NOVA

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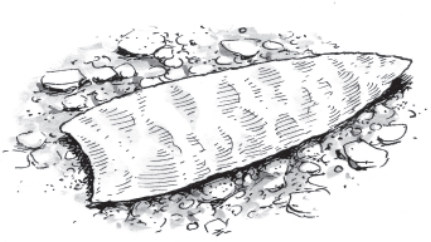
America's Stone Age Explorers

PROGRAM OVERVIEW



NOVA investigates the evidence for and controversies surrounding who the first Americans were, where they came from, and how they arrived in the Americas.

The program:

- reports how a type of prehistoric spearhead—known as the Clovis point—was found in 1933 in Clovis, New Mexico, and later discovered in all 48 contiguous states, Mexico, Belize, and Costa Rica.
- notes that mammoth bones found near the Clovis point were dated at 13,500 years ago, coinciding with the end of the last great Ice Age and mass extinction of some 35 genera of big animals, or megafauna.
- presents the conventional, so-called Clovis-first theory—that Clovis people crossed a now-submerged land bridge spanning the Bering Strait and then made their way south via an ice-free corridor between the great ice sheets that covered most of Canada.
- reviews controversial archeological evidence indicating the entry of pre-Clovis people, and reports on a possible Ice Age migration route along the Pacific coastline of Alaska.
- explains how mitochondrial DNA was used to strengthen the case that people migrated to the Americas at least 20,000 years ago.
- relates the search for the origins of the Clovis point and recounts the findings of similar spear points made by the Solutreans of Ice Age France and Spain.
- reports on evidence from a site in Virginia that some scientists claim bridges a 5,000-year gap between Solutrean and Clovis points.
- examines Inuit survival strategies to understand how prehistoric European travelers could have made an Ice Age Atlantic Ocean crossing.
- voices criticisms of the transatlantic theory, for instance, that many types of Solutrean artifacts and personal ornaments are not found in North America.
- reports on an emerging new portrait of the first Americans as people who arrived by various routes 20,000 years ago, spread throughout the country and eventually started making the Clovis point—perhaps the first great American invention—13,500 years ago.

BEFORE WATCHING

1 Have students research the Clovis-first theory. Ask students to share their knowledge about the questions central to the program—Who were the first Americans? Where did they come from? How did they get to America? Use a map to locate some of the places mentioned: the Bering Strait; Clovis, New Mexico; and Monte Verde, Chile.

2 Organize students into six groups. Have each group take notes on evidence presented in the program related to one of the following areas: the Clovis people; a pre-Clovis population; the Solutrean culture; possible migration routes to the Americas; archeological evidence; and genetic evidence.

AFTER WATCHING

1 Have students refer to their notes for a discussion about the evidence presented in the program. Survey the class. How many students feel the evidence for the existence of a pre-Clovis people is strong? Moderately strong? Weak? How many feel the evidence that the Solutreans may have come to the Americas from Europe is strong? Moderately strong? Weak? Have students defend their reasoning. What evidence supports or refutes various migration routes? After watching the program, whom do students think the first Americans were?

2 Ask students why it is important to find out who the first Americans were. What implications might it have for Native Americans? For Europeans? Have students explore some contemporary Native American views and expressions of their beliefs about their ancestry. Why might Native Americans be sensitive to a claim that prehistoric Europeans were among the earliest colonizers of the continent?

CLASSROOM ACTIVITY

Objective

To learn how mitochondrial DNA (mtDNA) is inherited.

Materials for each team

- copy of "The Hunt for mtDNA" student handout
- colored pencil or pen

Procedure

1. Because mtDNA is only passed down along maternal lines and mutates at predictable rates, it has been used to help trace migration routes of early humans. In this activity, students will learn how mtDNA gets passed along maternal lines.
2. To set up the activity, tell students that they will be working as forensic scientists to help solve a long-standing "missing persons" case. Provide each team with a copy of "The Hunt for mtDNA" student handout. Explain to students what mtDNA is, how it differs from nuclear DNA, and how it is inherited (see Activity Answer on page 3 for more information).
3. Set up the challenge: An anthropologist has found a few human bones at a site in South Africa. Investigators think they might belong to a Nobel Prize-winning dung beetle biologist who disappeared in Africa. Since the bones have been exposed to severe weather for many years, the only DNA that may be salvageable is mtDNA. Investigators have compiled a pedigree chart that lists all the missing person's relatives. But investigators are having problems identifying his maternal relatives. Which of the people in the "Who's Related by mtDNA?" pedigree chart carry the great-great grandmother's mtDNA, and of those people, which living relatives would be eligible to donate their mtDNA for comparison? (Mitochondrial DNA can be retrieved from exhumed remains, but this is a costly process and can be emotionally difficult for families. When possible, it is always best to retrieve mtDNA from a living relative. Mitochondrial DNA cannot be retrieved from cremated remains.) The missing person is labeled with a question mark in the pedigree chart.
4. After students have completed the challenge, discuss their results. What do students conclude about the inheritance patterns of mtDNA? Why aren't the dung beetle biologist's children eligible for testing? How far back can mtDNA of an individual be traced?
5. As an extension, have students research how mtDNA has been used to trace migratory routes of early humans.

STANDARDS CONNECTION

The "Hunt for mtDNA" activity aligns with the following National Science Education Standards.

GRADES 5–8
Science Standard C:
Life Science
Reproduction and heredity
- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce a sexually. Other organisms reproduce sexually.

GRADES 9–12
Science Standard C:
Life Science
The molecular basis of heredity
- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Video is not required for this activity.

Classroom Activity Author
This classroom activity originally appeared in a slightly different form in the companion Teacher's Guide for NOVA's "Last Flight of Bomber 31" program.

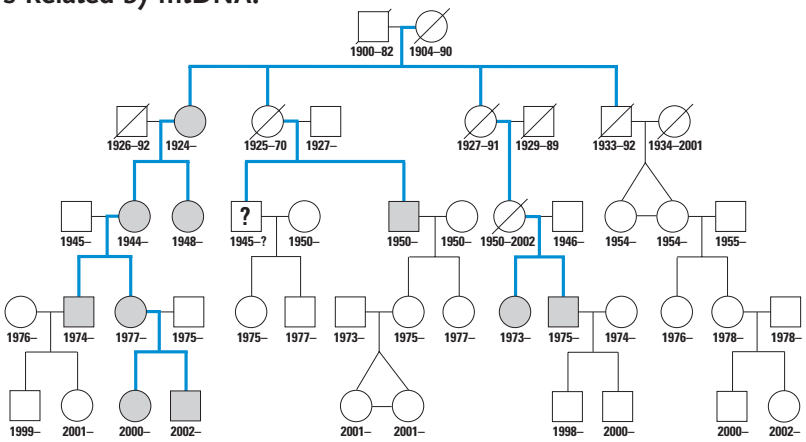
ACTIVITY ANSWER

Everyone carries two types of DNA: nuclear DNA, found in the nucleus of each body cell, and mitochondrial DNA (mtDNA), found in the mitochondria located in the cell's cytoplasm outside the nucleus. Nuclear DNA codes for most proteins made by the cell and is responsible for the inheritance of physical traits, such as hair color or whether a person has dimples, as well as inherited genetic disorders, such as sickle cell anemia or Tay-Sachs disease. Mitochondrial DNA codes for its own proteins and for ribosomal and transfer RNAs.

During reproduction, the father's sperm cell—which contains both nuclear DNA and mtDNA—donates only its nuclear DNA to the zygote that results from the fusion of the sperm with an egg cell. (Some researchers argue that a fragment of the father's mtDNA is in fact passed on, though it represents much less than 1 percent of the total.) Therefore, all the DNA in a person's mitochondria comes from his or her mother. This means that each new generation has only the mtDNA of the mother, who has only the mtDNA of her mother, and so on. (Males have only the mtDNA of their mothers as well but do not pass it on.) As a result, mtDNA samples can be used to identify any maternally related individuals.

The people related to the missing person's maternal grandmother (who are the candidates for getting mtDNA to compare to that of the missing person), are connected with heavy lines in the pedigree chart below. The 10 living relatives eligible for testing are shaded.

Who's Related by mtDNA?



Mitochondrial DNA could be used to confirm that two brothers with the same mother who died in a crash were related, but not to distinguish the brothers' remains from each other in the way that nuclear DNA could. In theory, mtDNA could be traced back to the first "mitochondrial Eve," a woman whom scientists have tried to pinpoint. However, controversy exists regarding the usefulness and accuracy of molecular clocks used to date when a mitochondrial Eve might have lived. (Molecular clocks are based on assumptions about how regularly DNA mutations occur.)

LINKS AND BOOKS

Links

NOVA Web site—America's Stone Age Explorers
www.pbs.org/nova/stoneage/
In this companion Web site to the program, consider who or what killed off the mammoths and other megafauna 13,000 years ago, view a gallery of images of Clovis artifacts, peruse an Ice Age North American map to learn more about pre-Clovis sites, and match Stone Age artifacts to their uses.

Center for the Study of the First Americans
www.centerfirstamericans.com/cat.html?c=4
Contains articles on theories regarding the peopling of North America.

Clovis and Beyond
www.clovisandbeyond.org/
Includes articles on possible coastal migration routes and the Solutrean-Clovis link.

Books

Adovasio, Jim and Jake Page.
The First Americans: In Pursuit of Archaeology's Greatest Mystery.
New York: Random House, 2002.
Challenges the theory that the Clovis people were the earliest settlers of the Americas.

Dixon, James E.
Bones, Boats, and Bison.
Albuquerque: University of New Mexico Press, 1999.
Argues that the earliest humans in North America were not big-game hunters following mammoths across the Bering Land Bridge but rather general foragers colonizing the New World.

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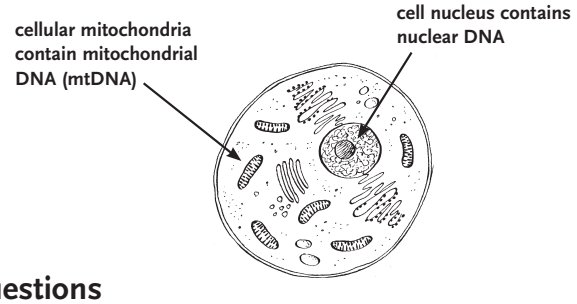
The Hunt for mtDNA

You are a forensic scientist recruited to help solve a long-standing "missing persons" case. Mitochondrial DNA, or mtDNA for short, is the key to your success.



Procedure

1. Read the *Guidelines for mtDNA Inheritance*.
2. Take careful notes as your teacher describes the important elements of the "Case of the Missing Dung Beetle Biologist." Identify which family members in the *Who's Related by mtDNA?* pedigree chart should be chosen to donate their mtDNA for comparison with the missing person's mtDNA (the missing person is noted by a question mark). All deceased individuals have been cremated and cannot be sampled for mtDNA.
3. Connect individuals who share mtDNA from the great-great grandmother by darkening the lines that link them to one another.
4. Of the individuals connected by dark lines, circle the living relatives who are eligible to be tested for mtDNA.

Questions

Write your answers on a separate sheet of paper.

1. How many living relatives could provide mtDNA to test against the mtDNA of the discovered remains that are believed to belong to the missing person shown by a question mark in the pedigree chart?
2. Describe the inheritance pattern of mtDNA.
3. If two brothers died in a crash, could you use mtDNA to distinguish their remains one from the other? Why or why not?
4. How far back could you trace a lineage of mtDNA?

Guidelines for mtDNA Inheritance

Mitochondrial DNA (mtDNA) is found in each cell's mitochondria, structures that produce ATP, the cell's main energy source. Here are some guidelines about how mtDNA is inherited:

- mtDNA can only be inherited from a woman.
- A man can inherit mtDNA from a woman.
- A man cannot pass mtDNA on to any children.

Who's Related by mtDNA?