Laboratory 2 Worksheet: Teeth

Mammalian teeth differ from teeth of earlier vertebrates, including most living “reptiles” in three general characteristics:

Characteristic	Early Vertebrate	Mammal	
Toothrow	Homodont	Heterodont	Mammal teeth differ from front to back, early vertebrate teeth tended to be similar in all parts of the jaw.
Tooth placement	Acrodont	Thecodont	Mammal teeth are set in sockets (see a skull with missing teeth) while in reptiles the teeth are close to the surface of bone
Tooth replacement	Polyphyodont	Diphyodont	Mammals have 2 sets of teeth, deciduous "milk teeth" and the permanent teeth. Milk teeth are lost as the permanent teeth move into place in the jaws.

There are four kinds of teeth in mammals: (1) incisors (for nipping), (2) canines for grasping prey, and cheekteeth of two kinds--(3) premolars ("bicuspids" in humans) and (4) molars--for shearing or grinding the food. Molars are only present in the permanent dentition (by definition).

Differentiated teeth are one of the features associated with increased metabolism and increased energy requirements in mammals. Specialization within the tooth row allows efficient processing of food. A higher surface:volume ratio increases the rate of digestion when chewed food comes into contact with digestive chemicals in the gut.

Tooth shape and the number of teeth have varied over evolutionary time in mammals. Many taxonomic groups have lost teeth compared to the original condition. Herbivores, such as rodents, rabbits, and most artiodactyls have no canines and have simple incisors. Carnivores do not need grinding cheekteeth because of their diet. Some whales and anteaters do not have teeth or have a very reduced dentition. Toothed whales have over 200 teeth. Notice the contrast between herbivores and carnivores on the skulls in the lab.

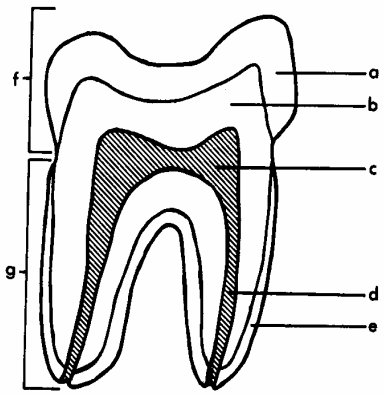
Teeth give clues to the diet of mammals. Molars of horses and mice have high crowns. Cheekteeth of carnivores form an efficient shearing mechanism. Incisors of rodents and rabbits grow continuously and are worn away by gnawing. Tusks of elephants, walruses, the narwhal, and the warthog are teeth that do not process food. Orders with relatively ancestral dentitions include insectivores, bats, carnivores, and primates.

Use the skull of a coyote or other canid. Identify structures with underlined names. Labial refers to the outside of the tooth, the side closer to the lips, and lingual refers to the inner border of the tooth, the side closer to the tongue (“ngu” in lingual and tongue).

The portion of the tooth exposed above the gumline is the crown. The portion fitting into the socket or alveolus is the root. The major portion of each tooth is made up of a bone-like substance called dentine. At the crown the dentine is covered with the harder enamel, the hardest substance in the vertebrate body. The root is covered with another bone-like substance, cementum. The central, living portion of the growing tooth is the pulp. The pulp is in the pulp cavity and is supplied with blood vessels and nerves through one or more openings in the endings of the roots.

Figure 12. Schematic cross-section of mammalian tooth (DeBlase and Martin 1981).

a: enamel
b: dentine
c: pulp
d: root canal
e: cementum
f: crown
g: root



In most mammals, teeth stop growing and the blood supply is reduced. Teeth of this type are termed rooted. Some teeth grow throughout an animal's life (e.g., incisors of rodents and cheekteeth of some rodents). Evergrowing teeth are said to be "rootless." Examine the evergrowing ("rootless") incisors of a rodent, such as a beaver. Don't try to pull teeth out of every skull, there are some skulls with loose teeth on the back bench. Note the size of the growing tooth and how far back into the dentary bone the tooth goes (Fig. 13). Also note the evergrowing cheek teeth of muskrat (Fig. 14).

Figure 13. Incisor of beaver (*Castor canadensis*). In the left image the extracted tooth is pasted on top of the dentary bone in its approximate correct location.

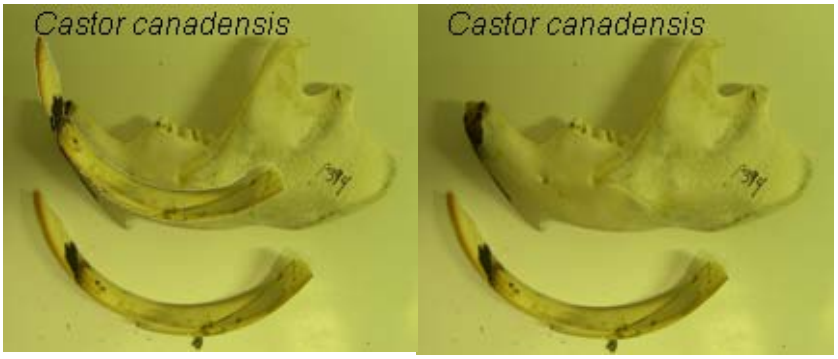
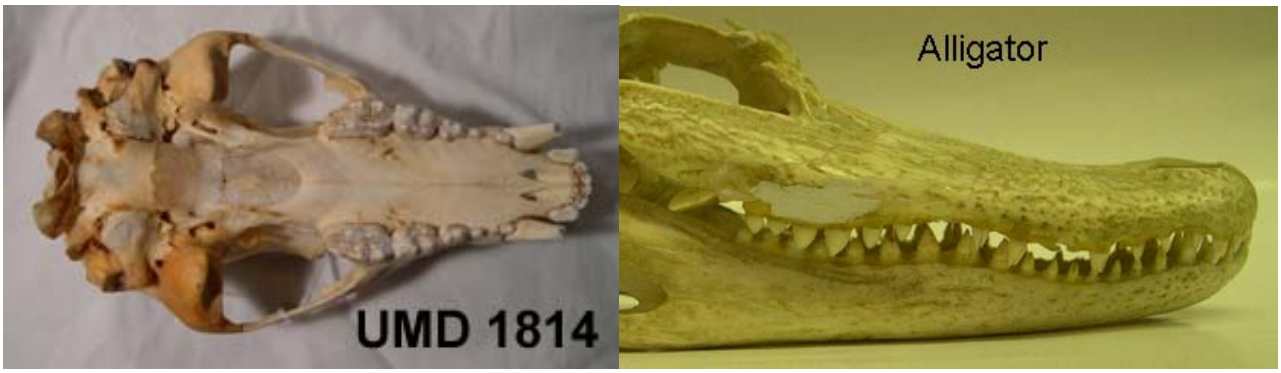


Figure 14. Cheek teeth of muskrat (*Ondatra zibethicus*).

Kinds of Teeth.--Mammalian teeth are heterodont. This means that they are different from front to rear in the toothrow (hetero = different, dont = teeth), compared to the homodont condition of most toothed vertebrates (Fig. 15).

Fig. 15. Contrast between heterodont teeth of a black bear (*Ursus americanus*) and the homodont teeth typical of reptiles. Photographs not to the same scale.



In typical mammals, there are four basic kinds of teeth: incisors, canines, premolars, and molars. The numbers of teeth are given per quadrant, (upper versus lower, right versus left) that means one half of the lower jaw or one premaxilla/maxilla combination of the upper jaw.

Incisors are the anteriormost teeth in the jaws of most mammals. The upper incisors are rooted wholly in the premaxillae. They are mostly simple in structure but in various groups have been modified for grooming, cutting, gnawing, and other functions. Placental mammals never have more than three incisors in each jaw quadrant. Marsupials such as the opossum (*Didelphis virginianus*) may have up to five in each half of the upper jaw and up to four in each half of the lower jaw.

Canines are the anteriormost teeth in the maxillae (located next to the suture between premaxillae and maxillae) and the corresponding teeth in the lower jaw. They are frequently used for holding and piercing prey. No mammal has more than one canine per quadrant.

Because cheekteeth mostly chew food to break it down, they have undergone structural changes as mammals have diversified and exploited new nutritional resources. The structure of cheekteeth is often used in taxonomy because teeth fossilize well, tooth shape is conservative, and tooth shape varies with diet.

It is not always possible to distinguish between premolars and molars based on appearance. Premolars may be smaller than molars, but are not always smaller. By definition premolars are present in both the deciduous and permanent dentitions, whereas molars are present only in the permanent dentition. The oldest known mammals (from the late Triassic) were insectivores, and their cheekteeth were adapted to crushing arthropod exoskeletons, appearing similar to modern insectivores (Fig. 16). These teeth had four main cusps arranged in a longitudinal or slightly triangular row and sheared together in a scissor-like action.

Figure 16. Teeth of a modern insectivore (*Blarina brevicauda*).

Identify the incisors, canines, premolars, and molars on a skull of a coyote or other canid (Figs. 3-6 from Lab 1, 18). Note which teeth arise from which bones. Can you tell which teeth are premolars and which are molars? Note the possible function of each type of tooth. Move the articulated jaws to see the shearing action of the sectorial teeth, called the carnassial pair, P4/m1 (Fig. 17).

Figure 17. Carnassial pair in wolf (*Canis lupus*).

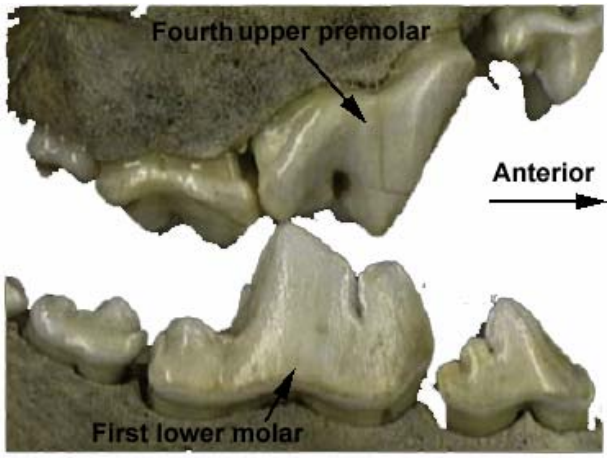


Figure 18. Teeth of a red fox (*Vulpes vulpes*).

Examine the skull of an opossum (Fig. 19). Compare and contrast with the coyote. Identify incisors, canines, premolars, and molars. Note which teeth arise from which bones. How do you know which teeth are premolars and which are molars? Note the possible function of each type of tooth. Again note the shearing action of the sectorial teeth.

Figure 19. Skull of an opossum (*Didelphis virginiana*).

Numbers of Teeth. Placental mammals usually have a maximum of four postcanine teeth in their milk dentition and seven postcanine teeth in the adult dentition. The four cheekteeth present both in the milk (deciduous) dentition and in the adult dentition are defined as the premolars. The three remaining teeth are termed the molars.

Marsupials have only one postcanine tooth per quadrant in their deciduous dentition. Ontogenetic investigations have shown that this tooth corresponds to the third postcanine in the adult. Therefore marsupials are regarded as having a maximum of three premolars and four molars.

Examine the skull of an omnivore, the hog, *Sus scrofa*. Compare the cheekteeth with those of a bear and those of a human (yours, no skull available), and also the peccary.

Figure 20. Cheekteeth of a pig (*Sus scrofa*).

Many specialized herbivores have evolved strategies to prevent the erosion of their teeth in response to the abrasive qualities of their food. One convergent adaptation in several groups is a hypsodont (high-crowned) dentition (Fig. 21). Grass contains large amounts of silica, which wears down teeth. Some herbivores, especially grazers, have evolved rootless, ever-growing teeth. Examine the dentition of a muskrat (*Ondatra zibethicus*) with rootless cheekteeth (Fig. 22).

Figure 21. Brachyodont or low-crowned teeth vs. hypsodont or high-crowned teeth. (Vaughn et al. 2000).

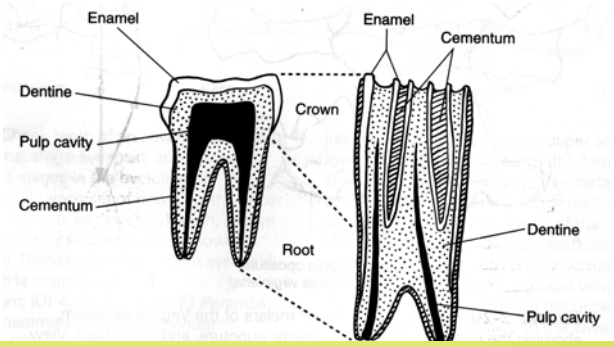


Figure 22. Muskrat tooth row.

Another adaptation that improved the effectiveness of the cheekteeth for mastication of plant material was to alter the anatomy of the teeth. To break open plant cells effectively the grinding surfaces of the cheekteeth have been modified. In the lophodont teeth of the horse, cusps fused to form elongated ridges and to broaden the grinding surface. Another example of this type of tooth is in the order Proboscidea (Elephants and Mammoths). See Fig. 23 which shows the lophodont tooth of a wooly mammoth (*Mammuthus primigenius*).

Fig. 23. Lophodont tooth fragment from a wooly mammoth (*Mammuthus primigenius*).

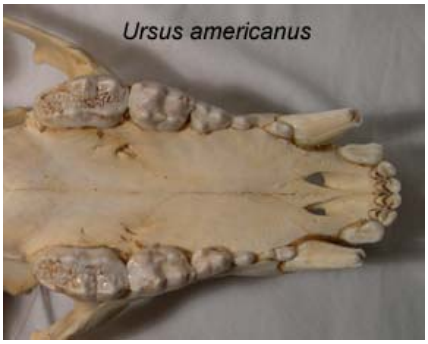
The selenodont teeth of a deer function in a similar way but the ridges are formed by the elongation of single cusps. The crescent-shape is visible in the teeth on the left in Fig. 24

Figure 24. Selenodont teeth of white-tailed deer (*Odocoileus virginianus*).

The other type of tooth is bunodont which is characteristic of omnivores such as bears, pigs, and humans (Fig. 25, 26).

Figure 25. Bunodont teeth of a collared peccary (*Tayassu tajacu*). On the left is a side view of skull with teeth, on the right are upper cheekteeth (lower set of teeth) and the lower cheekteeth (upper set of teeth). Compare these teeth to those of a pig.

Figure 26. Bunodont teeth of black bear (*Ursus americanus*).



The different hardness of enamel and dentine is used to improve efficiency of breaking down vegetation. Young herbivores have cheekteeth covered entirely with enamel. When the enamel on top of the cusps and ridges wears away, the underlying dentine is exposed. This leaves lakes of dentine surrounded by a ridge of enamel (Fig. 27). The enamel ridges wear away more slowly than the dentine, forming a grinding surface.

Fig. 27. Dentary bones of White-tailed deer (*Odocoileus virginianus*). On top is a young animal (about 1.5 years). On the bottom is an older animal. How might one know this? Clues are in the wear on individual teeth—note wear on entire tooth row in bottom image. In the top image, the very high ridges of enamel are apparent on most teeth. Also note the tooth with so much wear. It is being pushed out by the premolar below it.

Examine the dentition of a horse (Fig. 28). What term describes the occlusal surface? What term describes the crown height? Compare the dentition to that of a bovid (Fig. 29) and with a rodent, such as a beaver or porcupine (Fig. 30). Contrast occlusal surfaces and crown height.

Figure 28. Horse occlusal surface

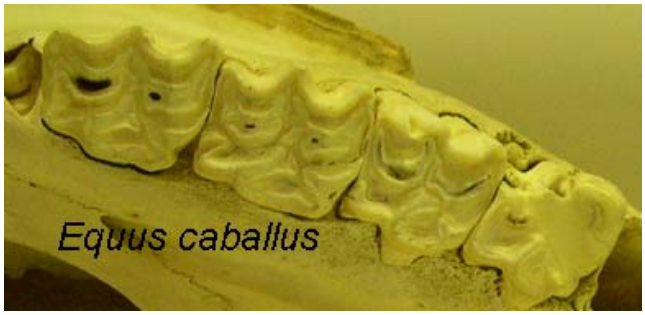


Figure 29. Cheek teeth of a bison (*Bison bison*). Note the emerging premolar in the image and in the dentary in the lab (if available).

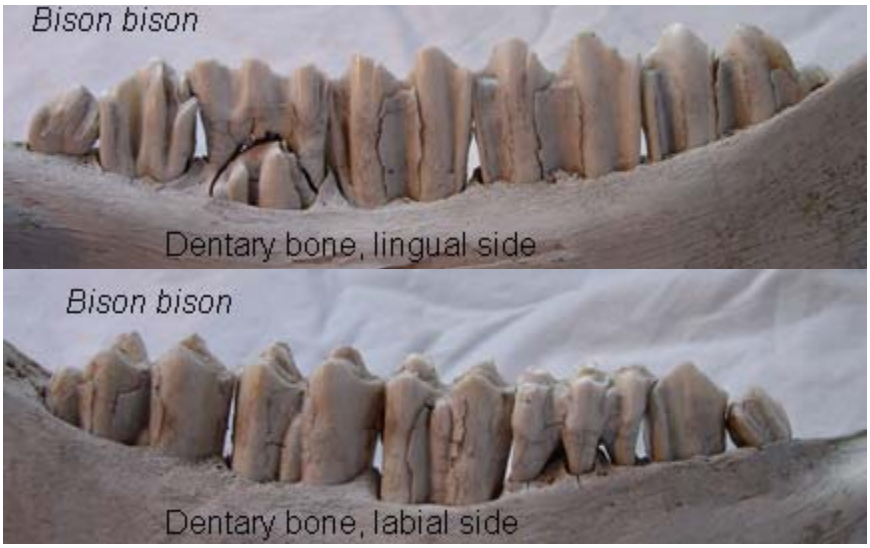
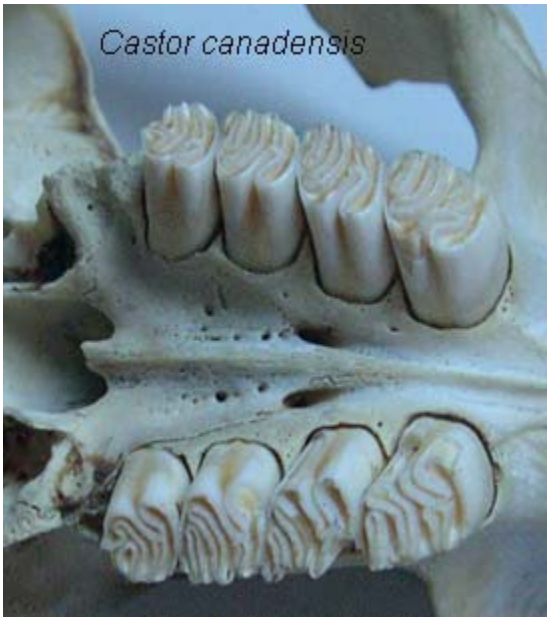


Figure 30. Cheek teeth of a beaver (*Castor canadensis*) and of a porcupine (*Erithazon dorsatum*).



Examine the dentition of a cervid such as a deer (Fig. 27) or elk (*Cervus elaphus*). What term describes the occlusal surface? What term describes the crown height?

Dental Formulae.--The dental formula is a shorthand method to indicate the number and variety of teeth in a particular mammal. Dental formulae frequently appear in keys. Dental formulae of common mammals are in Table 1.

Dental formulae are expressed in a variety of ways. For the genus *Canis* the dental formula is I = 3/3, C = 1/1, P = 4/4, M = 2/3, Total = 42. The number above each "slash" mark represents the number of teeth in one quadrant of the upper jaw; the lower numeral represents the teeth of one quadrant of the lower jaw. I stands for incisors, C for canines, P for premolars, and M for molars. The total number of teeth is shown, calculated by adding together all the numbers given in the dental formula and multiplying them by two, for the two sides of the jaw.

Initials for the tooth types can be deleted, e.g., 3/3, 1/1, 4/4, 2/3 = 42. A zero indicates that a particular kind of tooth is absent in a species. For example, many rodents lack canines and premolars. The dental formula for the deer mouse (*Peromyscus maniculatus*) is therefore: 1/1 0/0 0/0 3/3 = 16.

It can be impossible to distinguish premolars and molars in an adult animal. If a mammal has the maximal number of cheekteeth (four premolars and three molars in placentals), a complete and accurate formula is no problem. For carnivores, the shearing pair of carnassial teeth can almost always be identified and the carnassials are always P4/m1. With that knowledge as a starting point, one can determine the complete dental formula.

A single tooth is identified by giving the tooth type (I, C, P, or M) with a superscript (for the upper toothrow) or subscript (for the lower toothrow) numeral. P^4 is the fourth upper premolar, M_1 is the first lower molar.Upper teeth may be abbreviated with upper case letters (I, C, P, M) and the lower teeth with lower case letters (i, c, p, m), P4 = the fourth upper premolar, i1 the first lower incisor. From an evolutionary perspective premolars are lost from front to rear, and molars are lost from rear to front. Therefore, if a species has a single upper premolar it is P4; if it has a single lower molar it is m1.

Deciduous teeth are sometimes indicated by the letter d. Hence, dP4 = the last upper premolar in the milk dentition. Examine the skull of a felid (Fig. 31). Write a dental formula. Identify the carnassial teeth P^4/M_1.

Figure 31. Skull of a bobcat (*Lynx rufus*) or lynx (*Lynx canadensis*).

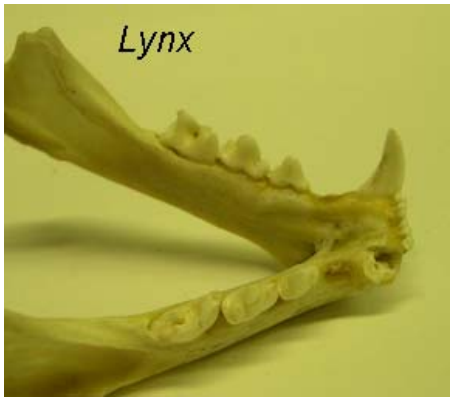


Figure 32. Gray wolf (*Canis lupus*) side view and ventral view.

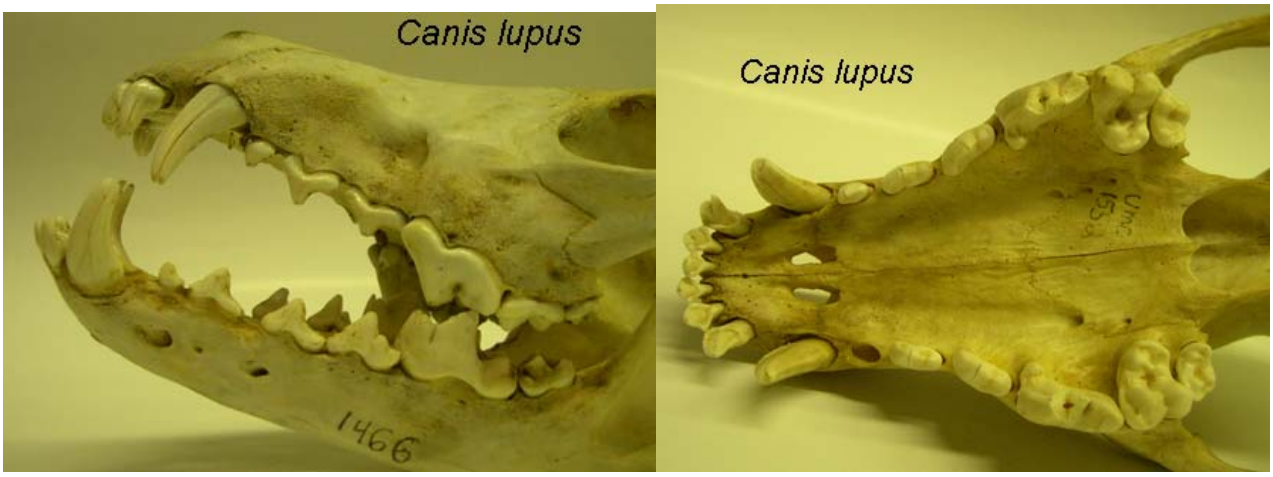


Table 1. Dental formulae of some mammals. Names listed refer to genera. Note: all of these genera are not out in lab today, some are not even in the UMD collection.

Formula	Genus
I 5/4, C 1/1, P 3/3, M 4/4 = 50	*Didelphis*
I 3/3, C 1/1, P 4/4, M 2/3 = 42	*Ursus*, Canis, Vulpes, Urocyon*
I 3/3, C 1/1, P 4/4, M 2/2 = 40	*Procyon*
I 2/3, C 1/1, P 3/3, M 3/3 = 38	*Myotis*
I 3/3, C 1/1, P 4/4, M 1/2 = 38	*Martes, Gulo*
I 3/2, C 1/0, P 3/3, M 3/3 = 36	*Scalopus*
I 3/3, C 1/1, P 4/3, M 1/2 = 36	*Lutra* (*Lontra)*
I 3/3, C 1/1, P 3/3, M 1/2 = 34	*Mustela, Mephitis, Taxidea, Spilogale*
I 0/3, C 1/1, P 3/3, M 3/3 = 34	*Cervus*
I 2/2, C 1/1, P 2/2, M 3/3 = 32	*Homo*
I 3/1, C 1/1, P 3/1, M 3/3 = 32	*Sorex*
I 4/2, C 1/0, P 2/1, M 3/3 = 32	*Blarina*
I 0/3, C 0/1, P 3/3, M 3/3 = 32	*Odocoileus, Alces, Bison, Antilocapra, Ovis,*
I 3/3, C 1/1, P 2-3/2, M 1/1 = 28 or 30	*Lynx, Felis*
I 2/1, C 0/0, P 3/2, M 3/3 = 28	*Lepus, Sylvilagus*
I 1/1, C 0/0, P 2/1, M 3/3 = 22	*Marmota, Spermophilus, Tamias, Tamiasciurus, Sciurus**
I 1/1, C 0/0, P 1/1, M 3/3 = 20	*Castor, Erethizon, Perognathus, Dipodomys*
I 1/1, C 0/0, P 0/0, M 3/3 = 16	*Onychomys, Phenacomys, Reithrodontomys, Clethrionomys, Microtus, Peromyscus, Ondatra, Rattus, Mus*

*May have one upper premolar missing.

Specimens that are available

Order	Family	Species	Common name
Didelphimorphia	Didelphidae	*Didelphis virginiana*	Opposum
Insectivora	Soricidae	*Blarina brevicauda*	Short-tailed shrew
Insectivora	Soricidae	*Sorex cinereus*	Masked shrew
Carnivora	Canidae	*Canis latrans*	Coyote
Carnivora	Canidae	*Canis lupus*	Gray wolf
Carnivora	Canidae	*Canis familiaris*	Dog
Carnivora	Canidae	*Vulpes vulpes*	Red fox
Carnivora	Felidae	*Lynx rufus*	Bobcat
Carnivora	Mustelidae	*Lutra canadensis*	Otter
Carnivora	Mustelidae	*Martes pennanti*	Fisher
Carnivora	Procyonidae	*Procyon lotor*	Raccoon
Carnivora	Ursidae	*Ursus americanus*	Black bear
Cetacea	Delphinidae		Dolphin
Proboscidea	Mammutidae	*Mammuthus primigenius*	Wooly mammoth
Perissodactyla	Equidae	*Equus caballus*	Horse
Artiodactyla	Suidae	*Sus scrofa*	Pig
Artiodactyla	Cervidae	*Cervus elaphus*	Elk
Artiodactyla	Cervidae	*Alces alces*	Moose
Artiodactyla	Cervidae	*Odocoileus virginianus*	White-tailed deer
Artiodactyla	Bovidae	*Bos taurus*	Cow
Artiodactyla	Bovidae	*Capra hircus*	Goat
Artiodactyla	Suidae	*Sus scrofa*	Pig
Rodentia	Muridae	*Peromyscus maniculatus*	Deer mouse
Rodentia	Sciuridae	*Marmota monax*	Woodchuck
Rodentia	Muridae	*Clethrionomys gapperi*	Red-backed vole
Rodentia	Muridae	*Ondatra zibethicus*	Muskrat
Rodentia	Muridae	*Rattus norvegicus*	Rat
Rodentia	Castoridae	*Castor canadensis*	Beaver
Rodentia	Erethizontidae	*Erethizon dorsatum*	Porcupine
Lagomorpha	Leporidae	*Lepus americanus*	Snowshoe hare
Lagomorpha	Leporidae	*Sylvilagus floridanus*	Eastern cottontail
Edentata			Anteater