NOVA

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Dogs and More Dogs

PROGRAM OVERVIEW

NOVA presents the story of dogs and how they evolved into the most diverse mammals on the planet.

The program:

- discusses the evolution and remarkable diversity of dogs.
- notes that there are currently more than 400 different breeds of dogs worldwide.
- relates two competing theories about how dogs were domesticated: Stone Age humans adopted and selectively bred wolves for tameness; wolves essentially "chose" domestication when they began to forage for food near prehistoric dumps. There, tameness was an advantage.
- considers why dogs have tails that stick up, droopy ears, and other traits that are not found in the wolf gene pool.
- recounts an experiment in which foxes bred for tameness produced dog-like traits, leading to speculation that the new traits were due to different levels of hormones created as a byproduct of tameness.
- explores how dominance hierarchies in wolf society have contributed to making dogs well suited to be pets.
- suggests that dogs specialized in specific behaviors—hunting, tracking, pointing, retrieving—and that over thousands of years humans used food to reward the dogs best at these behaviors. These better-fed dogs then had an improved chance at surviving and passing on their genes.
- proposes a theory that the diversity found in dogs is due to subtle changes in the regulatory DNA that instructs when a gene turns on and off.
- suggests that dogs' remarkable ability to adapt to different environments is due to an extended critical period of social development.
- reviews the problem of genetic diseases due to extensive inbreeding.

BEFORE WATCHING

1 To help students understand the program's basic science concepts, review the following terms with them: gene, gene pool, selective pressure, mutation, species, genetic isolation, inherited trait, and acquired trait. (See Activity Answer on page 3 for more information.)

2 Ask students to cite examples of some selective pressures humans place on wildlife (e.g., encroaching into wildlife areas, altering habitats, and polluting ecosystems). What are some ways these selective pressures might impact wildlife?

3 As students watch, have them take notes on the two explanations for the evolution of dogs: the adoption theory and the adaptation theory.

AFTER WATCHING

1 Discuss the two possible explanations for the evolution of dogs. Ask volunteers to cite reasons for each explanation. Which hypothesis do students support? Why?

2 Have students list some reasons why scientists study genetic diseases in dogs (to develop genetic tests to identify diseases in dogs and to gain insight into human genetic diseases).

CLASSROOM ACTIVITY

Objective

To learn through an evolution card game how selective pressures can affect an organism's evolution.

Materials for Each Team

- copy of the "From Wolf to Dog" student handout
- copy of the "Examining the Game" student handout
- 2 copies of the "Wolf Deck" student handout
- scissors
- 1 die

Procedure

1. Scientists know all dogs descended from the gray wolf, but they don't know exactly how that happened. Tell students that in this activity they are going to engage in a simulation to learn how selective pressures can affect an organism's evolution.
2. Review with students the concepts of gene, gene pool, selective pressure, mutation, species, and genetic isolation (see Activity Answer on page 3 for definitions).
3. Tell students that they will make a deck of cards that will represent the entire gene pool for a hypothetical group of genes responsible for temperament in a population of wolves. Each card will represent an individual gene and each six-card hand will represent the collection of genes that contribute to temperament for one wolf.
4. Organize students into teams of four and provide each team with a set of materials (teams of smaller size will need to use dummy hands to complete the activity). Have each team cut out and create a 24-card deck from the cards on its "Wolf Deck" student handouts. Assign half of the teams to be Wolf Group A and the other half to be Wolf Group B.
5. Have students do the activity as outlined on their student handouts. Students will calculate the new deck average for the 5th, 10th, and 20th rounds. At the end of the game, compare the final deck averages for each team. Have they all evolved from their original average? How much do the final averages from Group A and Group B teams differ from one another? Discuss with students how the selective pressures of each of their groups contributed to each population's evolution.
6. To conclude, have a class discussion about the difference between the conditions in this simulation and those occurring in nature. *(Selective pressures in the simulation occurred randomly; in nature, selective pressures would occur as a result of specific environmental influences.)*
7. As an extension, have students research and write a position paper regarding the controversy involving wolf-dog hybrids. Find more information at www.nal.usda.gov/awic/newsletters/v5n4/5n4wille.htm

STANDARDS CONNECTION

The "From Wolf to Dog" activity aligns with the following National Science Education Standards.

GRADES 5–8
Science Standard C:
Life Science
Reproduction and heredity
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

Diversity and adaptation of organisms
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations.

GRADES 9–12
Science Standard C:
Life Science
The molecular basis for heredity
- Changes in DNA (mutations) occur spontaneously at low rates.

Biological evolution
- Species evolve over time. Evolution is the consequence of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

Video is not required for this activity.

Classroom Activity Author
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ACTIVITY ANSWER

You may want to review the following terms with students:

gene: A segment of DNA that codes for a particular protein.

gene pool: All the genes of all the members in a population.

selective pressure: Any environmental factor that favors one trait over another.

mutation: A random change in a gene or a group of genes.

species: Any group of organisms, the members of which successfully breed with each other, producing healthy, fertile offspring.

genetic isolation: What occurs when two groups of one species are prevented from breeding with each other.

inherited trait: An inherited characteristic—such as hair and eye color or muscle and bone structure—that has been passed on from a previous generation.

acquired trait: An acquired characteristic—such as the ability to ride a bike or do karate—that is attained throughout life. Acquired traits are not passed on genetically.

This activity modeled the evolution of just one trait that contributes to making dogs the species that they are; many additional anatomical, physiological, and behavioral traits contribute to differentiating a dog from a wolf. And while there are dogs that are bred for aggressiveness, the activity addresses the evolution of genetic tameness in dogs as a species.

In the card game students played, higher hand totals represent wolves with genes that contribute to tame behavior; lower hand totals indicate fewer genes for tame behavior. Students were organized into two groups—Group A students modeled a wolf population that continued to have an intermediate temperament found in a wild wolf population. While this group underwent random mutations, the selective pressures of the wild continued to select for the average wolf. Group B students modeled a wolf population that evolved into dogs. Random mutations allowed Group B wolves to evolve past what would have been the tamest wolf in the wolf population *(Canis lupus)* and into the subspecies of increasingly tamer dogs *(Canis lupus familiaris)*.

In terms of the game, genetically isolating dogs and wolves means that the cards from the wolves-evolving-into-dogs decks are never mixed with the pure-wolf decks. If wolves and dogs were allowed to regularly interbreed, one prediction might be that the dog's tameness would be reduced and the wolf's tameness would be increased. In terms of real life, it would mean the two groups would be prevented from breeding (e.g., exchanging genes) with each other.

If dogs and wolves had not been isolated, the small number of "tameness" genes that arose in the population evolving into dogs would likely have been lost in the much larger wolf gene pool, where they would be selected against by the wolf's way of life. This would have made it very unlikely for dogs to ever evolve.

Sample Results

Group A: Wild Wolf Population		Group B: Tamer Dog Population	
Initial deck average	7.50	Initial deck average	7.50
5th-round average	7.00	5th-round average	10.00
10th-round average	6.20	10th-round average	12.00
20th-round average	6.25	20th-round average	19.45

LINKS & BOOKS

Links

NOVA Web Site—Dogs and More Dogs
www.pbs.org/nova/dogs/
In this companion Web site for the NOVA program, discover why there are so many breeds, read about why dogs are an evolutionary success, view a photo gallery of working dogs, and match breeds with their countries of origin.

American Kennel Club
www.akc.org/
Contains information about purebred dogs, including a list of recognized breeds, information on how to choose a puppy, and facts about DNA testing to prove dog parentage.

Dog Breed Info Center
www.dogbreedinfo.com/
Provides an alphabetical listing of dog breeds with additional information describing each breed and listing information about its temperament, living conditions, exercise requirements, and health conditions.

The Dog Genome Project
mendel.berkeley.edu/dog/manifesto.html
Outlines the goals of the dog genome project, similar to the human genome project, which is aimed at mapping all the chromosomes in dogs.

The Genetics of ... Dogs
www.discover.com/issues/apr-03/departments/featscienceof/
Looks at some of the genetic problems faced by purebred dogs, such as bulldogs with heads too large to fit through the birth canal and crippled German shepherds, and humans' influence on these problems through artificial selection.

The Human Role in Dog Evolution
www.nationalgeographic.com/xpeditions/lessons/08/g912/dogsevolution.html
Presents a lesson that asks students to investigate and consider the human role in the domestication and evolution of ancient and modern dog breeds.

The Truth About Dogs
www.theatlantic.com/issues/99jul/9907dogs.htm
Presents author Stephen Budianski's view on how dogs have evolved into a species uniquely adapted to getting food and shelter from people.

The Wolf-Dog Hybrid: An Overview of a Controversial Animal
www.nal.usda.gov/awic/newsletters/v5n4/5n4wille.htm
Reviews some of the anatomical and physiological differences between dogs and wolves and presents some of the breeding, genetic, and legal issues associated with wolf-dog hybrids.

Books

Budiansky, Stephen.
The Truth About Dogs: An Inquiry into the Ancestry, Social Conventions, Mental Habits, and Moral Fiber of Canis Familiaris.
New York: Viking Press, 2000.
Draws on evidence from behavioral science, archeology, biology, and neuroscience to probe how the relationship between humans and dogs developed.

Coppinger, Raymond and Lorna.
Dogs: A Startling New Understanding of Canine Origin, Behavior, and Evolution.
New York: Scribner, 2001.
Focuses on how dog breeds have evolved and examines how the dog became a distinct species from the wolf.

Padgett, George A.
Control of Canine Genetic Diseases.
New York: Howell Book House, 1998.
Includes chapters on modes of inheritance, tables and probabilities, genetic disease predisposition by breed, and definitions of canine genetic disorders.

Ritvo, Harriet.
The Animal Estate: The English and Other Creatures in the Victorian Age.
Cambridge, Massachusetts: Harvard University Press, 1989.
Discusses the role of animals in Victorian England and looks at selective breeding.

Serpell, James (editor).
The Domestic Dog: Its Evolution, Behaviour and Interactions with People.
New York: Cambridge University Press, 1995
Explores the natural history of the dog and its evolution, behavior, and interactions with humans.

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From Wolf to Dog

All dogs descended from the gray wolf. But dogs are so different from wolves that it seems difficult to imagine how one species led to another. How an organism evolves has to do with the selective pressures it is exposed to in its environment. In this activity, see what happens to two different populations of wolves as different selective pressures are applied.

Procedure

1. Cut apart the 24 cards from your "Wolf Deck" student handouts.
2. Appoint one member of your group to be the scorekeeper. The scorekeeper will record the total value of each student's hand of six cards before the game begins and after each round. The scorekeeper should also calculate the deck average by summing all 24 cards before the game begins, and after the 5th, 10th, and 20th round.
3. Have the scorekeeper calculate the initial value of the deck and record below. This represents the initial temperament of your wolf population.
4. Deal six cards. Each hand represents the collection of genes that contribute to the temperament for one wolf. A hand with low value represents an aggressive wolf while a hand with higher value represents a tamer animal.
5. Calculate the total of each hand. Follow the instructions in the box below for your group.
6. Shuffle all 24 cards together. This represents the mating of the wolves. As in nature, some of the offspring from this mating have random genetic mutations of their temperament genes. To simulate this, draw two random cards, keeping track of where they came from in the deck. Throw a die for each card you have removed and then change the value on the card (write the new number directly on the card) according to the following table:

Die Result	Card Change
1	+1
2	-1
3	+2
4	-2
5	+3
6	-3

Return the cards back to their original place in the deck.

7. Deal six cards to each player. Repeat steps 5–7.
8. Play a total of 20 hands, recording the entire deck average after hands 5, 10, and 20.
9. When you have finished the game, answer the questions listed on your "Examining the Game" student handout.

Deck Averages

Initial average _____

5th-round average _____

10th-round average _____

20th-round average _____

Wolf Group A
Due to selective pressures, the wolves with the most aggressive genes do not survive. To simulate this, the players who have the two lowest hand totals will remark their cards with numbers on the cards of the other two players. Twelve cards will be remarked.

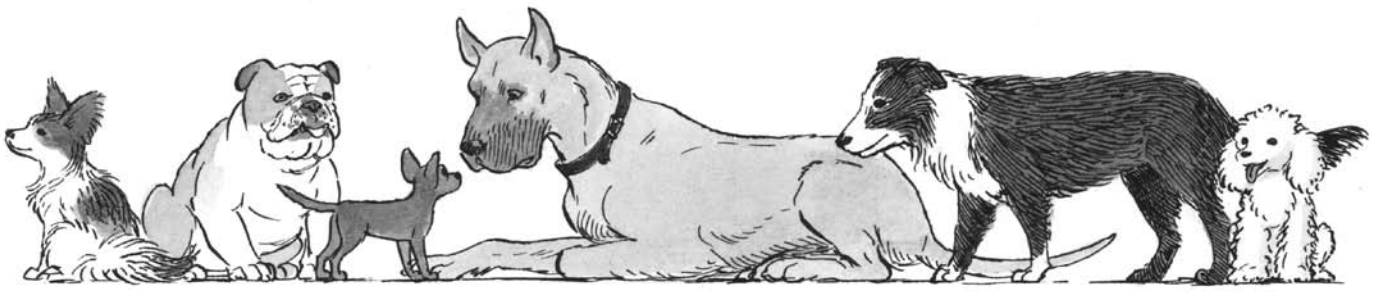
Wolf Group B
Due to selective pressures, the wolves with the most aggressive and most tame genes do not survive. To simulate this, the players who have the highest and lowest hand totals will remark their cards with numbers on the cards of the other two players. Twelve cards will be remarked.

Examining the Game

Questions

Write your answers on a separate sheet of paper.

1. What kind of animal do you think your initial average reflected? What kind of animal did the average of your final round reflect?
2. What happened to the temperament of your wolf population over time?
3. Do you think your group represents wolves in the wild or dogs that have evolved from wolves? Explain your answer.
4. The decks of cards representing wolves and dogs have been genetically isolated from each other for the entire game. Explain what this means in terms of the game and what it means in terms of real life.
5. What do you predict would happen to the tameness of dogs if wolves and dogs were allowed to regularly interbreed?
6. Why would the genetic isolation of wolves and dogs be important for dogs to become different from wolves?



Wolf Deck