk is comprised primarily of water, but it also contains necessary fats, carbohydrates, protein, minerals, and vitamins. Milk composition varies greatly among mammals: rabbit milk is different from fox milk, which is different from deer milk, and so forth. Generally, in species where the young rapidly increase body mass, their milk contains a large amount of fat; in species that display rapid skeletal growth, their milk often contains high levels of protein and certain minerals. The first milk produced by the adult female and initially ingested by the young is known as **colostrum**. Colostrum is typically high in fat, other nutrients, and vitamins, and it contains immunoglobulins (antibodies), which are important in preventing infections in newborn mammals. Depending on the species, within hours or days of birth, the immunoglobulins found in colostrum no longer pass through the gut of the young; however, the immunoglobulins obtained earlier from the mother remain in the newborn’s blood until the young develops its own the immune system.

Hair

Origin, structure, and types: Hair is another diagnostic feature of mammals. There are two layers to the skin of vertebrates, an outer **epidermis** and an inner **dermis**. In reptiles, birds, and mammals, the scales, feathers, and hair are part of the epidermis (i.e. epidermal in origin). In contrast, fish scales are products of the dermis (i.e. dermal in origin). Along with other functions, the dermis is a support layer for the epidermis. In some mammals,

the dermis is thick and especially tough; it is the dermis that we use and prepare to make shoes or leather jackets. A fur coat, though, is comprised of both the dermis and epidermis. The term **pelage** is used to refer to all of the hair possessed by a mammal, such as when describing “the animal has beautiful pelage.” In birds, the term for all of the feathers is plumage. Use of the word “fur” usually is confined to describing the soft, dense hair possessed by selected mammals such as mink or muskrat—that is, the fur-bearing mammals.

A strand of hair is an elongated rod (called the shaft) of keratinized (or cornified) cells. **Keratin** is unique to vertebrates and, in addition to scales, feathers, and hair, keratin is a major component of several other epidermal structures. Hair cells are alive only in the active growth site in the root located at the base of a hair follicle, a tube-like enfolding of the epidermis. It is in the root that this tough, insoluble keratin protein is secreted to form the shaft; as the new growth pushes the hair cells of the shaft outward, the hair dies. Pigment (coloration) is added during this initial formative period within the follicle. Hairs that are visible on mammals, including our own hair, contain no living tissue and cannot change color. Hair color sometimes can fade, but color changes only when new hair of a different color replaces the old hair or if the hair is constantly growing and the newer portions display more intense color. As is true in birds when they replace their feathers, mammals molt periodically and old hair is replaced by new hair. The new pelage often is the same color as the old, but, in some mammals, juveniles may be characterized by one color, whereas adults are a different color. Hair color also may vary seasonally. A case where hair color differs dramatically between seasons is in the snowshoe hare, where the pelage is brilliant white in winter, but brown in warm months.

The outer layer of cells on a strand of hair constitutes the **cuticle**—one of three hair layers. These outer cells create a pattern—the cuticular pattern—that often is unique to a certain species. We can use these characteristic patterns, in conjunction with a “key to the hair of local species,” when hair samples found in fecal remains are

examined under a microscope as a means to identify the species that was preyed upon. Hair identification can help us learn about the diet of a predator species, for example a weasel or fox, and also about the kinds of prey species that live in an area where the predator hunts.

Individual strands of hair that comprise wool, the hair produced by sheep, are very fine, often crimped, and the cuticle possesses small barbules that help hold the hairs together. En masse, the hairs create many dead air spaces, which makes wool such a fine insulator. It is these barbules that create the prickliness or scratchiness we sometimes feel when wearing wool garments next to our skin.

Sebaceous glands, generally associated with hair follicles but also present in hairless areas, produce an oily substance known as sebum. Sebum helps maintain the health of hair and skin by keeping them from becoming too dry, or conversely—in the case of those species that spend much time in water—keep the hair and skin from being damaged by too much wetness.

Most mammals possess two kinds of hair: a very fine **underfur**, which is short and dense and provides most of the insulation, and the outer **guard hairs**, which are longer and thicker. Guard hairs contain the pigment that typifies a mammal’s coloration. These sturdier, longer hairs lie over the dense underfur and protect it from abrasion as the mammal moves through its habitat. In nearly all mammals, the hairs are directed posteriorly—toward the tail—so that they do not catch on items as the mammal moves about. Muscles in the skin (arrector pili muscles) cause the hair to stand up or fluff by pulling on the follicles. By manipulating these hairs, a mammal wears a “light jacket” when the hairs are lying down and directed toward the back, but it can “slip on a warmer jacket” by activating the muscles to fluff up the fur. The whiskers on the face of a mammal are called **vibrissae**. Vibrissae have sensitive receptors at the base of their follicles; when the vibrissae touch something, the receptors are innervated. Small species and others that are active at night often have especially long vibrissae to help them move among obstacles in their

nocturnal activities. Porcupine quills and the hard, sharp spines of some other non-native mammals are examples of uniquely modified guard hairs. Quills are effective antipredator structures because of small barbules on them that allow them to penetrate only in one direction—deeper into the face and mouth of a predator.

Mammal coloration

Coloration in most mammals is relatively drab compared to other vertebrates, especially the many species of birds with very colorful males. Because many mammals are nocturnal and color cannot be distinguished at night, these species display brown to gray colors that blend well with their night-time haunts. The hairs on the back and sides are rarely a solid brown, or gray, or reddish color, but instead an alternating pattern of light and dark pigments known as agouti. This blended pattern of colors also works well for species that are active night or day, such as voles and cotton rats.

One of the more colorful local mammals is the chipmunk, a diurnal member of the squirrel family. However, the stripes that the chipmunk displays are not intended to enhance its visibility, but just the opposite. These stripes provide nice camouflage in the chipmunk’s natural situations—the coloration blends in with leaves and other features of the forest floor. Most carnivores also display coloration that provides camouflage, presumably so that the prey they seek or larger predators hunting them cannot see them as easily. The dorsal and ventral surfaces of mammals, such as on the head, body, and tail, often display different colors. This bicoloration is most pronounced in species that are active above groundlevel, for example, mice and other species that climb. Known as counter-shading, the darker dorsum (what usually would be the light side) and lighter ventral portions (normally the dark side) help break up the animal’s profile by reducing contours and shading—the resulting decrease in contrast confuses the predator.

The mammal skull

No part of a mammal tells us more about that animal’s natural history and its relationship to other mammals than its skull.

In addition to serving as a head—bilaterally symmetrical animals need a head end—the cranium contains and protects the brain and provides openings for the ears (auditory meatus). Receptors for the critical senses of vision and olfaction, as well as openings associated with gas exchange and nutrition functions, occur within the rostral (face/rostrum) area of the skull.

To facilitate discussion of the features of and differences among mammalian skulls, it would be handy to have a cleaned (skin and flesh removed) rodent skull (e.g., beaver or woodchuck) and skulls from carnivores with contrasting diets (e.g., raccoon and cat—figure 1). Why these three skulls? First, bear in mind that mammals have different kinds of teeth. Beginning in the center of the jaw, the front-most teeth are the incisors, which are for gnawing or nipping; next are the canines, which often are long and sharp for piercing; and finally are the premolars and molars (the cheek teeth or **molariform teeth**), which vary greatly in size, number, and appearance depending on the animal's diet.

The rodent skull is different from the other two forms in that it possesses no canines and displays a wide gap between the incisors and cheek teeth; this space is known as the **diastema**. Another distinction in rodents is that there are only two upper and two lower incisors instead of four or six, as seen on each jaw in most other mammals. The incisors in rodents grow continuously throughout life and their roots originate well within the skull, away from the exposed portions.

Both the raccoon and the cat skulls possess the full complement of teeth: both have

very evident canines, and both have six incisors above and six below (humans have four incisors above and below). Importantly, dentition adapted for three general diet types are also represented by these three skulls: rodent = herbivore; raccoon = omnivore; and cat = carnivore.

The molariform teeth differ among rodents depending on their specific diet. Those with a diet characterized primarily by grasses typically have cheek teeth with flat, grinding surfaces; those that eat less harsh vegetative matter have cheek teeth with small, rounded cusps.

Comparing the raccoon and cat skulls tells a subtler story. Cheek teeth of the omnivorous raccoon are unspecialized, that is, not very efficient for chewing either harsh vegetation or slicing flesh, but satisfactory for processing many different kinds of food. Humans are omnivores and have teeth similar to those of the raccoon. Cheek teeth of carnivorous mammals, like the cat, are highly specialized for processing flesh. Although carnivores have fewer cheek teeth than do other mammals, the ones they have display unique piercing and slicing edges. The cheek teeth of canids (e.g., fox, coyote, domestic dog) are somewhat intermediate between those of the raccoon and the cat; piercing and slicing cheek teeth are present, but they also possess teeth for grinding and crushing.

Tooth wear, or lack thereof, is very useful for determining relative age. In studies involving museum specimens, skulls are placed in age classes (e.g., young, young adult, adult, and old adult) based on the amount of tooth wear in the specimens when compared to a known-aged reference

specimen. Why is determination of age important? If you are examining geographic differences in the size of a certain species of mouse from Virginia with those from Wisconsin, you want to be sure you're not comparing adults in one instance with young in the other!

An older adult typically will show much more tooth wear, whereas a young animal will show no tooth wear or the presence of temporary ("milk" or deciduous) teeth. Estimates of age from tooth wear should corroborate estimates from other metrics, such as the use of sutures (joints between bones of the skull). In young, still-growing animals, these "zigzag" sutures are quite evident, and it is easy to differentiate the individual bones that make up the skull. As animals age, these sutures gradually fill in and harden (ossify), making the cranium appear to be made of a single bone rather than the series of individual plates that actually exist.

The various knobs, bumps, and ridges evident on a skull, as well as the bones they closely associate with, tell us much about that animal and play several important roles: They either form a joint with another bone or serve as a point of muscle attachment. Examples of knobs on the skull that form part of a joint are the occipital **condyles**. There are many different condyles in mammals, but they all represent "bumps" that form a joint. The occipital condyles are located on each side of the foramen magnum (hole in the skull where the spinal cord exits) and articulate with the first vertebra, the atlas. An example of a ridge that serves as a point of muscle attachment is the lambdoidal ridge, located along the upper-back part of the

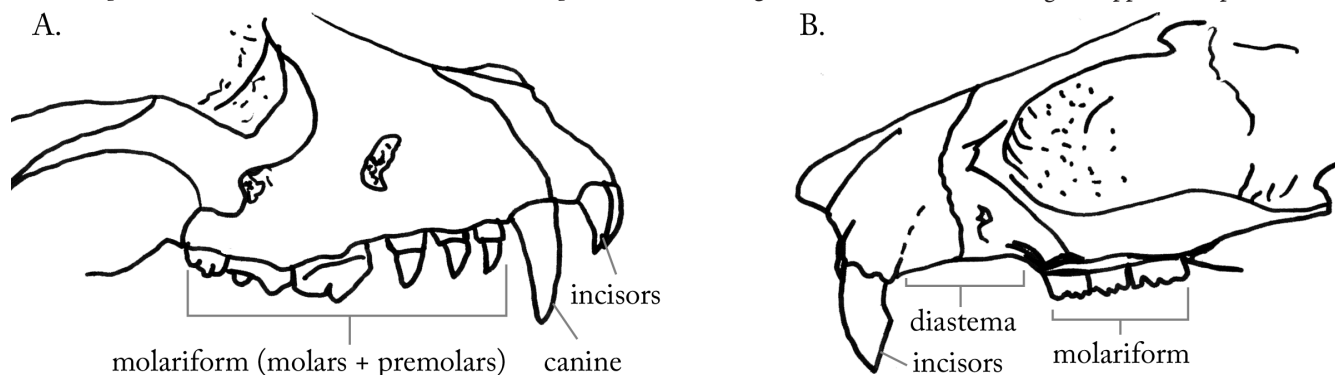


Figure 1. Diagram of the dentition of (a) a carnivore and (b) a rodent with each of the types of teeth: incisors, canines, premolars, and molars (or molariform teeth). Rodents lack canines and have a large space called the diastema between the incisors and the molariform teeth. Rabbits and hares also lack canines and have a large diastema, but they possess a tiny incisor behind each of the large incisors.

skull of many mammals, where tendons of the major neck muscles attach.

Nails, claws, and hooves

Similar to hair, the nails, claws, and hooves of mammals are epidermal structures, and keratin is the primary component of these hard structures.

Nails are found on the tops of the digits and are characteristic of species that grasp or hang onto objects (e.g., humans or monkeys hanging onto a branch).

Claws are found at the ends of digits and are curved and sharp at the tips. Claws serve a variety of functions within the species in which they are found. In some instances, claws are used to facilitate digging in the soil or to securely hold onto prey. Claws are also important to species that climb (e.g., tree squirrels), in that these extensions fit into the irregularities of the substrate—tree bark—and may dig in for better grip.

Hooves are weight-bearing structures found at the ends of the digits. The bones of the foot (phalanges, carpals, and tarsals) of the hoofed animals are highly modified and, among certain species, greatly elongated to enhance their running style of locomotion. Among our surviving native species in Virginia, only the deer possesses hooves, whereas many of our common domestic livestock (e.g., horses, pigs, cattle, goats, and sheep) all possess these structures.

Antlers and horns

Antlers and horns are at least partially epidermal and also include keratin. Although antlers often are called horns—especially during deer-hunting season when we hear comments such as, “did you see any horns?” or “he had a big set of horns”—antlers and horns are very different structures. Antlers are characteristic among male members of the family Cervidae—the deer family, which includes elk, moose, and caribou. However, in caribou and domesticated reindeer, antlers are present on females, too. Antlers are made of solid bone, are shed annually following completion of the rut (the mating season), and often become larger and more elaborate (greater

branching) with age. During spring and summer, when new antlers are actively growing, they are enveloped in a layer of skin covered by very fine hair known as velvet—a condition said to be “in velvet.” The skin and velvet give the main beams and tines (points) of growing antlers a very thick appearance. In late summer, when antlers have reached their full growth, the blood supply to the skin is cut off, and the skin gradually dries; the animal works hard to shed or rub off this dead, irritating skin, exposing the solid bone of the antler. Antlers are attached to the skull by bony pedicels on the frontal bones, which are not shed. Discussion of factors affecting antler size in deer is available from numerous sources, including state game agencies. Primary factors controlling antler size are age, genetic factors, and quantity and quality of diet.

Horns are possessed by cattle, bison, true antelopes, goats, sheep, and other members of the family Bovidae. Except for special breeds of hornless cattle, horns are present in both sexes; within cattle, one can not tell the difference between a male (bull) and a female (cow) simply on the basis of the presence or absence of horns. Like antlers, horns also originate on the frontal bone. A horn has a bony base that is hollow and covered by a sheath—a highly keratinized structure that antlers lack. It is this sheath, removed from the horns of (dead) cattle, that is often used to create the powder horns used to store black powder for muzzle-loading weapons. Also unlike antlers, horns are never branched and never shed. The pronghorn, an antelope-like mammal of the western plains, possesses neither true horns nor true antlers, but instead displays a kind of a hybrid structure—the pronghorn. These structures, possessed by both males and females, have a horny sheath that is shed annually, but the small, bone core is not shed.

The mammal external ear

The external ears (**pinnae**) are the outward features that help us identify mammals and tell much about a species' biology. All mammals possess ears—middle and internal ears—but the pinnae or ear flaps (singular pinna) vary greatly among species and can be important in differentiating certain species. But how can pinna size tell

us anything about a species' biology, especially if we have no knowledge about its habitat? Animals that spend much of their time living underground in burrows (said to be **fossorial**) have very reduced pinnae. The extremes in this case are the moles—fossorial animals that completely lack pinnae. However, most other fossorial species (e.g., weasels, woodchuck [or groundhog]) have very small or reduced pinnae. Shrews and voles also have relatively small external ears; these species spend their time both above and below ground level, within the leaf litter, in runways, or in nests in overgrown fields. However, if somebody handed you a mouse that had relatively large pinnae, such as a deer mouse, it should suggest to you that you are dealing with a species that likely spends considerable time in open areas where hearing is more critical to its survival than if it were underground or hidden by vegetation. Semi-aquatic furbearers represent a second group where the pinnae are characteristically reduced. The beaver, mink, muskrat, and river otter all have very small pinnae. As is true with fossorial species, large pinnae would be disadvantageous to these semi-aquatic animals, because large ears hinder movements, especially underwater.

The mammal tail

Obviously, tails are important to the species that possess them. We can also use characteristics about a mammal's tail as a means to gain information about that species' biology:

As was true with ear size, tails of a fossorial species and of those that confine their activity to the ground will typically be short. Woodland (pine) and meadow voles are good examples.

Deer mice and many other species of mice and rats have a long tail that serves as a balance and a prop when they climb.

The elongated tail of the opossum is prehensile, meaning it can wrap around and grasp an object. Young opossums sometimes ride on the back of their mother, hanging on to the mother's tail with their own tails. Opossums also use their tails to carry leaves for nesting, with the tail wrapped around leaves and curled downward and toward their abdomen.

The tail of the beaver is wide and flat and, among other uses, acts like a third leg when the beaver is upright and gnawing on a tree.

Virginia's two species of jumping mice, the meadow jumping mouse and woodland jumping mouse, have very long tails that act as counter balances. When these mice use their large hind legs and feet to push off and initiate a jump, they don't want to flip uncontrolled, so the tail provides proper counter-weight to that torque.

The tail of the white-tailed deer is very obvious as it runs away, but when the tail is not erect, the deer blends in with the forest background and makes it more difficult for predators to detect their presence. Does a predator—for example, a cougar or wolf—key in on the tail of their prey? Perhaps.

Cattle—with a long tail with a brush on the end—possess a great fly swatter.

Not all of the more than 900 species of bats in the world possess a tail, but all species in Virginia do. All of the bat species in Virginia—but not all bats in the world—have a flap of skin that extends from the tail to the hind legs. This tail membrane—or the **uropatagium**—serves various roles in flight. In most bats, the uropatagium is naked (i.e., hairless). Interestingly, of the five species in Virginia that roost in the foliage or on trees, the uropatagium is furred. Apparently, it makes a blanket for the ventral surface of these bats when they are roosting.

Whether short or a long, or wide or narrow, naked or hairy, we can learn something about the species' biology on the basis of its tail.

Mammal Habitats and Special Places

Table 2 presents the relative abundance and general habitat associations of native mammals (exclusive of aquatic species) known to live in Virginia. Many mammal species are considered habitat generalists, which means they can live in a variety of habitat types (e.g., both fields and forests) and survive quite well. Examples of habitat generalists include opossums, short-tailed shrews, woodchucks, white footed mice,

raccoons, and white-tailed deer. Others species are considered habitat specialists, meaning they are linked closely to a specific habitat type. Examples of species closely allied with forested habitats include smoky shrews, all of the tree squirrels (red, gray, and fox), flying squirrels, and gray foxes. Among the old-field habitat species are eastern cottontails, harvest mice, cotton rats, meadow voles, meadow jumping mice, and red foxes. Species associated with a given habitat type sometimes will venture into and take advantage of resources in other habitats, such as squirrels in a field or red foxes in the forest.

Certain species require special conditions above and beyond the dominant types of vegetation that may be present within a particular habitat:

Because water is critically important to some species, they are never found far from water—whether that be a stream, river, pond, lake, marsh, or swamp. The water shrew, marsh rabbit, muskrat, beaver, river otter, and mink are examples of species in this group. These are semi-aquatic species.

Mammal species endemic to more northern latitudes—but found here in Virginia at the extreme southern extent of their range—tend to occur only at higher elevations in the mountains where they find the cooler, moister environments they require. Species such as the rock vole, red-backed vole, northern flying squirrel, and select species of shrews would be affected very severely should these habitats become too warm or dry.

Many species of bats are dependent upon caves and mines, where the ambient temperature is mediated and satisfies their needs for roosting, thermoregulation, and hibernation.

Roles of Mammals in Virginia's Ecosystems

Although the role a given mammal species may play in the ecosystem is often expressed through the use of complex ecological models, such models usually are not necessary to observant naturalists who make good use of field observations. In Virginia, the white-tailed deer is a mammal known to exert considerable influence

on forested habitats. Where deer densities are high, their excessive browsing can have profound negative effects on plant abundance, plant-community structure, and the amount of cover or natural shading. Changes caused by deer affect the presence and/or abundance of other animals living in that system. Today's abundance of deer can be attributed to changes in their environment, such as the loss of their key predators (e.g., the mountain lion and gray wolf), controlled predation by humans in the form of hunting seasons, and more recently, the declining influence of regulated deer hunting.

Predatory species, such as foxes, coyotes, bobcats, and even raccoons, play an important role in regulating the abundance of other game and nongame prey species. Smaller prey animals, such as voles, characteristically display very high reproductive potentials as a strategy to counterbalance the effects of heavy predation. Because these prolific and abundant species are prime targets of predators, their presence may decrease the amount of pressure that predators exert on other potential prey species, especially those with lower reproduction potential, thereby helping to sustain a greater overall diversity of species. Such a scenario is most evident in early successional or old-field habitats where a rich mammal fauna exists, consisting of both habitat generalists and old-field specialists.

Despite displaying lower overall abundance than some of these prolific old-field species, certain mammal species—the ecosystem engineers—can still exert considerable influence on habitats through their ability to modify their environments. The beaver is the best known among these engineers in that they build dams, create ponds and wetlands, and alter stream habitats that lie below these created features. Following years of accumulation of silt, these ponds eventually fill in and become meadows, a completely new habitat characterized by a new suite of plant and animal species.

The groundhog (or woodchuck) is another mammal well-known for the profound effects it can have on other animals, plants, and soil. Although often a nuisance near buildings and agricultural crops, the

woodchuck is beneficial. Its abandoned burrows, whether in old fields, forests, or along fence rows, provide shelter for many other mammals of various sizes. In many areas, old woodchuck dens are critical to the survival of rabbit populations; these dens provide rabbits with protective escape sites from predators and suitable climate-controlled shelter during weather extremes.

A final example of the beneficial role mammals can play is provided by moles and their influence on soil ecosystems. The feeding and burrowing activities of moles

loosen and aerate the soil, bring leached nutrients up to the surface, enhance drainage, and provide sites for seed germination. Although much smaller than those of the woodchuck, the old burrow systems of moles are often used by voles and shrews.

Summary

As described in this chapter, Virginia possesses a rich mammal fauna. This richness is due largely to the variety of physiographic regions present in Virginia and the diversity of habitats found in each of those

regions. Many differing lifestyles are represented among the mammal species that occur here, each of which also demonstrate differences in locomotion, diet, coloration, body form, specializations of the ears and tails, and other features. As you gain additional experience and familiarity with Virginia's physiographic regions, you should reach a point where you can stand by the side of a stream that flows from a forest into an overgrown field and begin to anticipate the species of mammals that should be found living in and around these habitats.

Table 1. Native mammals known to occur in Virginia.^{1,2}

Distribution³: SW = statewide distribution, MO = mountains only, SE = southern and southeastern portion of Virginia

ORDER DIDELPHIMORPHIA—Opossums

Virginia opossum, *Didelphis virginiana* SW

ORDER INSECTIVORA—Insectivores

Masked shrew, *Sorex cinereus* MO

Rock shrew, *Sorex dispar* MO

Maryland shrew, *Sorex fontinalis* northern Eastern Shore

Smoky shrew, *Sorex fumeus* MO

Pygmy shrew, *Sorex hoyi* SW

Southeastern shrew, *Sorex longirostris* SW

Common water shrew, *Sorex palustris* MO

Northern short-tailed shrew, *Blarina brevicauda* SW except south central and parts of east

Southern short-tailed shrew, *Blarina carolinensis* south central and parts of east

Least shrew, *Cryptotis parva* SW

Hairy tailed mole, *Parascalops breweri* MO

Eastern mole, *Scalopus aquaticus* SW

Star-nosed mole, *Condylura cristata* SW

ORDER CHIROPTERA—Bats

Southeastern myotis, *Myotis austroriparius* SE

Gray myotis, *Myotis grisescens* MO, southwest

Eastern small-footed myotis, *Myotis leibii* MO

Little brown myotis, *Myotis lucifugus* SW

Northern myotis, *Myotis septentrionalis*, SW

Indiana myotis, *Myotis sodalists* MO

Eastern red bat, *Lasiurus borealis* SW

Hoary bat, *Lasiurus cinereus* SW

Northern yellow bat, *Lasiurus intermedius* SE

Seminole bat, *Lasiurus seminolus* SE

Silver-haired bat, *Lasionycteris noctivagans* SW

Eastern pipistrelle, *Perimyotis (Pipistrellus) subflavus* SW

Big brown bat, *Eptesicus fuscus* SW

Evening bat, *Nycticeius humeralis* SW, primarily east

Rafinesque's big-eared bat, *Corynorhinus (Plecotus) rafinesquii*, southwest and southeast

Townsend's big-eared bat, *Corynorhinus (Plecotus) townsendii* MO

Brazilian free-tailed bat, *Tadarida brasiliensis* one record, a vagrant?

ORDER LAGOMORPHA—Rabbits and hares

Eastern cottontail, *Sylvilagus floridanus* SW

Appalachian cottontail, *Sylvilagus obscurus* MO

Marsh rabbit, *Sylvilagus palustris* SE

Snowshoe hare, *Lepus americanus* MO (possibly extirpated)

ORDER RODENTIA—Rodents

Eastern chipmunk, *Tamias striatus* SW

Woodchuck (groundhog), *Marmota monax* SW except extreme southeast

Gray squirrel, *Sciurus carolinensis* SW

Fox squirrel, *Sciurus niger* mountains and southeast, not between

Red squirrel, *Tamiasciurus hudsonicus* MO, some areas upper Piedmont

Northern flying squirrel, *Glaucomys sabrinus* MO

Southern flying squirrel, *Glaucomys volans* SW

American beaver, *Castor canadensis* SW

Marsh rice rat, *Oryzomys palustris* middle to eastern

Eastern harvest mouse, *Reithrodontomys humulis* SW

Cotton mouse, *Peromyscus gossypinus* SE

White-footed mouse, *Peromyscus leucopus* SW

Deer mouse, *Peromyscus maniculatus* two subspecies occur in Virginia: one MO, the other the prairie deer mouse western subspecies, which occurs in the Shenandoah Valley

Golden mouse, *Ochrotomys nuttalli* southern half, mountains then to east

Hispid cotton rat, *Sigmodon hispidus* southern two-thirds, Blue Ridge to east and extreme southwest

Appalachian woodrat, *Neotoma magister* MO

Southern red-backed vole, *Myodes (Clethrionomys) gapperi* MO

Rock vole, *Microtus chrotorrhinus* MO

Meadow vole, *Microtus pennsylvanicus* SW

Woodland vole, *Microtus pinetorum* SW

Common muskrat, *Ondatra zibethicus* SW

Southern bog lemming, *Synaptomys cooperi* mountains and south-east, not between

Meadow jumping mouse, *Zapus hudsonius* SW

Woodland jumping mouse, *Napaeozapus insignis* MO

ORDER CARNIVORA—Carnivores

Coyote, *Canis latrans* SW

Red fox, *Vulpes vulpes* SW

Common gray fox, *Urocyon cinereoargenteus* SW

Black bear, *Ursus americanus* SW, primarily mountains and southeast

Common raccoon, *Procyon lotor* SW

Fisher, *Martes pennanti* MO

Long-tailed weasel, *Mustela frenata* SW

Least weasel, *Mustela nivalis* SW, may not be present in southeast

American mink, *Mustela vison* SW

Northern river otter, *Lontra (Lutra) canadensis* SW

Eastern spotted skunk, *Spilogale putorius* MO

Striped skunk, *Mephitis mephitis* SW

Bobcat, *Lynx rufus* SW

ORDER ARTIODACTYLA—Even-toed ungulates

White-tailed deer, *Odocoileus virginianus* SW

¹List is exclusive of aquatic species.

²Orders and genera are placed in conventional phylogenetic order; species are arranged alphabetically within each genus.

³In some instances, geographical ranges may be restricted to highly specialized habitats or small geographical areas. Therefore, it should not be inferred that "MO" indicates that a species occurs throughout all montane portions of the commonwealth.

Table 2. Relative abundance and general habitat associations of native Virginia mammals known to occur in Virginia^{1,2}

Abundance: C = common, U = uncommon, R = rare

Habitat: G = generalist, O = old field (overgrown fields, grass/shrubs), F = forested areas

ORDER DIDELPHIMORPHIA—Opossums

Virginia opossum, *Didelphis virginiana* C, G

ORDER INSECTIVORA—Insectivores

Masked shrew, *Sorex cinereus* C, G

Rock shrew, *Sorex dispar* U, rocky, talus

Maryland shrew, *Sorex fontinalis* R, G

Smoky shrew, *Sorex fumeus* C, F

Pygmy shrew, *Sorex hoyi* U, G

Southeastern shrew, *Sorex longirostris* U, O

Common water shrew, *Sorex palustris* R, mountain headwater streams

Northern short-tailed shrew, *Blarina brevicauda* C, G

Southern short-tailed shrew, *Blarina carolinensis* C, G

Least shrew, *Cryptotis parva* SW, O

Hairy tailed mole, *Parascalops breweri* U (relatively), G

Eastern mole, *Scalopus aquaticus* C, G

Star-nosed mole, *Condylura cristata* U (relatively), near water

ORDER CHIROPTERA—Bats (abundance and roosting locations)

Southeastern myotis, *Myotis austroriparius* R, buildings, caves

Gray myotis, *Myotis grisescens* R, caves and buildings

Eastern small-footed myotis, *Myotis leibii* R, caves

Little brown myotis, *Myotis lucifugus* C, caves and buildings

Northern myotis, *Myotis septentrionalis* C, caves and buildings

Indiana myotis, *Myotis sodalis* R, caves, hollow trees, under bark, i.e. shagbark hickory

Eastern red bat, *Lasiurus borealis* C, tree foliage

Hoary bat, *Lasiurus cinereus* U (sometimes common during migration), tree foliage

Northern yellow bat, *Lasiurus intermedius* U, tree foliage

Seminole bat, *Lasiurus seminolus* U, tree foliage

Silver-haired bat, *Lasionycteris noctivagans* C, under tree bark, tree foliage

Eastern pipistrelle, *Perimyotis (Pipistrellus) subflavus* C, caves and buildings

Big brown bat, *Eptesicus fuscus* C, caves and buildings

Evening bat, *Nycticeius humeralis* U, hollow trees

Rafinesque's big-eared bat, *Corynorhinus (Plecotus) rafinesquii* R, large hollow trees, cave entrances, buildings

Townsend's big-eared bat, *Corynorhinus (Plecotus) townsendii* R, caves near entrances

Brazilian free-tailed bat, *Tadarida brasiliensis* R, caves and buildings

ORDER LAGOMORPHA—Rabbits and hares

Eastern cottontail, *Sylvilagus floridanus* C, O

Appalachian cottontail, *Sylvilagus obscurus* U, forested brushy areas

Marsh rabbit, *Sylvilagus palustris* U, marshy, wet areas

Snowshoe hare, *Lepus americanus* R, openings in spruce forests

ORDER RODENTIA—Rodents

Eastern chipmunk, *Tamias striatus* C, G, however primarily near wooded areas

Woodchuck (groundhog), *Marmota monax* C, G

Gray squirrel, *Sciurus carolinensis* C, F

Fox squirrel, *Sciurus niger* U in most areas where it occurs, F

Red squirrel, *Tamiasciurus hudsonicus* C, mixed forests; hardwoods and usually abundant conifers

Northern flying squirrel, *Glaucomys sabrinus* R, spruce and fir forests

Southern flying squirrel, *Glaucomys volans* C, primarily hardwood forests

American beaver, *Castor canadensis* C, Forested areas by streams and reservoirs

Marsh rice rat, *Oryzomys palustris* C, most often near water, sometimes in dry fields and forests

Eastern harvest mouse, *Reithrodontomys humulis* U, O

Cotton mouse, *Peromyscus gossypinus* U, lowland forests, swamps

White-footed mouse, *Peromyscus leucopus* C, G

Deer mouse, *Peromyscus maniculatus* two subspecies occur in Virginia: the common one at high elevations largely in forested areas; the other a western subspecies, the prairie deer mouse that has expanded its range into the Shenandoah Valley and is associated with old-field situations

Golden mouse, *Ochrotomys nuttalli* U, disturbed areas in forests, forest edges

Hispid cotton rat, *Sigmodon hispidus* C, O

Appalachian woodrat, *Neotoma magister* U, boulders, cliffs, and caves

Southern red-backed vole, *Myodes (Clethrionomys) gapperi* C, F at high elevation, moss-covered rocks, rotting logs

Rock vole, *Microtus chrotorrhinus* R, high elevation; cool, moist, rocky areas

Meadow vole, *Microtus pennsylvanicus* C, O

Woodland vole, *Microtus pinetorum* C sometimes, brushy areas in forests, edges, sometimes orchards and yards

Common muskrat, *ondata zibethicus* C, streams near by herbaceous growth, marshes

Southern bog lemming, *Synaptomys cooperi* U, bogs, moist meadows, marsh edges, sometimes dry fields

Meadow jumping mouse, *Zapus hudsonius* U, sometimes locally abundant, usually in fields, sometimes forests

Woodland jumping mouse, *Napaeozapus insignis* U, sometimes locally abundant, generally in open areas in forests, often near streams

ORDER CARNIVORA—Carnivores

Coyote, *Canis latrans* U to relatively C in selected areas. G, but typically near fields

Red fox, *Vulpes vulpes* C, O and forest edges

Common gray fox, *Urocyon cinereoargenteus* C, F

Black bear, *Ursus americanus* R to relatively C in selected areas, F primarily

Common raccoon, *Procyon lotor* C, G, typically most abundant near water

Fisher, *Martes pennanti* R, high-elevation forests

Long-tailed weasel, *Mustela frenata* relatively C, G
 Least weasel, *Mustela nivalis* U, O and forest edges
 American mink, *Mustela vison* C, near water
 Northern river otter, *Lontra (Lutra) canadensis* C east and U
 western areas, near water
 Eastern spotted skunk, *Spilogale putorius* U, rocky/boulder areas
 in forests

Striped skunk, *Mephitis mephitis* C, G
 Bobcat, *Lynx rufus* U to relatively C in selected areas, F most
 often, much cover

ORDER ARTIODACTYLA—Even-toed ungulates

White-tailed deer, *Odocoileus virginianus* C, G

¹ List is exclusive of aquatic species.

² Orders and genera are placed in conventional phylogenetic order; species are arranged alphabetically within each genus.

Glossary

Altricial – born in an early developmental state, typically requiring more parental care and protection (e.g., opossums, mice, and humans have altricial young)

Colostrum – special milk consumed by young immediately after birth and for a short period thereafter. Antibodies (immunoglobulins) that help protect the newborn mammal are included in colostrum

Condyles – rounded projections on a bone where two bones come together, one with the condyle, the other with a depression, to form a joint (e.g., occipital condyles are bumps on the back of the skull where the skull and first vertebra of the “backbone” articulate)

Cuticle – the outer layer of cells on a strand of hair

Dermis – inner layer of skin

Diagnostic character – a characteristic that is unique to a certain group; hair, milk, and three bones in the middle ear are among the diagnostic characteristics of mammals

Diastema – the wide space or gap between the incisors and the molariform teeth, found especially in rabbits and rodents

Endotherm – an organism that obtains its body heat from within by oxidative metabolism

Ectothermy – controlling body temperature through external means, such as exposure to sunlight

Endothermy – controlling body temperature internally through metabolism

Epidermis – outer layer of skin

Extirpated – local extinction, loss of a species from a given area, but it still exists elsewhere

Fossorial – adapted for burrowing and spending much time underground (e.g., moles are fossorial mammals)

Guard hairs – the longer, outer hair that protects the underfur and contains pigment that gives mammals their typical coloration

Homeothermy – maintaining a constant body temperature in a range of ambient temperatures

Keratin – a tough protein that is a major component to hair and nails

Molariform teeth – all the teeth posterior to (behind) the canines (i.e., the premolars and molars)

Pelage – all of the hair on a mammal; the equivalent of “plumage” in birds

Pinnae – external ear flaps, the size of which is a useful indicator of a mammal’s biology

Precocial – born in a later developmental state, such as with eyes fully opened and the ability to walk and follow the mother soon after birth (e.g., deer have precocial young)

Underfur – short, dense, insulating hair located beneath the guard hair

Uropatagium – flap of skin between the tail and the hind legs of bat species

Vibrissae – sensory hairs, including whiskers



Study/Review Questions

1. What is a diagnostic character(istic)? List three characteristics of mammals.
2. What is the difference between a precocial (newborn) mammal and one that is altricial? Provide three examples of each type.
3. What is the difference between a nipple and a teat?
4. Describe general differences in the young and the habitats of animals that possess teats vs. those that possess nipples.
5. How can the presence or absence of a diastema be used to differentiate selected mammals?
6. What is meant by a boreal species? List 10 boreal species.
7. Describe live traps that might be used for a mouse, a fox, and a squirrel.
8. What is meant by the cuticular pattern of hair? What can we learn from that?
9. What are arrector pili muscles? Describe two reasons why hair typically lays flat and directed toward the posterior.
10. List—from front to back—the kinds of teeth found in mammals. Which of these are missing in rodents and lagomorphs?
11. What can tooth wear and the sutures of the skull tell us about a mammal?
12. Contrast nails, claws, and hooves.
13. Describe three ways that antlers and horns differ.
14. Describe three ways that certain mammals use their tails.
15. What is a habitat generalist? A habitat specialist? Name several mammals that fall under each category.
16. What is a habitat modifier or a habitat engineer? Provide two examples.

Additional Resources

National Audubon Society. 1996. *Field Guide to North American Mammals*. New York: Knopf.

Reid, F. A. 2006. *Peterson Field Guide to Mammals of North America*. New York: Houghton Mifflin.

Webster, W. D., J. F. Parnell, and W. C. Biggs. 2003. *Mammals of the Carolinas, Virginia, and Maryland*. Chapel Hill: University of North Carolina Press.

Linzey, D.W. 1998. *The Mammals of Virginia*. Knoxville: University of Tennessee Press.

Virginia Department of Game and Inland Fisheries, Fish and Wildlife Information Database: <http://vafwis.org/fwis/>.

University of Michigan Museum of Zoology, Animal Diversity Web: <http://animaldiversity.ummz.umich.edu/site/index.html>.