Man's Best Friend? Using Animal Bones to Solve an Archaeological Mystery*

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Part I—Too Good To Be True?

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As a specialist in zooarchaeology, you are an expert in the analysis of animal bones from archaeological sites. Some of your other archaeology colleagues want to drag you to a press conference at which Jasper Eraillure, an archaeologist you went to graduate school with, is promising to change our perception of the human past. Initially, you are not very enthusiastic about attending the talk because you are a specialist in animal remains and Jasper is a specialist in stone tools, so his research is not usually directly related to yours. However, your friends are insistent and you are curious—you want to know what Jasper has to say and you want to see the reaction of the world's biggest audience, the global press.

You walk into the auditorium and take a seat in the last row with a few of your colleagues. People are chatting, contributing to the general buzz in the auditorium. There are rumors that this is a big find and the anticipation is building. Soon, Dr. Jasper Eraillure steps out onto the podium (egad, is he wearing a purple corduroy suit?) and the entire room goes silent. He clears his throat and begins:

"Thank you all for coming," Jasper Eraillure says, addressing the crowd of academics and members of the press. "I wanted to announce to all of you simultaneously the exciting discoveries we have made at Grotte Mestiche. We have a burial of an adult female Neanderthal and what we believe to be a domestic dog, dating to about 40,000 years before the present. This is an exceedingly unusual find. We know that Neanderthals buried their dead, but we have never found domestic dogs in such an old context, nor have we found any domesticated animals associated with anything but morphologically modern humans, what you in the press may have heard referred to as 'Cro Magnon.' This is a doubly amazing find."

Suddenly, everyone forgets Dr. Eraillure's questionable fashion sense (seriously, a purple corduroy suit, with a red bow tie and red socks?). What was nervous silence becomes a roar of amazement. When the volume dies down a bit, Dr. Eraillure offers to answer questions.

A young woman with a press pass stands up and asks "So, are you are saying that man's best friend is actually Neanderthals' best friend?"

Jasper nods. "Yes, quite. You might want to call dogs our 'first friend' as well."

A friend next to you quips, "Yes, and obviously woman's first friend, not man's best friend."

You laugh quietly in the back row with your cronies, but quickly hush yourself before anyone hears you.

Another member of the press stands to ask a question and Jasper nods at her.

*Editor's Note: This case study is a work of fiction. The scenario presented, as well as Grotte Mestiche and Jasper Eraillure, are the creation of the author. All photographs and illustrations appearing in this case study were also created by the author.

"Is this the oldest dog specimen we have?" the journalist asks.

"It depends on what you mean by dog. It isn't the oldest canid, but it could be the oldest domestic dog," Jasper replies. "Compared to archaeological finds, this is a radical discovery. Domestic dog remains have usually been less than 10,000 years old, although a few isolated examples of older remains have been found. For example, a woman was found buried with a puppy in her arms at a site in Israel, a site dated to 12,000 years ago, but nothing from as long ago as 40,000 years before present. And up until now, domestic dogs have always been found with morphologically modern people, never with other hominids. Now we think we have a domestic dog associated with Neanderthals, evidence of domestication extending significantly back before the end of the Ice Age. This find could seriously challenge our ideas of what makes us human and sets us apart from Neanderthals and other hominids—our views of what makes us special. We also have to rethink our assumptions about domestication as a basically post-Ice-Age adaptation, which means we have to come up with new explanations for the process of domestication."

"And by 'domesticated' you mean what exactly?" asks the same journalist. "Can you go back in time and watch Neanderthals feed and pet these animals?"

"It's not really like that," says Jasper. "Domestication has a behavioral component—care, feeding, etc. When you capture a wild animal and raise it in captivity, we just usually refer to it as 'captive.' To be truly domestic, a species of animals or even plants has to enter into a longer-term relationship with humans. Humans have to influence the offspring, the future breeding populations over several generations. In domestication, there is a process that leads to a change in the species being domesticated. For example, people breed domestic grasses like wheat to have larger seeds in greater quantities on each plant. The same is true with dogs. As successive generations of dogs and people interacted, there was a change in the frequency of certain genes in the dog population due to human action. Some changes could come about accidentally by a release of natural selective pressures. If people are feeding dogs, for instance, the dog will no longer have to rely on a sharp sense of smell to locate food at a distance for its survival—the whole apparatus might be free to change in new ways. Some changes might be intentional and due to artificial selection. For example, people might selectively breed dogs for certain aesthetically pleasing characteristics of the face, tail, legs, ears, or coat. Another example would be that people tend to nurture and desire dogs that are 'cute' and we define 'cute' as pedomorphic or neotenous."

Realizing that he is getting blank stares from the press, Jasper continues, "By pedomorphic I mean very much like cute babies—round instead of elongated heads, a change in the slope of the face that demarcates a forehead, big eyes, stubbier and rounder features in general, you know, cute."

A new reporter stands up and asks "So, how do you know this is a domestic dog—did you look at the DNA to show there were changes?"

"DNA would be great," responds Jasper, "but this find is quite old. First, it is priceless and we want to conduct only nondestructive tests on it—DNA testing requires at least some of the material to be destroyed. If this really is a 40,000-year-old domestic dog skull, we want to preserve it for future generations. Second, DNA is not very stable over long time periods; trying to sequence this find wouldn't be likely to yield useful results. Those who have looked at modern dog DNA, though, have suggested that domestic dogs separated from wild ones as long as 100,000 years ago, so this very well might be a domestic dog."

"If you didn't use DNA, what did you use?" asks the reporter in a follow-up question

"Bone morphology, the overall shape and physical features of the bone, has been well preserved at this site. We compared this canid skull with known modern skulls from domestic and wild canids. We looked at the shape of the skull and teeth, and found that our discovery has many features in common with modern domestic dogs. We would love to compare other characteristics, such as the coat color, the musculature of the legs, and such, but we recovered only a skull at this site."

"Has this been independently confirmed by other researchers?"

Jasper fidgets a tiny bit and replies "No, not yet." Searching the audience, he spies you and continues. "But my old friend and colleague in the back row," he says looking at you, "is an expert on such things and would doubtless be thrilled to analyze this material. Please, please, stand up," he says, pointing at you.

The press turns to you and asks, "Would you?"

Jasper motions you to stand up and you do. You clear your throat and say, "Certainly. I would be thrilled to contribute to this investigation of our past," and so begins your new and unexpected research project.

Part II—Comparative Collection Analysis

Your task is to answer the following question: "Is the Grotte Mestiche skull that of a domestic dog?" You and your team must determine whether Jasper's animal is domestic or wild, and give gross anatomical evidence to support your conclusion, explain the data, and put the results into a larger, meaningful context. First, however, you must ask yourself: "What are the main differences in morphology between known wild and domestic canid skulls?"

In teams of three to five students you will examine modern comparative materials to generate a diagnostic key for evaluating and assigning an unknown canid skull to either the domestic or wild category. Answer the following questions, which will step you through the process. In answering these questions, remember to look at relative proportions and shapes, and use technical terms relating to canid skull anatomy. You may wish to use terms such as:

- *cranium:* skull
- *mandible:* lower jaw
- *incisors:* 1st nearest midline, then 2nd, and 3rd furthest back
- *canine teeth:* fangs
- *premolars:* 1st, 2nd, 3rd, and 4th
- *molars:* 1st and 2nd
- *diastema:* a significant gap between two teeth
- *buccal:* cheek side
- *lingual:* tongue side
- *palate:* bony roof of the mouth
- *zygomatic arch:* bony bridge across the bottom of the eye orbit
- *orbit:* eye socket
- *foramen:* a naturally occurring hole or opening in bone, usually for the passage of nerves and/or blood vessels (Note: the plural of foramen is foramina
- *incisive foramen:* a natural hole in the palate, near the incisors
- *rostral:* towards the tip of the snout
- *caudal:* towards the tail
- *dorsal:* the top, where you pat a dog's head
- *ventral:* the bottom (belly), or underside
- *medial:* along the midline
- *lateral:* furthest out from the midline, a.k.a. the sides
- *bulla* or *tympanic bulb:* bulbous ear bone seen on the bottom of a canid skull (Note the plural of bulla is bullae
- *external auditory meatus:* ear hole
- *foramen magnum:* large opening in the skull through which the spinal cord enters
- *sagittal crest:* ridge on top of the midline of the skull for jaw muscles
- *nuchal crest:* ridge above the foramen magnum (in canids) for neck muscles
- *paired bones:* premaxilla, maxilla, nasal, parietal, palatine, frontal

See **Handout 1: Canid Skull Anatomy** for help with these terms. You will need to use some, but not necessarily all, of this technical terminology in your report.

Questions

Use extra sheets for more space if necessary. Try to spend about 40 minutes or less collecting this information and discussing it in your groups. Take home and finish answers if necessary. Base your answers on observations made on the modern **comparative domestic canid skull** and the **comparative wild canid skull**.

1. What difference(s) do you see between the incisive foramina of the domestic and the wild canids? Measure the rostral-caudal "length" and the medial-lateral "width." Then calculate an incisive foramen index (ratio of length to width) for the domestic and wild canid.

   Domestic canid:
   - incisive foramen's rostral-caudal "length" (in mm) =
   - incisive foramen's medial-lateral "width" (in mm) =
   - incisive foramen index (ratio of length to width) =

   Wild canid:
   - incisive foramen's rostral-caudal "length" (in mm) =
   - incisive foramen's medial-lateral "width" (in mm) =
   - incisive foramen index (ratio of length to width) =

2. How "short" is the palate? Construct a ratio of length to width for the known domestic and wild canid skulls you were given.
   a. What points or landmarks did you choose for the ends of the length measurement? (Write a verbal description of the end points and draw this line on the canid skull handout in red.) Use anatomical terminology to name the axis this line runs along.
   b. What points or landmarks did you choose for the ends of the width measurement? (Write a verbal description of the end points and draw this line on the canid skull handout in blue.) Use anatomical terminology to name the axis this line runs along.
   c. Give an appropriate name to your index.
   d. What is the value of your index for the domestic canid? What is the value of your index for the wild canid?

3. What differences do you see between the domestic and wild canid bullae and, optionally, in the external auditory meatus? List *qualitative* and *quantitative* measures.

4. Describe differences in the last two molars of the upper jaw (ignore wear and posthumous tooth loss).
   a. Describe this verbally *(qualitatively).*
   b. Now describe this *quantitatively*—measure the width of the 1st and 2nd molars (buccal to lingual).

      Domestic canid:
      - width of 1st molar (in mm) =
      - width of 2nd molar (in mm) =
      - ratio of the 1st to 2nd molar =

      Wild canid:
      - width of 1st molar (in mm) =
      - width of 2nd molar (in mm) =
      - ratio of the 1st to 2nd molar =

c. Give an appropriate name to your index.

5. What differences do you see in the profiles or lateral views of the canid skulls? (Do both have a "stop"? If so, how do they differ? If not, why not?)
6. What differences do you see in the sagittal crests?
7. What other pertinent differences do you observe between domestic and wild canid skulls? (Are there, for example, differences in the eye orbits? The space behind the eyes for jaw muscles? Breadth of forehead?)
8. Now look at your answers to the questions in this section. For which questions (1 through 7) are your answers observations?
9. For which questions (1 through 7) are your answers interpretations?

Part III—Evaluating the Grotte Mestiche Canid Skull

Jasper has given you photos of the canid skull he found in Grotte Mestiche, which he claims to be a domestic canid. You must analyze these photos to determine what the "unknown" actually is. Collect information on this skull similar to the data you collected in Part II by examining the **photos of the canid found by Dr. Eraillure**. Plan to spend at most 20 minutes examining the photos of the unknown canid skull.

Questions

Use extra sheets for more space if necessary. Try to spend about 20 minutes or less on collecting and discussing this information in your groups. Make sure you record all basic observations. You can take this home to finish writing up answers if necessary.

1. Verbally describe and measure the incisive foramen of the unknown.

   Description:

   Mestiche skull:
   - incisive foramen's rostral-caudal "length" =
   - incisive foramen's medial-lateral "width" =
   - incisive foramen index =

   Is this most similar to the wild or domestic modern comparative specimen? Explain.

2. How "short" is the palate? Construct a ratio of length to width for the unknown (the Mestiche skull), making this identical to the ratio you constructed for the modern comparative skulls.

   Your ratio for the Mestiche skull:

   What does the ratio for the Mestiche skull indicate?

3. Describe the bullae of the Mestiche skull. List qualitative and quantitative measures. How do the Mestiche bullae (and, optionally, the external auditory meatus) compare to those on the domestic and wild skulls? What does this tell you about the unknown skull?

4. Describe differences in the last two molars of the upper jaw of the Mestiche skull (ignore wear and posthumous tooth loss).
   a. Describe the molars verbally *(qualitatively).*
   b. Now describe the molars *quantitatively* for the Mestiche skull.

      Mestiche skull:
      - measure the width of the 1st molar (in mm) =
      - measure the width of the 2nd molar (in mm) =
      - calculate the ratio of 1st to 2nd molar =

   c. How does the Mestiche skull compare to the ratios of the domestic and wild skulls?

5. Describe the profile or lateral view of the Mestiche skull.

   Compare and contrast the Mestiche skull with the domestic and wild canid skulls in profile.

6. Describe the sagittal crest of the Mestiche skull and discuss if this is more like the modern domestic or wild comparative specimen.

7. What other pertinent information can you observe about the Mestiche skull?

Part IV—Implications and Explanations

Now think about the differences in morphology between the domestic and wild canid skulls, and how those differences came to be. You should use some (but not necessarily all) of the following words and concepts: natural selection, selection pressure, artificial selection, selection, genetic drift, growth and development, phenotype, genotype, morphology, neoteny, pedomorphism, adaptation, domestication, captivity (see **Handout 2: Non-Anatomical Terms** if you need help with these words).

Questions

Use extra sheets for more space if necessary. Plan to spend a maximum of 20 minutes discussing this section in your groups. Complete this portion outside of class as home work if time does not allow you to finish this portion in-class.

1. Why are there differences in the bullae and external auditory meatus of the domestic and wild canids? (Explain in terms of selection and/or growth and development).
2. Are the incisive foramen index, size of 2nd upper molar, and stubbiness of snout related? If so, how? If not, why not?
3. Why is there a difference in the narrowness of the snout between domestic and wild canids? (Explain in terms of selection and/or growth and development.)
4. Why is there a difference in the sagittal crest between domestic and wild canids? (Explain in terms of selection and/or growth and development.)
5. Why is there a difference in the forehead/stop of the domestic and wild canids? (Explain in terms of selection and/or growth and development.)
6. If you found other differences, list and explain them.
7. Now think about the Grotte Mestiche skull. Based on your answers to Part III, what is your determination—is the canid from Grotte Mestiche domestic or wild? Briefly explain/defend your answer.

   How certain are you? Would you stake your career on your findings? Why or why not?

   Is this determination an observation or interpretation?
8. Given your answer to Question 7 above, what implications would this have for our knowledge of the human past?
9. Are there any potential problems with this research? (Discuss and explore potential problems—stratigraphy? dating? anything?)

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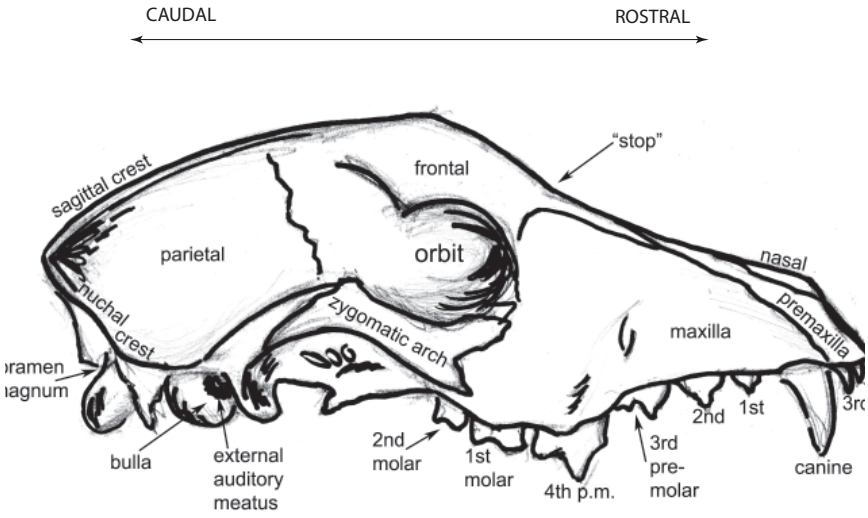
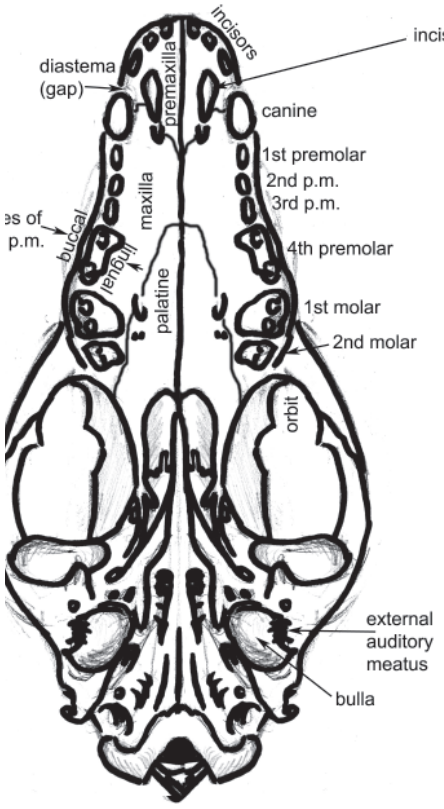
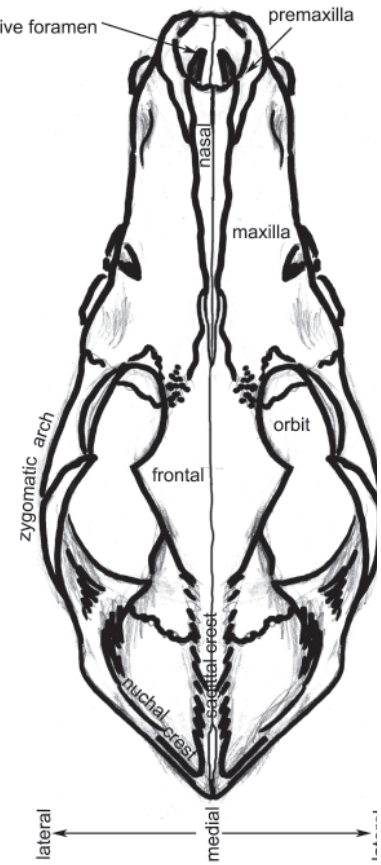
Handout 1—Canid Skull Anatomy



Lateral View



Ventral



Dorsal

Handout 2—Non-Anatomical Terms

- *Natural selection:* a non-cultural (i.e., environmental) condition that leads to differential reproductive success of individuals with certain characteristics, resulting in differential future representation of characteristics in the gene pool.
- *Selective pressure:* the severity of the force that leads to differential reproductive success of individuals.
- *Artificial selection:* a cultural (i.e., human-controlled) condition that leads to differential reproductive success of individuals with certain characteristics, resulting in changes in representation and/or retention of characteristics in the gene pool. To say that people breed dogs for a certain feature means that there is artificial selection for that feature.
- *Selection:* a process that results in certain individual(s) having greater reproductive success, resulting in future changes in the frequency of various traits in the gene pool.
- *Genetic Drift:* change over time in a gene pool due to chance.
- *Growth & Development:* the changes in an individual's body over time from the time they are conceived to adulthood.
- *Phenotype:* the expressed and observable physical characteristics of an individual (morphology, body chemistry, etc.).
- *Genotype:* the set of genes (DNA) inherited by an organism.
- *Morphology:* the shape/form of an organism or a part of an organism.
- *Neoteny:* retaining features of an earlier stage of development.
- *Pedomorphism:* a retention of juvenile characteristics.
- *Domestication:* the process by which a population diverges from its wild parent population due to interactions with humans. Often these changes make the plant or animal less fit to survive under natural conditions.
- *Captivity:* the capture and penning of wild individuals (removing an individual animal from natural conditions).
- *Fitness:* the extent to which an individual succeeds in their environment, contributing relatively more to the future generations (measured by reproductive success).
- *Adaptation:* the manner (physical or behavioral) by which an organism relates to its environment.

Comparative Domestic Canid Skull Photos

Comparative Wild Canid Skull Photos

Unknown Canid Skull (Mestiche Site) Photos

Domestic Canid Skull—Ventral Aspect

Domestic Canid Skull—Dorsal Aspect

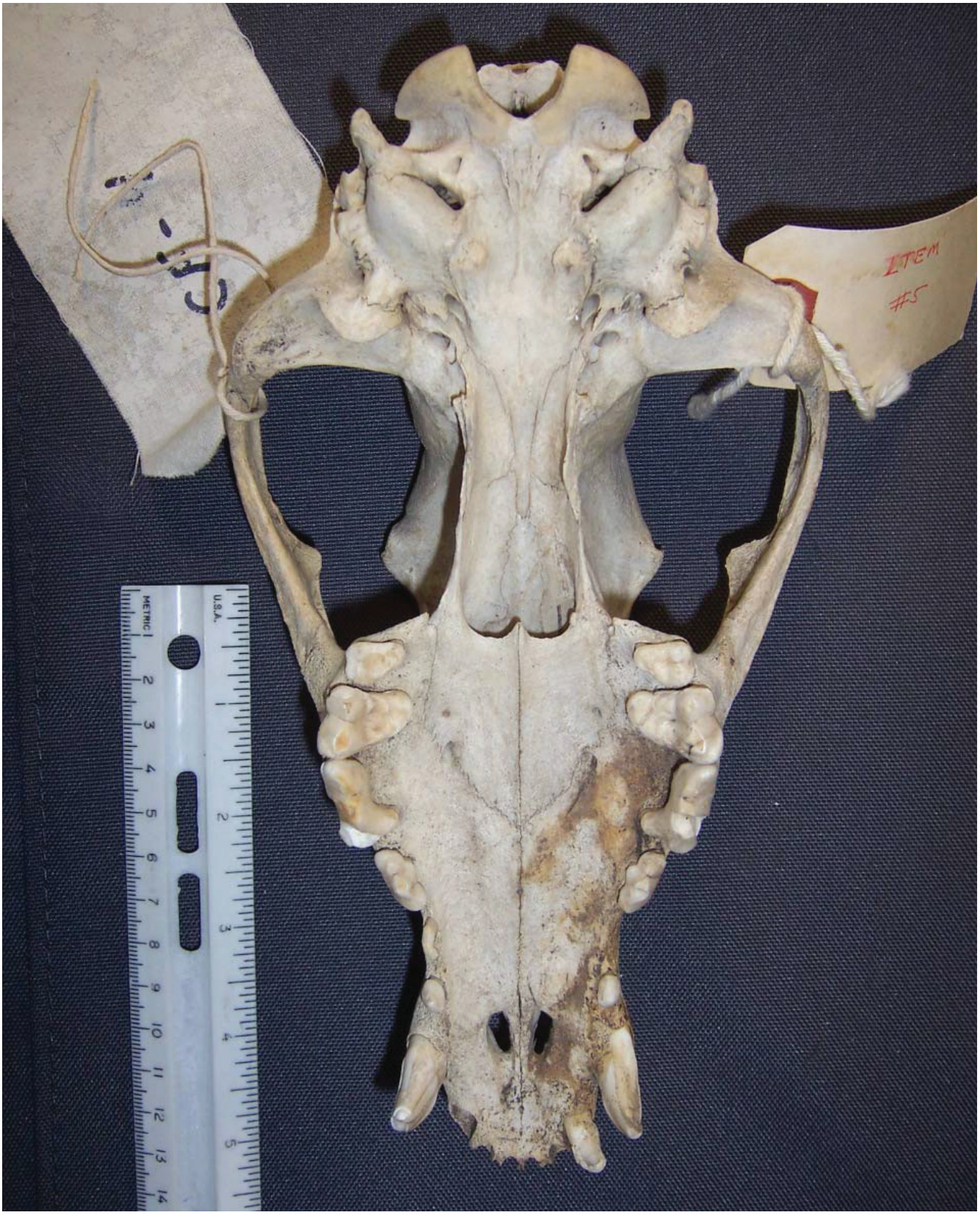
Domestic Canid Skull—Lateral Aspect

Wild Canid Skull—Ventral Aspect

Wild Canid Skull—Dorsal Aspect

Wild Canid Skull—Lateral Aspect

Unknown Canid Skull (Mestiche Site)—Ventral Aspect



Unknown Canid Skull (Mestiche Site)—Dorsal Aspect

Unknown Canid Skull (Mestiche Site)—Lateral Aspect