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BioEd℠

Complex Traits

Genotyping a Mixed Breed Dog

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Baylor College of Medicine

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Printed in the United States of America.
ISBN: 978-1-944035-08-2

BioEd℠
Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

Development of Complex Traits educational materials was supported, in part, by a grant from the Science Education Partnership Award Program Office of the Director, National Institutes of Health grant 5R25OD011134 (Principal Investigator, Nancy Moreno, Ph.D.). Activities described in this book are intended for middle school students under direct supervision of adults. The authors, Baylor College of Medicine and NSF cannot be held responsible for any accidents or injures that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of BCM or the sponsoring agency.

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ACKNOWLEDGMENTS

This project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators in a wide range of specialties. Our heartfelt appreciation goes William A. Thomson, Ph.D., Professor and Director of the Center for Educational Outreach, and C. Michael Fordis, M.D., Senior Associate Dean and Director of the Center for Collaborative and Interactive Technologies at Baylor College of Medicine, who have lent their support and expertise to the project.

We are especially grateful to the many classroom teachers in the Houston area who participated in the field tests of these materials and provided invaluable feedback.

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OVERVIEW

Students follow the case study of a "mutt," whose breed identity is uncovered by its owners through commercial genotyping. In addition, students learn about variation within and among dog breeds, and the origins of common breed clusters.

Genotyping a Mixed-breed Dog

As described in the previous activity, all dogs are members of the same species (*Canis familiaris*). Even though members of different dog breeds vary physically and even behave in different ways, all domestic dogs can interbreed and produce viable offspring. The variation among (i.e., "between") dog breeds is the result of selective breeding over time. In many cases, distinctive traits of a particular breed is the result of the crosses between close relatives. Unfortunately, inbreeding also will consolidate undesirable traits, such as hereditary diseases. Thus, breeders and owners have considerable interest in knowing about the genetic makeup of their dogs. Breeders, for example, would like to avoid breeding dogs that can pass on genetic diseases, such as von Willebrand's disease (an inherited bleeding disorder), to their offspring.

DOVEKIE AS A PUPPY

Several companies now provide genetic tests for many disease-causing mutations and common physical characteristics, such as coat color. In addition, genetic testing can provide insights into the ancestry of mixed breed dogs. This information is useful to owners, who would like to know if their dog has hidden disease tendencies or has ancestors with specific behaviors (such as herding or barking).

BETWEEN VS. AMONG

Geneticists often refer to variation or differences "among" groups. This is equivalent to saying that there are differences "between" two groups, but the word, "among," is used when more than two groups are being considered. In other words, we can talk about differences "between" two groups, and "among" three groups.

Genetic testing does not examine the entire genome of an individual. Instead, it looks for irregularities in the chromosomes themselves, changes in specific sections of DNA or even proteins that are associated with a specific trait or disease. The dog genome is divided into 78 chromosomes, with 38 pairs of non-sex chromosomes and a pair of sex chromosomes. Sex in dogs in determined the same way as in humans: females have two "X" chromosomes (one from each parent) and males have one "X" and one "Y" chromosome. The DNA is chromosomes stays in a tightly wound or bunched state, until a section is "unwound," to enable the DNA to be read.

Pictured above is a set of unmatched dog chromosomes, and the same chromosomes matched into pairs. The paired depiction of chromosomes is called a karyotype. Chromosomes are found within the nucleus of a cell.

In this activity, students will learn how one family used genetic testing to uncover the ancestry of an unusual puppy. In addition, they will examine the relationships

among common clusters of dog breeds, and investigate the characteristics of different breeds.

MATERIALS

- Complex Traits slide set (slides 11–15), available at http://www.bioedonline.org/slides/classroom-slides1/genetics-and-inheritance/complex-traits/
- Computer and projector, or interactive whiteboard
- Copies of student page, "Dog Breeds Diagram" (one per student or one per group)

PROCEDURE

1. Play the NPR radio story, Hounded by Doubt, Dogged Owners Probe a Mystery, which may be found at the link below. Or download the transcript and have students read the story. Photographs of Dovekie and a purebred golden retriever are provided on Slide 11.

   http://www.npr.org/templates/story/story.php?storId=127484075

2. Encourage a discussion by asking students, *Have you heard about genetic testing before? What does genetic testing examine? Do you think they will be able to figure out who Dovekie's parents are?* Tell students that genetic tests can be developed to identify unique hereditary information, and that genetic information often is used to understand relationships among different families or groups. Remind students that most organisms (including humans and dogs) have two sets of genetic information, with a single set coming from each of the individual's two parents. This information is carried on DNA molecules (students will learn more about this process in the activity, "Mapping a Mutation").

3. Display Slide 12 showing a litter of puppies and their parent (or print copies of the slide for students to share). Ask students, *What do you observe about the puppies in this photograph?* Students should notice that several different coat colors and patterns of markings are present. In addition, none of the puppies has the same markings as the mother. Ask, *Where did this variation come from?* Invite student responses—they should identify the parents (through genetic information, genes, DNA etc.) as the sources of the observed variations in the puppies.

CATAHOULA LEOPARD DOGS

4. Next, show Slide 13, which shows several different dog breeds. Ask students to identify the ways in which the different kinds of dogs differ in appearance [body size and shape; head shape; coat length, color and curliness]. Tell students that modern dogs provide an interesting model for learning genetics, because humans selected desirable dogs to breed—based on the parent dogs' appearance or behaviors. This process over many generations, and many crosses, led to the different kinds of dog breeds.

5. Have students work in teams of two, and give each team a copy of the "Dog Breed Diagram" page, and display Slide 14. Tell students that the diagram represents the complex genetic relationships among different dog breeds and was developed using information similar to that used for genetic tests ordered for Dovekie. Clarify for students that the circular diagram was created

Catahoula Leopard Dogs. Wikipedia Commons CC-BY-SA 3.0. https://commons.wikimedia.org/wiki/File:CatahoulaLitter_wb.jpg

from a linear branching diagram like the one in the activity, "Dogs—A Model for Modern Genetics.".

Have students answer the questions on their student sheet and discuss as a group. (Answers are provided below.)

- What is the closest ancestor to dogs? [Wolves]
- How many major clusters of dog breeds have been identified? [10]
- What is the closest branch to the retriever group? [Newfoundland]
- Why are Mastiff-like dogs shown in several different branches of the tree. [They contain genetic similarities to several other groups, probably because of crosses between groups.
- Which breed clusters might be represented in Dovekie based on his appearance?

DOVEKIE AND HENRY: WIRE-HAIRED POINTING GRIFFONS

6. Play the radio story, The Case of the Mystery Puppy Solved! (Sort Of). The story can be found at the link below. Tell students that they should be prepared to discuss the following questions after listening to the story. Alternatively, you may download and print the transcript and have student read the story.

   http://www.npr.org/templates/story/story.php?storyId=127563468

7. Have students work in groups to answer the following questions (Slide 15). Afterward, conduct a class discussion about the story and guiding questions, such as the following.
   - What did his owners learn about Dovekie?
   - What kind of dog is Dovekie?
   - What does this story tell us about the commercial applications of genetic testing?

   Dovekie is a mixed breed dog with an unusual appearance. After genetic testing by three different companies, his owners learned that he had a mix of genetic material from a rare breed (purebred wirehaired pointed griffon) and almost purebred golden retriever , or golden retriever mix. The somewhat different results from each lab demonstrate that genetic testing techniques still are being refined, and that results, while informative, may need interpretation.

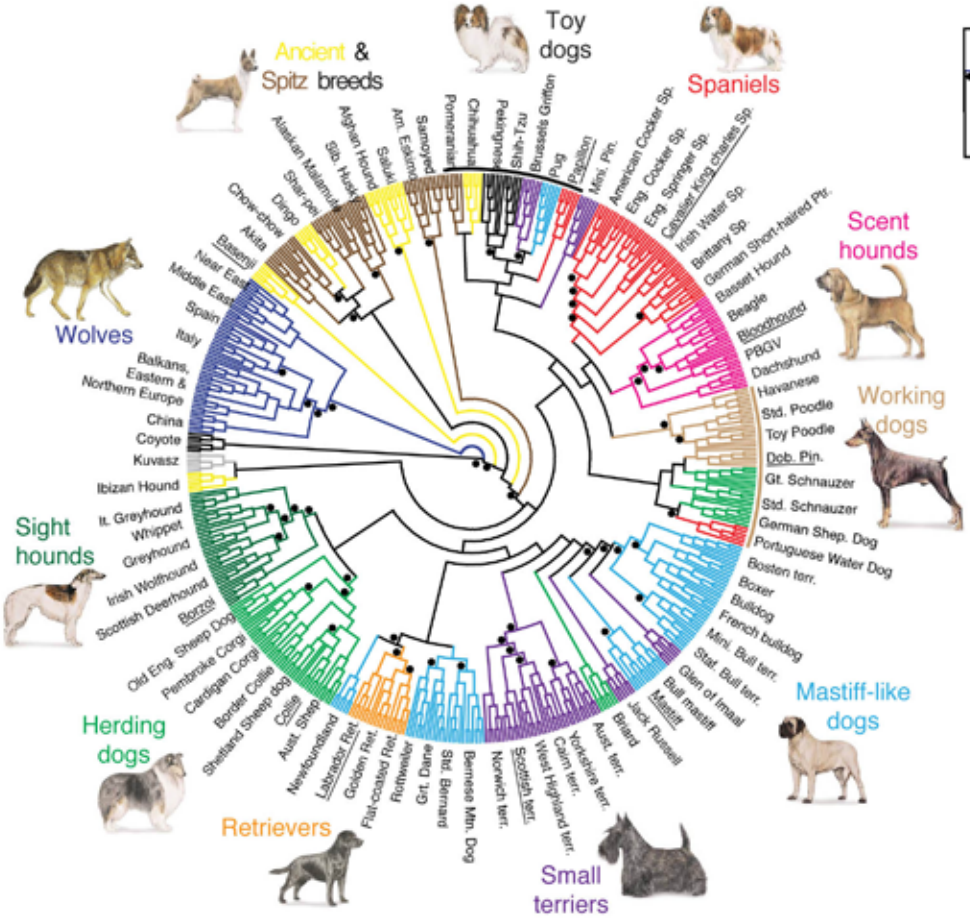
8. To conclude, have each team of students select a dog breed from the diagram, and use resources on the website of the American Kennel Club (www.akc.org) to learn more about their assigned or selected breed. Each team should prepare a written description of the origin, original purpose, physical characteristics and unique attributes of their selected breed. Have students report their findings during the next class period.

EXTENSION

If students have immediate questions about DNA and genes, have them complete the online Tour of the Basics found at the Learn Genetics website (http://learn.genetics.utah.edu/content/begin/tour/). The tutorial will introduce and explain key concepts and terms related to genetics, which also will be introduced as they move through this unit.

Dog Breed Diagram

This diagram shows represents complex genetic relationships among different dogs breeds, and was similar to that used for genetic tests ordered for Dovekie. Study the chart, then answer the questions below on the back of this sheet.



1. What is the closest ancestor to dogs?
2. How many major clusters of dog breeds have been identified?
3. What is the closest branch to the retriever group?
4. Why are Mastiff-like dogs shown in several different branches of the tree.
5. Which breed clusters might be represented in Dovekie based on his appearance?

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