

# Investigating the Domestication Syndrome

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Domestication Syndrome takes note of the shared physical appearance of domesticated animals when compared to their wild relatives. In this laboratory exercise, students observe and compare the skulls of wolves, the wild ancestors, and dogs, their domesticated counterparts, to determine the key changes in skull anatomy that characterize domestication: smaller skulls, smaller and rounder craniums, wider faces, shorter snouts, smaller teeth, and fewer teeth. Students then examine and compare the skull of Neanderthal (*Homo neanderthalensis*) to that of a modern human (*Homo sapiens*) for the following features: skull size, size and shape of cranium, prominence of brow ridge (supraorbital ridge), facial shape, slope of forehead, prominence of nasal bone (vomer,) protrusion of jaws, tooth size, and tooth number to determine if domestication has shaped the evolution of modern humans as some recent research has suggested.

**Keywords:** domestication syndrome, evolution, human anatomy

## Introduction

Darwin (1859) remarked in *The Origin of Species* that a wide variety of domesticated animals look different and in a consistent way from their wild counterparts. This observation is now known as the **Domestication Syndrome** for which there are reliable physical and behavioral changes seen in domesticated animals when compared to their wild ancestors (Larson and Fuller et al., 2014).

Recent research has proposed a unifying explanation for the shared characteristics of domesticated animals in observed changes in the number of neural crest cells. The neural crest is a strip of cells in the ectoderm germ layer of all vertebrate embryos. Specifically neural crest cells are located between the area in the ectoderm that produces skin and the area that gives rise to the central nervous system. During embryonic development, neural crest cells migrate to different parts of the embryonic body and eventually give rise to a number of different cells: skeletal and connective tissues in the face, teeth, external ears, pigment cells (melanocytes), adrenal glands, the forebrain, nerves, and hormonal glands.

In 2014, Adam Wilkins proposed that domestication ultimately selects for pre-existing variants in the number of genes affecting neural crest development. These variants result in changes in a broad range of tissues that can account for the structural and behavioral changes seen in the domestication syndrome.

According to his theory, domestication results from a modest reduction in neural crest cell number and/or activity. Essentially domestication then is a mild, neurocristopathy. Neurocristopathy is a pathology that arises from defects in the development of tissues derived from neural crest cells. More extensive alterations in genes controlling neural crest development cause more deleterious neurocristopathies, for which a number of syndromes have been documented in humans and animals.

Features commonly seen in domesticated animals include: wider faces, shorter muzzles, smaller and fewer teeth, floppier and smaller ears, white patches of fur, shorter and curly tails, docility and juvenile (neotenus) behavior, and in females, more frequent reproductive cycles.

It has been suggested by several researchers (Cieri et al. 2014, Engelhaput 2017, and Theofanopoulos et al. 2017) that comparing the structural changes of modern humans to their ancestral counterparts may indicate that human evolution has also been shaped by self-domestication.

Since most of the changes seen in the domesticated animals are centered in the skull, students will first examine the skulls of wolves and dogs to determine the key differences between a wild ancestor and its domesticated counterpart. With these characters in mind, students will then compare the skull of an ancient human, Neanderthal, to that of a modern human to see if domestication of humans has taken place.

## Student Outline

### Investigating the Domestication Syndrome in Humans

#### Objectives

- Compare the skulls of wolves (*Canis lupus*) and dogs (*Canis lupus familiaris*) to identify the structural changes associated with Domestication Syndrome
- Compare the skulls of ancient humans (*Homo neanderthalensis*) and modern humans (*Homo sapiens*) to detect structural differences
- Conclude if modern humans exhibit structural changes consistent with the Domestication Syndrome and speculate if self-domestication was advantageous to human evolution

#### Introduction

Darwin (1859) remarked in *The Origin of Species* that domesticated animals look different and in consistent ways from their wild counterparts. This observation is now known as the **Domestication Syndrome** for which there are reliable physical and behavioral changes seen in domesticated animals when compared to their wild ancestors.

The changes seen in domesticated animals include: wider faces, shorter muzzles, smaller and fewer teeth, floppier and smaller ears, white patches of fur, shorter and curly tails, docility and juvenile or neotenuous behavior (friendly, playful, lacking fear of strangers) and in females, more frequent reproductive cycles. Many of these changes are located cranially with the exception of white patches in the fur which can occur in the head and as well as trunk and short, curly tails and reproductive changes which are also located in the trunk.

Recent research has proposed that the characteristics of domesticated animals can be explained by changes in the number of cells in the neural crest. The neural crest is a strip of cells found in the ectoderm, the outer germ layer of all vertebrate embryos. Specifically the neural crest is located between the area of the ectoderm that produces skin and the area that gives rise to the CNS. During embryonic development, neural crest cells migrate to different parts of the embryonic body and from a number of different tissues and structures: skeletal and connective tissues in the face, teeth, the external ears, pigment cells in the skin (melanocytes), the adrenal glands, the forebrain, nerves, and other hormonal glands.

Adam Wilkins (2014) proposed that domestication actually selects for pre-existing variants in a number of genes that affect neural crest development resulting in changes in a broad range of tissues that can account for all of the structural and behavioral changes common to domesticated animals. He concluded that domestication results from a modest reduction in either the number of neural crest cells and /or their activity. In essence, domestication is a mild, type of neurocristopathy, a pathology that arises from defects in the development of tissues derived from neural crest cells. More extensive alterations in the genes controlling neural crest development result in more detrimental syndromes for which a number have been identified in both animals and humans.

Since most of the changes seen in the domesticated animals are centered in the skull, you will first examine the skulls of wolves and dogs to determine the key differences between a wild ancestor and its domesticated counterpart. With these characters in mind, you will then compare the skull of an ancient human, Neanderthal, to that of a modern human to determine if domestication of humans has taken place and to speculate on the advantages of self-domestication in the evolution of human society.



**Figure 1.** Wolf skull (left) and dog skull (right).



**Figure 2.** Measurement of snout length in a wolf skull (top) and dog skull (bottom).

**Protocol**

1. Examine the skulls of wolf (*Canis lupus*) and dog (*Canis familiaris*) (Fig. 1). Compare the following features: overall skull size, size of braincase, braincase shape, shape of face, snout length, too size, and tooth number. Record your results in Table 1.

Table 1. Compare the differences between the skulls of the wolf and the dog.

<b>Character</b>	<b>Wolf</b>	<b>Dog</b>
<b>Overall Skull Size – Larger or Smaller</b>		
<b>Braincase Size – Larger or Smaller</b>		
<b>Braincase Shape – Elongated or Rounder</b>		
<b>Face Shape– More Long than wide or More Wide than long</b>		
<b>Snout – Longer or Shorter</b>		
<b>Tooth Size – Larger or Smaller</b>		
<b>Tooth Number – Fewer or More</b>		

2. What are the key differences seen in the dog skull when compared to the skull of its wild ancestor the wolf? Are these differences supported by the Domestication Syndrome?

3. How have the differences in skull anatomy and other characteristics found in the domesticated dog enabled interactions between humans and dogs?

4. Examine the skulls (Fig. 3) of the Neanderthal (*Homo neanderthalensis*), an ancestral human species, and the modern human species (*Homo sapiens*). Compare the following features: overall skull size, size of braincase, shape of braincase, face shape, slope of forehead, size of nasal bone (vomer), prominence of brow (supraorbital) ridge (Fig. 4), protrusion of jaws, tooth size, and tooth number. Record your observations in Table 2.



**Figure 3.** Neanderthal skull cast (left) and modern human skull (right).



**Figure 4.** Measurement of the brow (supraorbital) ridge of a Neanderthal skull cast (left) and modern human skull (right).

**Table 2.** Compare the differences between the skulls of the ancient human (*Homo neanderthalensis*) and modern human (*Homo sapiens*).

<b>Character</b>	<b>Ancient Human</b>	<b>Modern Human</b>
<b>Overall Skull Size – Larger or Smaller</b>		
<b>Braincase Size – Larger or Smaller</b>		
<b>Braincase Shape – Elongated or Rounder</b>		
<b>Brow (Supraorbital) Ridge – More Pronounced or Less Pronounced</b>		
<b>Face Shape– More Long than Wide or More Wide than Long</b>		
<b>Forehead Slope – Slanting or Vertical</b>		
<b>Nasal Bone (Vomer) – Larger or Smaller</b>		
<b>Protruding Jaw – More Pronounced or Less Pronounced</b>		
<b>Tooth Size – Larger or Smaller</b>		
<b>Tooth Number – More or Fewer</b>		

5. What are the key differences seen in the modern human skull (*H. sapiens*) when compared to the skull of the ancient human (*H. neanderthalensis*)? Are these differences supported by the Domestication Syndrome?

6. Does the evidence support that *Homo sapiens* is a domesticated version of ancient humans? Why or why not?

7. If modern humans are indeed the result of self-domestication, how has self-domestication influenced the development of human society?

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## Materials

### Sources for Skulls

*Bone Clones* <https://boneclones.com>

Siberian (Gray Wolf) Skull (Cast) - \$199

*Carolina Biological* [www.carolina.com](http://www.carolina.com)

Domestic Dog Skull (Plastic) - \$98

*Skulls Unlimited International*

<https://www.skullsunlimited.com/>

Economy Domestic Dog Skulls (Real) - \$69

*Homo sapiens* (Cast) - \$230

Neanderthal (Cast) - \$198

Neanderthal Half Size (Plastic) - \$80

### Notes for the Instructor

I have successfully incorporated this exercise as part of a larger lab on the anatomy of the human skull in The Human Anatomy Laboratory (Biol 2151). The students found the investigation interesting as it reinforced the anatomy of the human skull in a practical application. It is also a way to introduce a human evolution exercise in an anatomy lab. For the same reason, I think this exercise would also be a good fit in an evolution class or a general biology lab that includes an exercise on evolution.

Students are provided with calipers and rulers to measure variations in size between skulls.

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### About the Authors

Karen McMahon is an instructor of Biological Science at The University of Tulsa in Tulsa OK. She has taught human anatomy and physiology laboratory, human anatomy laboratory, and human physiology to nursing and allied health majors for several years in addition to Plants and Society, Environment & Humanity, Field Botany, and Organismic Biology. She is also a co-author of the textbook *Plants and Society 8<sup>th</sup> Ed* (9<sup>th</sup> Ed. in press) and the accompanying *Laboratory Manual for Applied Botany*.

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