Handout 7-A
Teeth Tell All

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

Animal skulls provide a wealth of information to the scientist. Besides the important identification of the species, the skull can show the animal's eating preferences, size, gender, brain development, health, cause of death, classification levels, and much more. Investigators of wildlife crimes who need to match a particular animal or species victim to the evidence can also run DNA tests from the cells of the skull.

What Does the Forensic Scientist Need to Know?

The forensic scientist must know the parts of the skull and the differences among skulls of animal groups. Using dichotomous keys and other resources to examine and measure, they look for distinguishing characteristics to identify the species of the skull.

How Can a Skull Be Identified?

The types, shapes, and patterns of teeth give the quickest clues about the owner, but if the teeth are missing, scientists can identify the skull from other characteristics. For instance, the shape of a feline skull is always round when viewed from the top compared to the shape of a canine skull, which is oblong. Other clues about the species of the skull are found in the size and position of the eye sockets and nasal passage, the shape of ear bullae or tubes, and the size of the brain case. Some species are identified by distinct suture patterns on the skull.

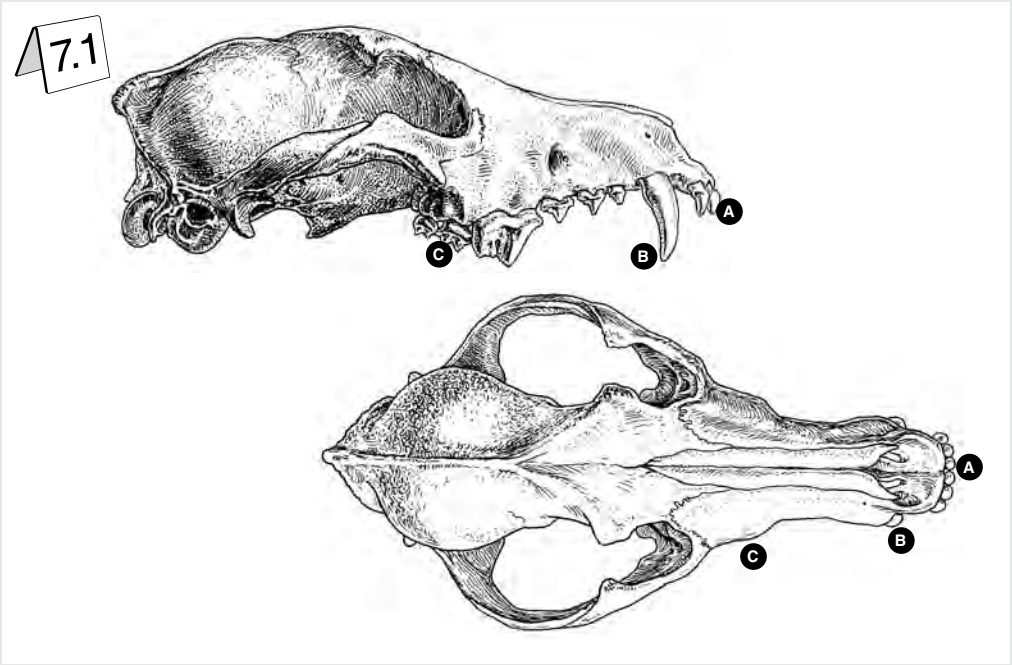
Types of Teeth

Incisors—Located across the front of the mouth; used for cutting (Figure 7.1).

Canines—One canine can be located behind each side of the incisors (four at the most). They work like daggers and are used to grab and hold onto prey. Clues to what an animal eats are given by the presence or absence of the canine, as well as its length.

Molars and premolars—These cheek teeth are located behind the canines and continue to the back of the jaw. They are wide teeth used for grinding, crushing, or cutting.

Handout 7-A
Teeth Tell All

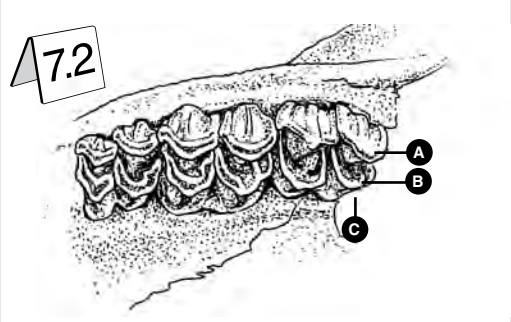


Side and top views of a mammal skull (coyote)
A: Incisors B: Canines C: Molars

Teeth Patterns Tell Eating Tales

Herbivores

Examples of herbivores are deer, elk, bison, moose, goats, sheep, peccaries, musk ox, horses, and cattle. These plant-eating animals have wavy-topped cheek teeth (molars and premolars) to grind apart tough plant parts. In some herbivores, these teeth look like a geologic cut through a mountainside because they show alternating layers of hard white enamel and softer darker dentine. As the animal eats, the dentine wears away faster than the enamel to create a sharp edge good for grinding tough plant parts (Figure 7.2).



Herbivore molars and premolars
(white-tailed deer)
A: Enamel
B: Dentine
C: Sharp ridges

Handout 7-A
Teeth Tell All

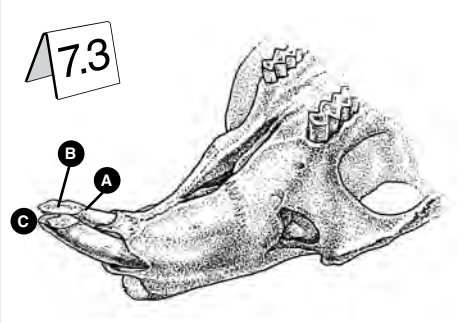
Most herbivores do not have canines. Exceptions are male horses, with small canines used for defense, and animals in the pig family with tusks. One group of herbivores, the North American artiodactyls, are missing both top incisors and canines. These animals—deer, goats, sheep, cattle, and musk ox—chew with only cheek teeth (peccaries are the exception).

Gnawing Herbivores

Examples of gnawing herbivores are prairie dogs, beavers, porcupines, squirrels, and rabbits. These rodents and rabbits are also plant eaters, but they have specialized, long, curved incisors to crack nuts, rip apart tough plant parts, or chew through wood (Figure 7.3). These teeth are quickly worn down from gnawing, so they must grow continually throughout the animal's lifetime.

These incisors must stay sharp to cut through tough plant parts. What's the trick? It's all in the enamel. The outer face of the incisors has an extra layer of enamel that strengthens and protects the teeth, but the inner face is covered with softer dentine. When the animal gnaws, it is constantly sharpening its teeth by shaving off layers of the inner dentine faster than the outer enamel.

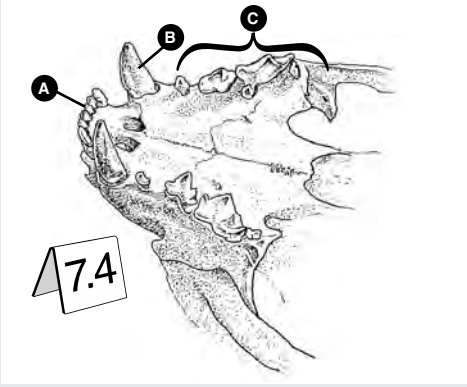
The other teeth of gnawing herbivores are like those of other herbivores—wavy-topped cheek teeth for grinding, and no canines.



Gnawing herbivore incisor (hoary marmot)
A: Enamel
B: Dentine
C: Constantly sharpened point

Carnivores

Examples of carnivores are the cat family, wolves, ferrets, mink, badgers, and river otters. Since carnivores hunt and eat other animals, their teeth are completely sealed and protected by hard white enamel. Carnivores have



Carnivore teeth (bobcat)
A: Incisor
B: Canine
C: Molars/premolars

Handout 7-A
Teeth Tell All

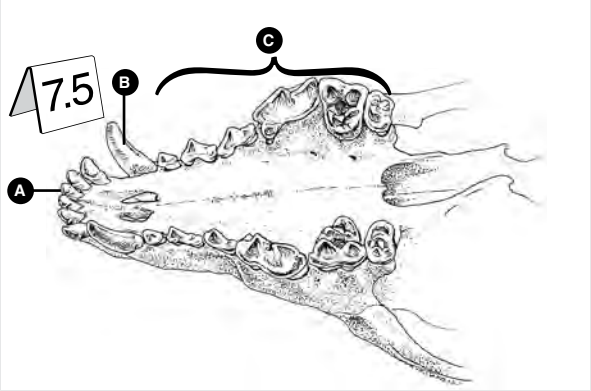
long pointed canines to grab and hold onto prey, and sharp-edged incisors to cut through the tough muscle and body parts (Figure 7.4). The cheek teeth are different sizes and shapes, with most having deep grooves and sharp points that resemble a cluster of tiny canines. This shape is best for crushing and cutting prey.

Omnivores

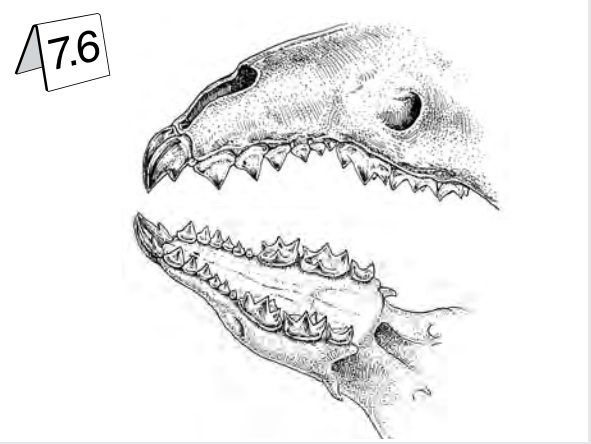
Examples of omnivores are foxes, coyotes, raccoons, bears, and skunks. Omnivore teeth are a mix of herbivore and carnivore teeth since omnivores eat both plants and animals. Their sharp-edged incisors and long canines look like those of carnivores, though the canines are not as sharp (Figure 7.5). The cheek teeth are a blend of herbivore and carnivore cheek teeth—they do not have the tall, sharp points of the carnivore, but do have more grooves and blunt points (e.g., see human molars) than the flatter herbivore teeth. All teeth are sealed in hard white enamel.

Insectivores

Examples of insectivores are bats and shrews. These animals look like they have a mouthful of canines (Figure 7.6). All teeth (incisors, canines, and cheek teeth) are small, sharp daggers. In bats, the incisors are smaller than the canines. All teeth are sealed with hard enamel for protection as the insectivores catch and crush hard-shelled insects, other arthropods, and small animals.



Omnivore teeth (coyote)
A: Incisor
B: Canine
C: Molars/premolars



Insectivore teeth (shrew)

STUDENTS: TAKE A CLOSER LOOK

- What information can an animal skull tell about the animal?
- Can an animal skull be identified if all the teeth are missing?

Handout 7-B
Check Out Those Teeth! Student Lab Investigation

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

1. Examine 3–4 skulls at lab stations. Describe the shape and structure of the different types of teeth, comparing them to the information in "Teeth Tell All" (Handout 7-A).

Data Table: Skull Observations

	Incisors	**Canines**	**Molars, premolars (cheek teeth)**
Skull 1			
Skull 2			
Skull 3			
Skull 4			

Handout 7-B

Check Out Those Teeth! Student Lab Investigation

2. Based on your observations, predict if each animals ate plants, animals, or both. Write an "I think… because..." statement for each skull.

   Skull 1:

   Skull 2:

   Skull 3:

   Skull 4:

3. Based on your observations, what animal do you think each skull belongs to?

   Skull 1:

   Skull 2:

   Skull 3:

   Skull 4:

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

Use the dichotomous key on pages 148–152 to identify the skull. In the data table that follows the key, record the key number and characteristics for each step you choose.

Key to Skulls of North American Mammals

This key is intended as a first step in identifying skulls of some representative North American mammals.

This is a "dichotomous key"; that is, you identify a specimen by working through the key and making a series of "either/or" (dichotomous) choices. Choices are arranged in "couplets," or pairs of statements. From each couplet, choose the statement that best describes your specimen. This will lead you to the name of a mammal or group of mammals or it will lead you to another couplet farther down the key. Simply work through the steps in sequence until you have a tentative identification.

Check your tentative identification against published pictures or other descriptions. Suggestions for further reading are provided on page 154. There are excellent resources on the Web. For example, the University of Michigan's Museum of Zoology maintains an excellent site that provides photographs of skulls of most of the mammals listed here: *http://animaldiversity.ummz.umich.edu/site/accounts/specimens/Mammalia.html*

This key uses features of the skulls and teeth only. That is because such cranial and dental remains are the remains that are usually found in the field, in owl pellets, and the like. Some basic vocabulary is needed to use this key. Terms that are likely to be unfamiliar are defined in parentheses or labeled on the accompanying diagrams.

A dental formula is a shorthand method to indicate the number and variety of teeth in a particular mammal. Dental formulas frequently appear in keys. Here is the dental formula for the genus *Canis*: I = 3/3, C = 1/1, P = 4/4, M = 2/3, Total = 42.

- Note that the formula describes one side of the skull. The total number of teeth is calculated by adding together all the numbers given in the dental formula and multiplying by 2, for the two sides of the jaw.
- Teeth are described per "quadrant"—upper left, lower right, etc. The number above each "slash" mark represents the number of teeth in one quadrant of the upper jaw; the lower

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

numeral represents the teeth of one quadrant of the lower jaw.

- Abbreviations: I = incisors, C = canines, P = premolars, and M = molars. A dental formula can be further abbreviated by deleting initials for the various types of teeth, for example: 3/3, 1/1, 4/4, 2/3 = 42.

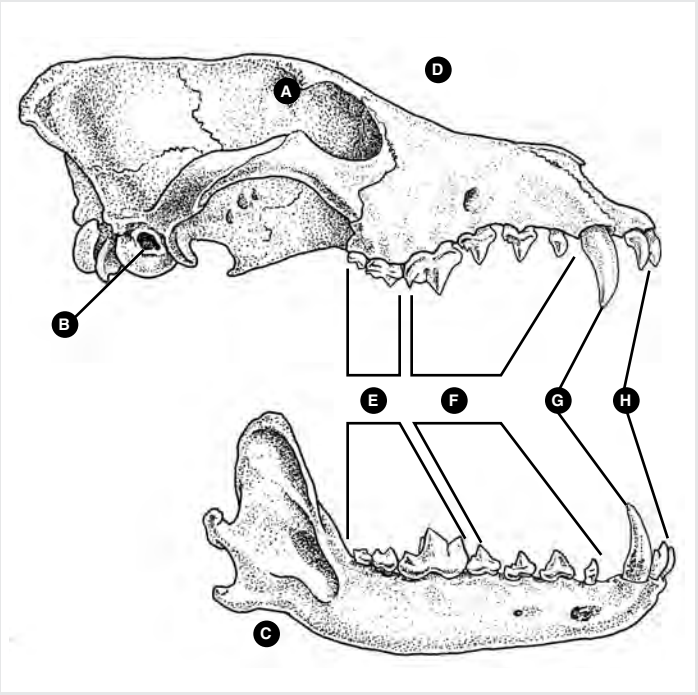
If a particular kind of tooth is not present in a species, a zero appears in the formula. For example, rodents lack canines and many species (such as the Norway rat, *Rattus norvegicus*) lack premolars. The dental formula of the rat is therefore:

1/1, 0/0, 0/0, 3/3 = 16.

The creator of the "Key to Skulls of North American Mammals " on pages 148–152 is David M. Armstrong, Department of Ecology & Evolutionary Biology and University Museum, University of Colorado-Boulder. Reprinted with permission.

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation



Coyote top and bottom teeth

A: Postorbital process
B: Auditory bulla = ear capsule
C: Mandible
D: Skull
E: Molars (cheek teeth)
F: Premolars (cheek teeth)
G: Canine
H: Incisors

1 Cheek teeth all about the same shape: simple, peg-like, widely spaced; no incisor teeth ..... **Armadillos**

Cheek teeth different in shape from front to back in the tooth-row, or if all similar in shape, then incisors absent 2

2 Incisors 5/4 on each side of the jaw; posterior of mandible with prominent, inward-directed shelf ..... **Opossums**

Incisors 3/3 or fewer on each side of the jaw; posterior of mandible without inward-directed shelf 3

3 Upper incisors present 4

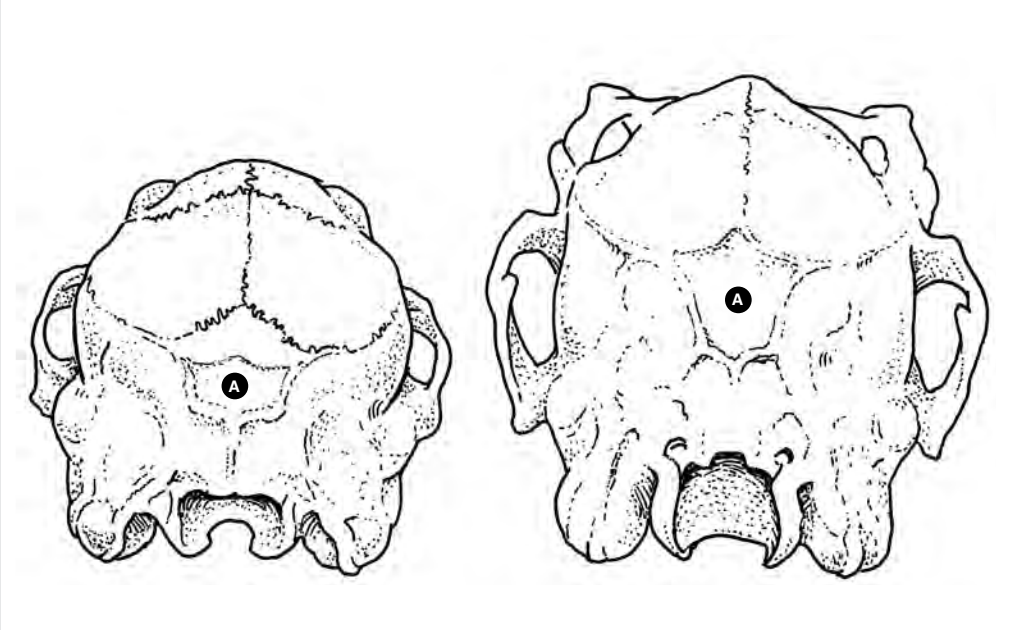
Upper incisors absent 21

4 Canine tooth absent 5

Canine teeth present 13

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation



Backs of hare and rabbit skulls showing interparietal bone (A).

5 Incisors 2/1.....Lagomorphs: pika, rabbits, hares, 6

Incisors 1/1..... Rodents, 7

6 Interparietal bone distinct;
skull usually less than 75 mm long..... **Cottontail Rabbits**

Interparietal bone fused to parietal in adult, indistinct; skull greater than 75 mm long..... **Jackrabbits**

7 Infraorbital foramen (opening below eye socket) oval, larger than foramen magnum (canal for spinal cord at back of skull). ..... **Porcupines**

Infraorbital foramen (opening below eye socket) smaller than foramen magnum (canal for spinal cord at back of skull).....8

8 Size large, greatest length of skull > 125 mm..... **Beavers**

Size smaller, greatest length of skull < 125 mm 9

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

9 Opening beneath eye socket (infraorbital foramen) small, rounded to triangular in shape; lower premolars present, total teeth 20 or more.....Squirrels, 10

Opening beneath eye socket (infraorbital foramen) of moderate size, a vertical slit, no lower premolars, total teeth 18 or fewer.....Rats and mice, 12

10 Cheekbones angled toward midline of skull, so cheek region narrower in front, broader in the rear (look at shape from top).....11

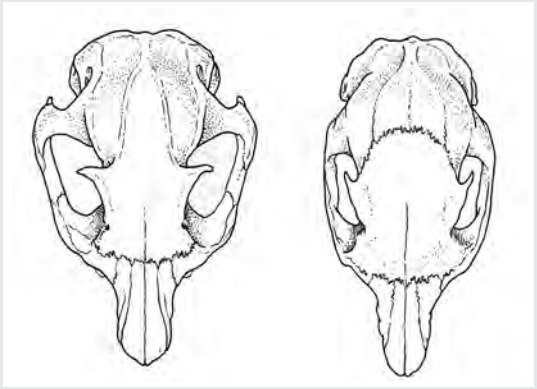
Cheekbones roughly parallel, not strongly angled toward midline of skull (look at shape from top)..... **Tree squirrels**

11 Skull greater than 63 mm long, cheekbones relatively heavy .....Prairie dogs

Skull less than 63 mm long, cheekbones not particularly robust .....Ground squirrels

12 Skull less than 30 mm long.....Native mice

Skull more than 40 mm long .....Native rats: woodrat = "packrat"



Tree squirrel and prairie dog skulls (top views).

13 Canine not markedly longer than adjacent teeth; size small, skull less than 25 mm long..... **Shrews**

Canine markedly longer than adjacent teeth; size medium to large, skull greater than 30 mm long.....Carnivores, 14

14 Shearing teeth (carnassials, last upper premolar over first lower molar) poorly developed; skull greater than 250 mm long ..... **Bears**

Shearing teeth (carnassials, last upper premolar over first lower molar) well developed, skull less than 250 mm long ..... Other carnivores, 15

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

15 Molars 2/2, total teeth 40.....**Raccoons**

Molars 1/,1 1/2, or 2/3 on each side of jaw 16

16 Molars 2/3 on each side of jaw .....Dog Family, 17

Molars 1/1 or 1/2 on each side of jaw.....18

17 Postorbital process thick, convex (bulged outward) on top; skull greater than 160 mm long.....**Coyotes**

Postorbital process thin, concave (dished in) on top; skull less than 150 mm long.....**Foxes**

18 Molars 1/1, total teeth 28 or 30 .....Cat Family, 19

Molars 1/2, on each side of jaw 20

19 Skull greater than 150 mm long ..... **Mountain lions**

Skull less than 125 mm long ..... **Bobcats, lynx**

20 Auditory bullae (ear capsules) small and flattened..... **Skunks**

Auditory bullae (ear capsules) not conspicuously flattened, but larger and rounded.....**Weasels**

21 Males (less well-developed in females) with horns over permanent bony core .....Cow Family, 22

Males (but not females) with antlers (branching structures of bone); if antler shed, then "stump" ("pedicel") still obvious.....Deer Family, 24

22 Horns branched; horn sheath shed annually .....**Pronghorn**

Horns not branched 23

23 Horns of males robust (increasingly heavy with age), yellowish brown in color, strongly curved backwards.....**Bighorn Sheep**

Horns of moderate size, black in color, only slightly curved backwards .....**Mountain Goats**

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

24 Antlers with prominent branch over eye (brow tine); upper canines present; length of skull from sockets of incisors to foramen magnum (canal for spinal cord) greater than 350 mm ..... **Wapiti, or Elk**

Antlers without prominent brow tine; upper canine absent; length of skull from sockets of incisors to foramen magnum (canal for spinal cord) less than 300 mm 25

25 Antlers with Y-shaped (dichotomous) branches..... **Mule Deer**

Antlers with one long anterior beam bearing secondary tines .....**White-tailed Deer**

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

Key #	Characteristics

Species Identification: _____

Handout 7-C

Key to Skulls of North American Mammals: Student Lab Investigation

REFERENCES

Burt, W. H., and R. P. Grossenheider. 1976 *Field guide to the mammals: Field marks of all North American species found north of Mexico.* Peterson Field Guide Series. Boston: Houghton Mifflin.

Fitzgerald, J. P., C. A Meaney, and D. M. Armstrong. 1994. *Mammals of Colorado.* Denver, CO: Denver Museum of Natural History and Boulder, CO: University Press of Colorado.

Glass, B. P., and M. L. Thies. 1997. *A key to the skulls of North American mammals*, 3rd ed. Privately printed. See the "classifieds" in a recent number of the *Journal of Mammalogy* for availability. This differs from Jones and Manning (1992) in that illustrations are line drawings rather than photographs.

Hall, E. R. 1946. *Mammals of Nevada*. Berkeley: University of California Press. This classic reference has been re-issued by the University of Nevada Press (1995); it is particularly valuable for its illustrated glossary.

Jones, J. K., Jr., and R. W. Manning. 1992. *Illustrated key to skulls of genera of North American land mammals.* Lubbock, TX: Texas Tech University Press.

Martin, R. E., R. H. Pine, and A. F. DeBlase. 2001. *A manual of mammalogy with keys to families of the world,* 3rd ed. Dubuque, IA: W. C. Brown.

Roest, A. I. 1991. *A key-guide to mammal skulls and lower jaws. A nontechnical introduction for beginners.* Eureka, CA: Mad River Press.

Handout 7-D
What Did I Discover About Mammal Skulls?

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

Answer these questions after completing the lab investigation "Check Out Those Teeth!" and/or "Key to Skulls of North American Mammals."

1. An animal skull was found at the scene of a wildlife crime. What kind of information would investigators want to learn about the skull from the forensic lab?

2. What can you conclude about this animal's eating preferences?

   a. A skull with no canines or incisors.

   b. A skull with long canine teeth, incisors, and sharp high-crowned (deep grooved) molars.

   c. A skull that has no canines but has pairs of long, curved, sharp incisors.

3. The soft and hard layers of teeth are seen in some animals like deer and elk.

   a. What are these two layers called?

   b. How do these layers create the grinding structure of the tooth?

4. Read your comments on skulls in your Investigator Notebook *(What do I know about skulls? What do I want to know about skulls?)*. Then respond to the following question: *What have I learned about skulls?*