NATIONAL GEOGRAPHIC

RESOURCE LIBRARY I ACTIVITY : 50 MINS

Genetic Markers: Connecting the Dots

Students simulate the passing on of genetic markers and make connections to ancient human migration routes.

GRADES

9 - 12

SUBJECTS

Anthropology, Biology, Geography, Human Geography

OVERVIEW

Students simulate the passing on of genetic markers and make connections to ancient human migration routes.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/genetic-markers-connecting-dots/

Program

THE GENOGRAPHIC PROJECT

DIRECTIONS

1. Introduce the activity and build students' background about genetic markers.

Tell students that they are going to engage in a hands-on activity that simulates how genetic markers (also called genetic signposts) are passed on from one population of humans to another. Explain that mistakes occasionally happen when DNA is replicated, and that these mistakes can be passed from a person to his or her descendants. Information can get

switched, dropped, or repeated. These mistakes are called mutations. Although we often think of mutations as being harmful, most mutations have no effect on an individual's survival. Because most mutations have no effect, they can become more and more common with each generation, and ultimately can be found in large proportions of a population. For these reasons mutations can be used as genetic markers of human migration. Explain that each population starts with the set of mutations inherited from its ancestral population, and over many, many generations, new mutations are added, making the descendant population's DNA unique from the DNA of any other population. These mutations, or genetic markers, are used to reconstruct the migration, ancestor to descendant, of humans around the world over the past 60,000 years. Explain that several students will play the role of scientists trying to reconstruct a human migration route using genetic markers to infer ancestor/descendant relationships between populations living in different regions. Other students will represent populations that inherited the markers along the route.

2. Assign students their roles and begin the activity.

Select 2-3 students to be the scientists, and have them leave the room. Then give a blank piece of paper to each student in the class. Explain that each desk represents a different geographical location. The papers are going to record the movement of human populations from location to location by keeping track of the set of genetic markers that they carry from their ancestors, in addition to the unique additional markers that arise along the migration route. Give a clipboard with another blank piece of paper on it to one student. Tell the student to draw a unique symbol (e.g., a star, circle, or square) anywhere on the paper. Explain that the symbol represents a new genetic mutation that after many, many generations is now present in the entire population. Have the student pass the clipboard to a second student at an adjacent desk. Explain that a group broke off and moved to a new location, and they carried with them the unique mutation of their ancestral population. Have the second student copy the symbol onto his or her paper, and then pass the clipboard to another adjacent student. Do this two more times. Ask students to describe what they just represented in terms of the migration of human populations and their DNA. Discuss that each population that has migrated to a new place has maintained the set of genetic markers that their ancestors acquired, and no new mutations have been passed through the populations. Note that this doesn't mean that none have occurred; they just haven't spread through the entire population. Then have the fifth student add a new and different symbol to the clipboard—as well as to his or her paper—and pass the clipboard on. Ask students to describe what the addition of this symbol represents. Make sure they understand that a person was born with a

genetic mutation at this location, and that mutation was passed through the entire population, creating a new genetic marker for that population. Repeat this for four to five more students, having each one copy both symbols onto the papers on their desks. Continue until there are at least six symbols on the clipboard and most of the students have had a turn. Tell students to turn over the papers on their desks.

3. Give the scientists their task.

Call the scientists back into the room. Explain what happened while they were out. Then give them the clipboard, and explain that it contains all the symbols generated during the activity. Their task is to determine what route the clipboard took by looking at the clues on the clipboard and on the desks. Have students turn their papers over so that the symbols are visible, and tell the scientists to begin looking for clues.

4. Help students reconstruct the route.

Give the students in the scientist role an opportunity to work out a strategy on their own. If they have trouble, suggest that they focus on the pages with just one symbol and try to determine which one came first. Remind them that the clipboard moved to just one adjacent desk each time. As they continue, provide additional clues as necessary until they have reconstructed the route.

5. Relate the activity to ancient human migration routes.

Ask the scientists to describe how they used those symbols to help them figure out the route that the clipboard took around the classroom. If students are not already familiar with the Genographic Project, explain how researchers on that project use genetic markers from different locations as clues, or signposts, to help them reconstruct the routes early humans took from Africa to the rest of the world. Remind students what genetic markers are: occasional mutations in DNA that are passed on through generations. Relate genetic markers to the new symbols added to the clipboards. Ask students to describe what the papers on their desks represent—the ancestor population that used to live at a location while a descendant population (the clipboard) migrates. Emphasize that there is an important aspect of the stationary population's DNA that is not represented well in this activity. Over time, each

population will continually add new mutations, regardless of whether they stay in place or move. Ask students how they could adjust this activity to better reflect what we understand about population genetics. One possibility is that students could add new, unique symbols to those papers, in addition to the clipboard. Ask students if there is anything else that this simulation does not represent well; for example: the simulation does not give a sense of the timescale or geographic distance. Ask:

- *How was the simulation like the Genographic Project?* (The Genographic Project is also looking at mutations to establish how different human populations have moved through different geographical locations over time.)
- *How was it different?* (The Genographic Project mostly looks only at populations living today, and so some of the connecting dots will be missing. It is these missing pieces of the jigsaw that the Genographic Project is trying to identify.)
- *How would the simulation have been different if there had been 100,000 different markers?* (This makes the simulation much more complicated, and when there are this many markers a computer is used to establish the order in which mutations occurred, and therefore how populations are related.)
- *What information helped you "connect the dots?" What other kinds of information, besides genetic markers, might scientific researchers use to "connect the dots?"* (Other information comes from archaeological material (such as human remains) and linguistics (the way in which languages spoken by different populations are related to each other). Information can also be obtained from geology and climatology. Past environments affected the types of landscapes humans could move into.)

Modification

Modify this activity using a different exercise, involving two clipboards. Begin the activity in the same way, except this time after the clipboard has been passed around a few desks, give the student who currently has the original clipboard a second clipboard and ask the student to copy all of the symbols to the new clipboard. Then have the student pass the clipboards in two different directions. Each clipboard will now be on a different journey and will accumulate its own mutations. When the scientists return, ask them to reconstruct the two migration routes, and the point where they converge to a common ancestor. Explain that the two clipboards represent two living populations separated in the past that moved in different directions. Reinforce that the desk papers represent those populations' ancestors, and not people living in those areas now. Ask students if they know of a method that could be used

to work out what mutations the ancestors had. One answer is to look at "ancient DNA" or DNA from archaeological material such as bones. This is what one of the Genographic Project labs based in Australia is doing.

Informal Assessment

- Ask students to explain what a genetic marker is and how scientists use them to reconstruct migratory routes.

Extending the Learning

- Repeat the activity with a different team of scientists. Before they return, collect and shuffle all the papers, and redistribute them randomly. Tell scientists to reconstruct the route the clipboard took, but alert them that something has changed. After a few minutes have the scientists stop trying. Ask: *Why is the activity now so difficult? What important clue is missing?* (It's the geographic location.)

OBJECTIVES

Subjects & Disciplines

Anthropology

Biology

Geography

- Human Geography

Learning Objectives

Students will:

- explain what a genetic marker is
- describe how genetic markers pass from one person to another
- explain how scientists can use genetic markers to reconstruct human migratory routes

Teaching Approach

- Learning-for-use

Teaching Methods

- Discovery learning
- Discussions
- Hands-on learning
- Role playing
- Simulations and games

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Analyzing
  - Applying
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Answering Geographic Questions

National Standards, Principles, and Practices

IRA/NCTE STANDARDS FOR THE ENGLISH LANGUAGE ARTS

• **Standard 7:**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

• **Theme 3:**
People, Places, and Environments

NATIONAL GEOGRAPHY STANDARDS

- **Standard 3:**
How to analyze the spatial organization of people, places, and environments on Earth's surface
- **Standard 9:**
The characteristics, distribution, and migration of human populations on Earth's surface

PREPARATION

What You'll Need

MATERIALS YOU PROVIDE

- Clipboards
- Paper
- Pencils

PHYSICAL SPACE

- Classroom

SETUP

Arrange desks in vertical rows.

GROUPING

- Large-group instruction

BACKGROUND & VOCABULARY

Background Information

This activity can be used to simulate how genetic markers move through space and time, and to show students how mutations can be used to trace ancestry. However, student may misinterpret this simulation. It is important for students to understand that the clipboard

represents people currently living. The pieces of paper on the desks represent their ancestors and not the people living in those locations currently, because those people will have continued to evolve their own mutations after the clipboard passed through. For example, examine the route where people moved from Africa, to Asia, and then to the Americas across the Bering Strait. The people that were left behind in Asia, after some of their descendants moved to the Americas, will have accumulated some of their own mutations. Thus, there will be mutations that are unique among Asian populations, even though those populations share a common ancestor with American populations. If it were true that the people on the desks were alive today, then we would have the scenario where one extant population is the ancestor of another extant population. Despite this scenario (in almost all situations) violating evolutionary theory, it is a common misconception. It can result in some very wrong conclusions, such as Africans being the ancestors of non-Africans. It will be important to clarify that:

- Only the clipboard represents people living today.
- The desks represent adjacent geographical locations and consecutive time periods.
- The desk papers represent the clipboard's ancestors.
- Although the people living on those desks (locations) today will have the mutations on the papers (ancestors), they will also have accumulated some new mutations of their own.

Prior Knowledge

["genes", "DNA mutation", "Human migration"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
ancestor	*noun*	organism from whom one is descended.
descendant	*noun*	children, grandchildren, and other offspring.
DNA	*noun*	(deoxyribonucleic acid) molecule in every living organism that contains specific genetic information on that organism.

Term	Part of Speech	Definition
generation	*noun*	group in a species made up of members that are roughly the same age.
genetic marker	*noun*	gene that is located on a specific place on a chromosome.
Genographic Project	*noun*	National Geographic project that uses genealogy to trace the migratory history of the human species.
human migration	*noun*	the movement of people from one place to another.
human population	*noun*	distinct group of people who share a language, culture, economic status, or physical proximity.
mutation	*noun*	sudden variation in one or more characteristics caused by a change in a gene or chromosome.
route	*noun*	path or way.

For Further Exploration

Articles & Profiles

- National Geographic Explorers: Spencer Wells, Geneticist

Audio & Video

- Journey of Man, PBS/National Geographic Documentary

Books

- Wells, Spencer. *The Journey of Man: A Genetic Odyssey.* New Jersey: Princeton University Press, 2002. Print.
- Wells, Spencer. *Deep Ancestry: Inside The Genographic Project.* Washington, D.C.: National Geographic, 2006. Print.

Websites

- National Geographic: The Genographic Project
- National Geographic: The Genographic Project—The Human Journey: Migration Routes

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