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Complex Traits

Dogs — A Model for Modern Genetics

Nancy P. Moreno, Ph.D.



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Track patterns by Karen Converse. <https://www.wildlife.ca.gov/Conservation/Mammals/Gray-Wolf/Identification>
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OVERVIEW

Students explore variation among dog breeds, and compare variation within domesticated dogs to variation within wolves. Students also determine relationships among the dog and its closest relatives using a phylogenetic tree.



Dogs — A Model for Modern Genetics

From the tiny, long-haired Pekingese to the tall, short-haired Great Dane, domestic dogs show immense variety in their sizes, shapes, coat colors and textures, and behaviors. Selective breeding by humans for desirable genetic changes or mutations generated this variability. Today, more than 400 distinct breeds of dogs are recognized.

Because of its wide range of characteristics, the domestic dog (*Canis familiaris*) has become an important model for modern genetic studies. However, most of this diversity is found only between dog breeds. The characteristics of individuals within a particular dog breed are very uniform—genetically and



MACKENZIE GRAY WOLF

in appearance. In other words, dogs are homogeneous in their appearance (phenotype) and genetic makeup (genotype) within breeds, and are phenotypically and genetically heterogeneous among or between breeds. This pattern of variability, in which particular traits are accentuated within breeds, results from inbreeding (breeding of close relatives).

Dogs are members of the Canidae family of mammals. This group also includes coyotes, foxes, jackals, and wolves. The gray wolf is the closest relative of the dog. However, the gray wolf (*Canis lupus*) does not show the wide range of phenotypic variability found in the dog.

Even though dog breeds appear quite distinct, they still freely interbreed without physical or other barriers. In other words, all domestic dogs are members of the same species. Even with their wide range of appearances, dogs are more similar to one another genetically than they are to grey wolves, their closest relatives.

Dogs and wolves, which are separate species, also occasionally do interbreed. Normally, the two species maintain separate identities, have different physical characteristics and have different evolutionary histories. In addition, dogs and wolves usually are isolated reproductively (in natural circumstances, dogs and wolves rarely interact or have opportunities to breed).

Experts believe that the domestication and divergence of dogs from wolf populations began about 15,000 years ago. Most modern dog breeds originated within the past few hundred years. Domestication led to selection for and retention of certain favorable traits, such as herding or tracking behaviors, in addition to preferred physical characteristics.



PEKINGESE

GREAT DANE

FAST FACTS

A dog's ears are usually large relative to head size; its tail may curl upward, especially when running; the chest is broad so legs are separated; feet typically are not splayed; and its eyes may be blue.

A wolf's ears are small relative to its head size; its tail does not curve upward, even when running; the chest is very narrow so legs are close together; feet may splay outward; and its eyes are never blue.

(Source: California Department of Fish and Wildlife.)



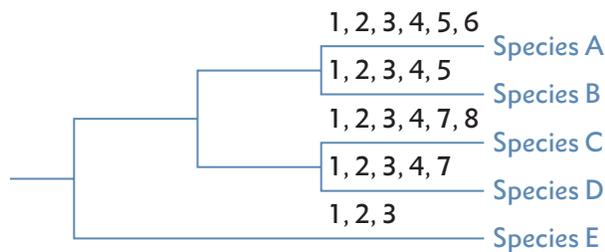
DID YOU KNOW?

Wolves tend to walk more directly when traveling, and circle widely rather than varying off of a path. Its hind foot tracks are placed within or directly in front of its forefoot tracks. (See track pattern, upper left.)

Dogs tend to walk all over—they have no need for stealth. As a result, a dog’s hind foot tracks seldom register within its forefoot tracks. (See track pattern, upper right, p. 3. Source: California Department of Fish and Wildlife. Patterns by Karen Converse.)

As part of this activity, students examine a diagram that shows the relationships among species in the dog family (Canidae) based on molecular genetic information. It is important to note that diagrams of this type are not family trees or genealogies.

Instead, they represent similarities or differences among living (extant) groups based on their genetic information. Groups that are found on the same branches (or clades) of the tree share unique genetic information and are descendants of the same founding or ancestral population.



In the diagram above, species A and B are more closely related to each other more than to any other species or cluster of species on the diagram. Similarly, species C and D are more closely related to each other than to a member of any other group. Of the species on the diagram, species E is the least related to any of the other groups.

This type of diagram, in which groups are defined by shared inherited characteristics, usually is called a phylogeny or phylogenetic tree. The term phylogeny comes from the Greek words, *phylon* (tribe or clan) and *genesis* (origin).

MATERIALS

- Complex Traits slide set (slides 2–10), available at <http://www.bioedonline.org/slides/classroom-slides/genetics-and-inheritance/complex-traits/>
- Computer and projector, or interactive whiteboard
- Copies of “The Domestic Dog and Related Species” (one per student or group)
- *Optional:* Copies of “Examples of the Dog and Related Species”

PROCEDURE

1. Share with students that they will be starting a unit on modern genetic information, using examples from dogs. Project Slide 2 as an introduction to the unit, then show Slide 3 and ask students, *Would you have this animal as a pet?*



MACKENZIE GRAY WOLF

Allow a few minutes for students to respond to your questions.

2. Project Slide 4 to students, and ask, *What about this animal? Is it suitable as a pet? Why or why not?* Tell students that the slide depicts a common dog breed, an English springer spaniel.



ENGLISH SPRINGER SPANIEL

- After students have discussed characteristics of the dog, present Slide 5, which shows the gray wolf and dog, side by side.
- Create a table at the front of the class and present Slide 6, which provides samples of characters and traits of the wolf and dog shown in the previous slides. Have students work in groups of two or four to create similar charts that list at least five characters that differ between the wolf and dog. OR conduct a discussion and create a class chart.

Character (Category)	Wolf Trait (<i>Canis lupus</i>)	Dog Trait (<i>Canis lupus familiaris</i>)
1. Ear shape	Pointed	Rounded
2. Eye color	Yellow	Brown
3.		

Note: You may want to clarify for students that “character” refers to a feature that can vary from one individual or group to another. “Trait” refers to a specific variation or form of a given feature. For example, hair texture is a character. Curly hair and straight hair are two different traits.

- Show students Slide 7, and explain that scientists now can use genetic information to estimate the relationships among different groups of species. Species that are more closely related share more genetic information. In the slide, the numbers represent similar versions of genes. Ask, *Which numbers are shared by all of the groups?* [1,2,3]. *Which numbers distinguish the branch containing Species A, B, C and D, from the branch with Species E?* [4]. *How are the branches with Species A and B, and C and D different?*

One also can say that Species A and B share a common ancestor, as do

Species C and D. The entire group of Species shares a more distant common ancestor, which was characterized only by genes 1, 2 and 3.

- Give each student or group of students a copy of the page, “Dogs and Related Species” (see page 4 and Slide 8).

Explain to students that this diagram was created using real genetic information from the different species. Have students interpret the diagram to answer the questions at the bottom of the student page.

Optional: Project photos of the dog and some related species for students to see unique genetic variations (see page 5, and Slides 9–10).

An “Answer Key” is provided on page 6.

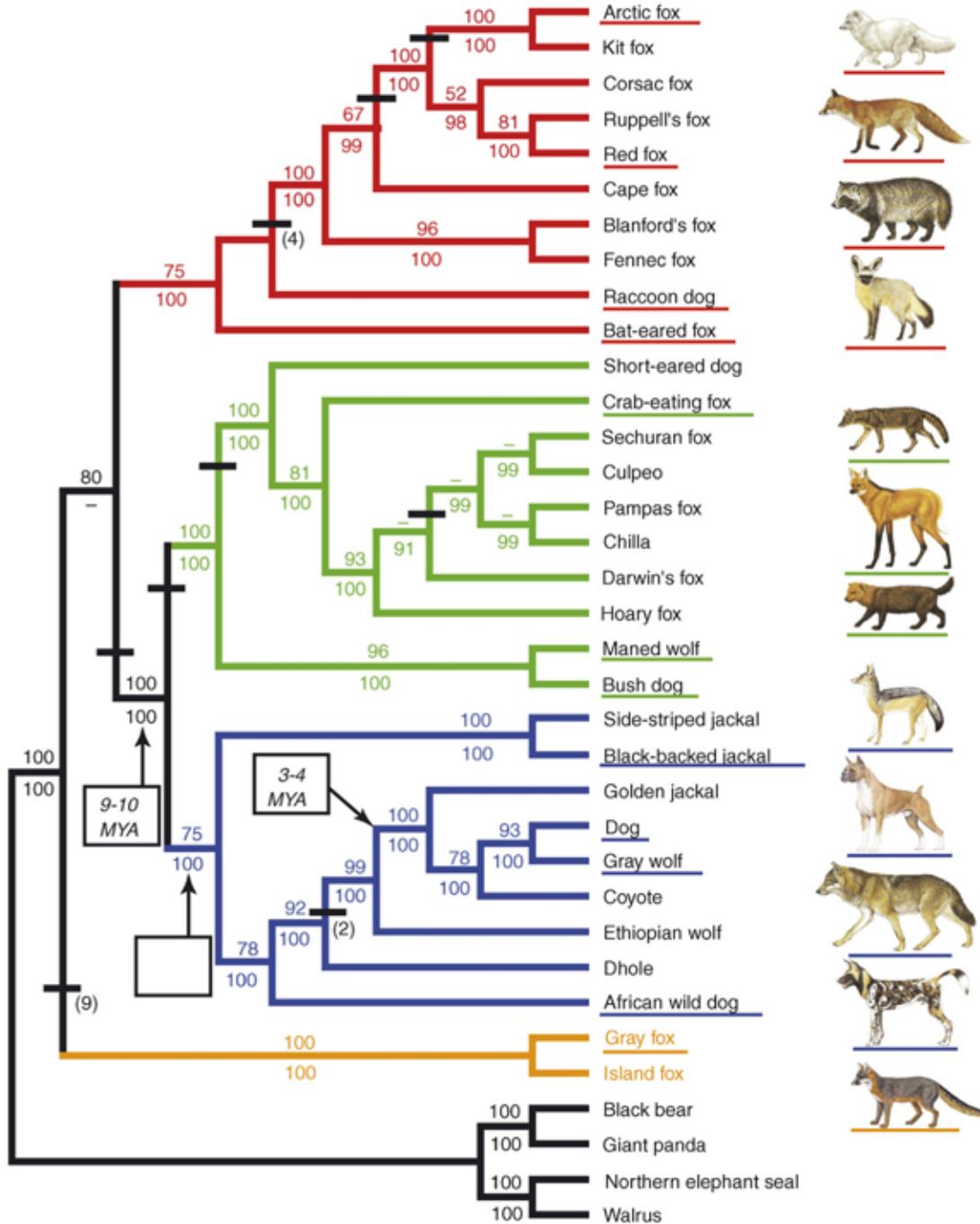
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The Domestic Dog and Related Species



This diagram shows genetic similarities among 31 species of the dog family (Canidae). Each branch represents a group that shares the same ancestral genetic information. Study the chart, then answer the questions below on the back of this sheet.



1. The diagram has a reference group of other mammals. Find this group and list the members.
2. Find the four main groups of dog relatives, and list the members of each group.
3. Which species is the closest relative to the Dog? Explain your answer.
4. Which species or branch of species can be considered the least related to the Dog? Explain your answer.

Examples of the Dog and Related Canids



AFRICAN WILD DOG



ARCTIC FOX



BAT-EARED FOX



BLACK-BACKED JACKAL



BUSH DOG



CRAB-EATING FOX



DOG



GRAY FOX



GRAY WOLF



MANED WOLF



RACCOON DOG



RED FOX

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Answer Key



1. The diagram has a reference group of other mammals. Find this group and list the members.

Black Bear

Giant Panda

Northern Elephant Seal

Walrus

2. Find the four main groups of dog relatives, and list the members of each group.

Red fox-like Canids

Arctic fox

Bat-eared fox

Blanford's fox

Cape fox

Corsac fox

Fennec fox

Kit fox

Raccoon dog

Red fox

Ruppell's fox

South American Canids

Bush dog

Chilla

Crab-eating fox

Culpeo

Darwin's fox

Hoary fox

Maned wolf

Pampas fox

Sechuran fox

Short-eared dog

Wolf-like Canids

African wild dog

Black-backed jackal

Coyote

Golden jackal

Dhole

Dog

Ethiopian wolf

Gray wolf

Side-striped jackal

North American Gray Canids

Gray fox

Island fox

3. Which species is the closest relative to the Dog? Explain your answer.

The Gray wolf, because it shares the most recent branching point with the Dog.

4. Which species or branch of species can be considered the least related to the dog? Explain your answer.

The branch containing the Gray fox and Island fox is the least related (most distant branch from the Dog).