LESSON PLAN & TEACHER'S GUIDE

How Does Ancestry Testing Work? Exploring Admixture Testing

Overview

This lesson explores the science of genetic ancestry testing. Together with pgEd's companion lesson on Ancestry and Identity in the Genomic Age, students will also examine the impacts that direct-to-consumer ancestry tests can have on people's understanding of their familial and cultural identity.

Suitable for in-class use as well as distance-learning

Guiding questions

- How are new genetic tools providing a lens for examining human ancestry?
- Why might a person's ancestry results be subject to change?

Learning objectives

By the end of this lesson, students will be able to:

- Explain how ancestry testing companies use DNA samples to estimate individuals' ancestry.
- Compare multiple ancestry test results for the same individual.
- Understand why one person may receive different ancestry estimates from different companies and why these estimates may change over time.

Materials

Device with internet connection for viewing PowerPoint file and accompanying videos, Student Handouts, colored pencils or markers (4 colors per student or group)

Time

This lesson takes approximately 30-60 minutes.

Standards alignment

Common Core Standards

CCSS.ELA-LITERACY.RH.11-12.1 Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

CCSS.ELA-LITERACY.RST.11-12.2 Determine the central idea or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

CCSS.ELA-LITERACY.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Next Generation Science Standards

This pgEd lesson integrates some of the NGSS practices and cross cutting concepts associated with the following disciplinary core ideas. The relevant portion of each disciplinary core idea is written out below.

HS-LS3: Inheritance and Variation of Traits

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

LS3.B: Variation of Traits

- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

Background information

Advances in genetics have given researchers new tools for analyzing people's DNA to gain insights into the ancestral histories of human populations. The rise of low-cost DNA ancestry tests marketed to consumers is enabling people to discover their own personal ancestry. Ancestry tests are nuanced, and the results are subject to limitations. Still, these tests can yield results that are warmly welcomed or fill in missing pieces of a

family story. They may also provide results that cause people to feel upset or worried, and the results may conflict with an individual's personal and cultural identities.

This lesson explores the science of genetic ancestry testing as well as the impacts direct-to-consumer ancestry tests can have on people's understanding of their familial and cultural identity. Students will watch a pair of animations and play the role of a scientist in an activity where they are asked to interpret a customer's ancestry test results, as they learn how genetic ancestry testing works and why a person's results may vary from one company to the next. The lesson ends with a video showing a group of young people who decide to take a DNA test to learn about their genetic ancestry. They reflect on the personal impacts of their test results - for some, filling in important pieces of their personal story; for others, giving them a sense of belonging; and still others, causing them to grapple with a newfound genetic ancestry that differs from family stories. The video also highlights how, for some individuals and families, ancestry testing can reveal evidence of the painful history of colonization and slavery. It also reinforces the idea that people are more alike than different from a genetic perspective.

Vocabulary

There are a number of vocabulary words that may be unfamiliar to students. You can provide a vocabulary list, or have students look up words themselves.

- **Admixture Testing** – A type of (DNA) Ancestry Testing that analyzes a person's DNA to estimate where their ancestors came from. Also known as biogeographical ancestry analysis.
- **(Genetic) Ancestry** – An estimate of the population(s) that an individual inherited genetic material from.
- **(DNA) Ancestry Testing** – A service that analyzes a person's DNA to provide an estimate of the population(s) that an individual is descended from or to identify probable.
- **DNA – (short for DeoxyriboNucleic Acid)** – Hereditary material that encodes information to build and maintain an organism.
- **Gene** – A sequence of DNA code that influences some specific characteristic(s) of an organism.
- **Genetic test** – A procedure used to identify genetic variants in DNA. Often performed on a sample from saliva, blood, or cheek swab.

- **Genetic variant** – One of several possible DNA sequences at a particular location in the genome.

- **Genome** – An individual's full set of genetic information, including all genes as well as other sections of DNA that may regulate the activity of those genes.

- **Population** – In the field of population genetics, a "population" refers to a group of individuals who are more likely to have children with others within the group than outside the group.

Outline of activities and resources in this lesson

The set up for this lesson (in class or distance-learning) is outlined on pages 5-7. This set up includes links to the 3 videos as well as detailed instructions for the student activity. Student handouts for the activity can be found on pages 8-13 and the answer key on pages 15-16. Finally, student questions are included on page 14, with the respective answer key on page 17.

Related pgEd lesson plans

- pgEd has a companion lesson on Ancestry and Identity in the Genomic Age. This lesson delves deeper into the exciting and complicated layers that ancestry testing can add to people's concepts of identity and history.

- pgEd regularly updates our lessons to reflect the latest developments in science and society and to include more voices in our materials. For more information, visit our lesson plan page and join our mailing list to find out about our latest offerings.

How Does Ancestry Testing Work? Exploring Admixture Testing

LESSON SET UP – TEACHER NOTES

The goal of this lesson is for students to explore how genetic ancestry testing works and to realize that ancestry test results are not definitive, but rather estimates of a person's probable ancestry.

Step 1 – Animation

Students watch the video: "How does Ancestry Testing work? Exploring Admixture Testing".

Step 2 – Student Activity

Set-up

Students are asked to imagine that they are in charge of an ancestry testing company. They are asked to use the knowledge they gained from the "How does Ancestry Testing work? Exploring Admixture Testing" video (Step 1) to estimate the ancestry of a fictional customer named Sam. Sam has provided a saliva sample to three companies, and students will analyze the results from each. As students interpret the data, they should find that each company comes up with a somewhat different estimate for Sam's ancestry.

a) Ask students to analyze Sam's ancestry tests from the three companies.

For each company, there is a Student Handout that provides Sam's data from that company, data from the company's reference populations, and a worksheet for students to complete (see pages 8-13 for Handouts). Students will need a copy of the Student Handout for each company they are assigned. Here are two options for setting up this activity:

- Ask students to work through the data from Company A, B, and C (or, if time is limited, you can assign students two companies to compare).
- Alternatively, split students into three groups and assign each of them a company. Then, have each group report their results back to the class.

You may want to give your students some prompts as they begin this activity. For example, you may want to tell them that each DNA site is named by a numeric

identifier. For each DNA site, students should find which variant Sam carries and then look at the frequency of this variant in the company's reference populations. If students are not sure what to do next, you may want to suggest that they revisit the "How does Ancestry Testing work? Exploring Admixture Testing" video (Step 1). This will remind them to look for the reference population in which the variant that Sam carries is most common. This datapoint will reveal the reference population that Sam is most likely to share ancestry with (though it is possible that Sam could share ancestry with any of the populations in which this variant is found).

b) Students should begin to realize that the three companies come up with different estimates of Sam's ancestry.

- If students are working independently: Ask them to reflect on why this happened.

- If students are working in groups: After the groups have reported out to the class, switch up the groups so that each new group has one or more representatives from each company. Ask students in these new groups to compare the data from all the companies and discuss why the companies arrived at different results.

We have provided teachers with an Answer Key for the worksheets from all three companies (see pages 15-16), as well as an explanation for why each company produces a different estimate of Sam's ancestry:

Why did each company report a different result for Sam's ancestry?

1. DNA site 18034: Company A reports Sam carries the 'c' variant, whereas Company B and C report they carry the 'b' variant. This is likely due to a mistake from Company A in reading Sam's DNA at this site.

2. DNA site 46754: Company A and C include this site in their analysis, whereas Company B does not.

3. Reference populations: Company A and B include 'Pacific Islander' as a reference population in their database, whereas Company C does not.

These are examples of common reasons why different ancestry companies might produce different ancestry testing estimates for the same customer. After students complete the activity, they will explore this phenomenon in more detail by watching the video "Why did my Ancestry Results change? Exploring Admixture Testing" (Step 3).

Step 3 – Animation

Students further explore the phenomenon they observed in the activity by watching the video "Why did my Ancestry Results change? Exploring Admixture Testing".

Step 4 – Video

Students watch the final video to see a real-life example of people reflecting on their ancestry test results.

Step 5 – Student Questions

Students answer the questions on the Handout on page 14. An answer key is provided on page 17.

How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY A

Name: _____ Date: _____

Imagine you have decided to open an ancestry testing company. You have watched pgEd's video "How Does Ancestry Testing work? Exploring Admixture Testing", and you plan to use what you've learned to estimate your customers' ancestry based on their DNA.

You have created a database of reference populations that you will use to estimate your customers' ancestry. This database lists the DNA sites that your company uses (for example, DNA site 46754). Each DNA site has four variants (a, b, c, and d).

Below, you have a table that shows how common each variant is in your reference populations. For example, if a customer carries variant 'b' at DNA site 95005, the chart tells you that this variant is most common in the African reference population (30%) and least common in the Native American reference population (5%).

Company Database:

DNA site 46754	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	60	20	10	10
Pacific Islander	40	15	25	20
African	15	15	50	20
European	10	5	75	10
Asian	50	10	20	20

DNA site 95005	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	65	5	10	20
Pacific Islander	0	15	80	5
African	45	30	15	10
European	20	20	15	45
Asian	10	15	35	40

DNA site 53134	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	30	10	5	55
Pacific Islander	20	60	10	10
African	25	20	15	40
European	10	0	10	80
Asian	40	30	15	15

DNA site 123030	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	40	10	25	25
Pacific Islander	50	40	0	10
African	15	60	20	5
European	5	10	15	70
Asian	30	5	45	20

DNA site 18034	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	10	20	65	5
Pacific Islander	50	30	5	15
African	15	15	5	65
European	45	5	5	45
Asian	30	40	20	10

How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY A

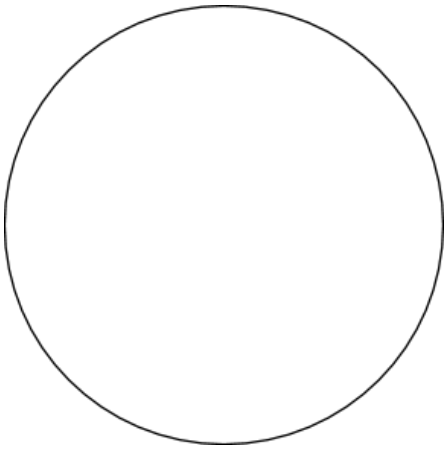
Name: _____ Date: _____

1. You have a customer named Sam. You have analyzed Sam's DNA, and you have determined the variants that they carry at the DNA sites that your company uses. For each DNA site, look at which variant Sam carries:

	DNA variant detected	Most likely ancestry according to Company A
DNA site 46754	a	
DNA site 53134	a	
DNA site 18034	c	
DNA site 95005	c	
DNA site 123030	c	

2. Then, decide which population Sam is most likely to share ancestry with, and note your findings in the second column of the table above.

3. Using the information gathered in step 2, draw a pie chart in the circle below to display Sam's estimated ancestry. For example, if you found that Sam has 2 variants that most likely represent ancestry from Africa and the other 3 variants most likely represent ancestry from Europe then divide the circle so that 2/5 (40%) represents African ancestry and 3/5 (60%) represents European ancestry. Make sure to label your pie chart clearly.



How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY B

Name: _____ Date: _____

Imagine you have decided to open an ancestry testing company. You have watched pgEd's video "How Does Ancestry Testing work? Exploring Admixture Testing", and you plan to use what you've learned to estimate your customers' ancestry based on their DNA.

You have created a database of reference populations that you will use to estimate your customers' ancestry. This database lists the DNA sites that your company uses (for example, DNA site 46754). Each DNA site has four variants (a, b, c, and d).

Below, you have a table that shows how common each variant is in your reference populations. For example, if a customer carries variant 'b' at DNA site 95005, the chart tells you that this variant is most common in the African reference population (30%) and least common in the Native American reference population (5%).

Company Database:

DNA site 53134	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	30	10	5	55
Pacific Islander	20	60	10	10
African	25	20	15	40
European	10	0	10	80
Asian	40	30	15	15

DNA site 95005	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	65	5	10	20
Pacific Islander	0	15	80	5
African	45	30	15	10
European	20	20	15	45
Asian	10	15	35	40

DNA site 18034	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	10	20	65	5
Pacific Islander	50	30	5	15
African	15	15	5	65
European	45	5	5	45
Asian	30	40	20	10

DNA site 123030	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	40	10	25	25
Pacific Islander	50	40	0	10
African	15	60	20	5
European	5	10	15	70
Asian	30	5	45	20

How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY B

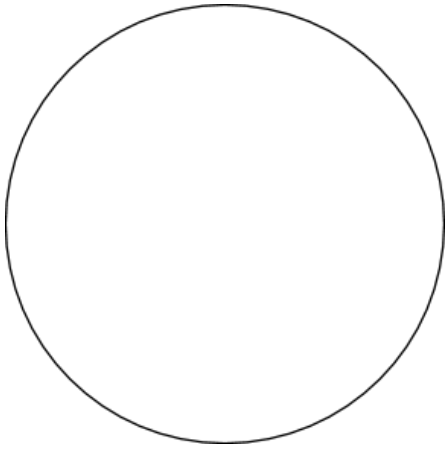
Name: _____ Date: _____

1. You have a customer named Sam. You have analyzed Sam's DNA, and you have determined the variants that they carry at the DNA sites that your company uses. For each DNA site, look at which variant Sam carries:

	DNA variant detected	Most likely ancestry according to Company B
DNA site 53134	a	
DNA site 18034	b	
DNA site 95005	c	
DNA site 123030	c	

2. Then, decide which population Sam is most likely to share ancestry with, and note your findings in the second column of the table above.

3. Using the information gathered in step 2, draw a pie chart in the circle below to display Sam's estimated ancestry. For example, if you found that Sam has 2 variants that most likely represent ancestry from Africa and the other 2 variants most likely represent ancestry from Europe then divide the circle so that 2/4 (50%) represents African ancestry and 2/4 (50%) represents European ancestry. Make sure to label your pie chart clearly.



How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY C

Name: _____ Date: _____

Imagine you have decided to open an ancestry testing company. You have watched pgEd's video "How Does Ancestry Testing work? Exploring Admixture Testing", and you plan to use what you've learned to estimate your customers' ancestry based on their DNA.

You have created a database of reference populations that you will use to estimate your customers' ancestry. This database lists the DNA sites that your company uses (for example, DNA site 46754). Each DNA site has four variants (a, b, c, and d).

Below, you have a table that shows how common each variant is in your reference populations. For example, if a customer carries variant 'b' at DNA site 95005, the chart tells you that this variant is most common in the African reference population (30%) and least common in the Native American reference population (5%).

Company Database:

DNA site 46754	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	60	20	10	10
African	15	15	50	20
European	10	5	75	10
Asian	50	10	20	20

DNA site 95005	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	65	5	10	20
African	45	30	15	10
European	20	20	15	45
Asian	10	15	35	40

DNA site 53134	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	30	10	5	55
African	25	20	15	40
European	10	0	10	80
Asian	40	30	15	15

DNA site 123030	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	40	10	25	25
African	15	60	20	5
European	5	10	15	70
Asian	30	5	45	20

DNA site 18034	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	10	20	65	5
African	15	15	5	65
European	45	5	5	45
Asian	30	40	20	10

How Does Ancestry Testing Work? Exploring Admixture Testing

HANDOUT - COMPANY C

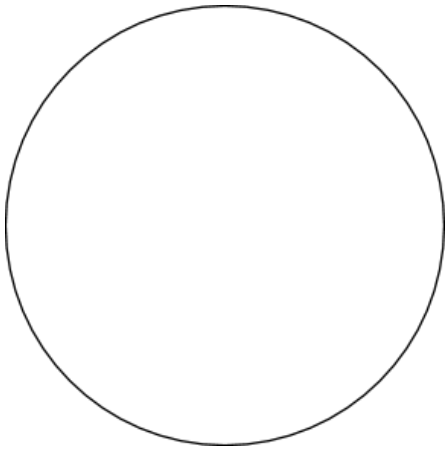
Name: _____ Date: _____

1. You have a customer named Sam. You have analyzed Sam's DNA, and you have determined the variants that they carry at the DNA sites that your company uses. For each DNA site, look at which variant Sam carries:

	DNA variant detected	Most likely ancestry according to Company C
DNA site 46754	a	
DNA site 53134	a	
DNA site 18034	b	
DNA site 95005	c	
DNA site 123030	c	

2. Then, decide which population Sam is most likely to share ancestry with, and note your findings in the second column of the table above.

3. Using the information gathered in step 2, draw a pie chart in the circle below to display Sam's estimated ancestry. For example, if you found that Sam has 2 variants that most likely represent ancestry from Africa and the other 3 variants most likely represent ancestry from Europe then divide the circle so that 2/5 (40%) represents African ancestry and 3/5 (60%) represents European ancestry. Make sure to label your pie chart clearly.



How Does Ancestry Testing Work? Exploring Admixture Testing

STUDENT QUESTIONS

Name: _____ Date: _____

1. How does an Admixture Test work? Fill in the blanks, choosing from the following:

reference **estimate** **DNA** **mathematical formulas** **variants**

An admixture test starts when a customer sends a(n) _____ sample to an ancestry testing company. When the customer's sample arrives in the lab, the DNA is read to determine which DNA _____ the customer has at specific sites in their DNA. The customer's information is then compared to _____ populations to determine who they are most likely to share ancestry with. After analyzing hundreds of thousands of DNA sites, the company uses complex _____ to put together all the data and provide their customer with a(n) _____ of their ancestry.

2. Imagine your ancestry testing company decides to use a new DNA site, 26948, in your analysis. Sam carries variant 'a' for this new DNA site. Below you will find the data from your company's reference populations for DNA site 26948. Respond to the following questions using only the data provided for this new DNA site.

DNA site 26948	variant a (%)	variant b (%)	variant c (%)	variant d (%)
Native American	50	30	20	0
African	0	50	20	30
European	5	25	45	25
Asian	60	10	20	10

A) Which reference population is Sam most likely to share ancestry with?

B) Is it certain that Sam shares ancestry with the reference population you named in part A? Why or why not? If your answer is 'yes', please explain how you came to this conclusion. If your answer is 'no', please explain why and list the other reference population(s) that Sam might also share ancestry with.

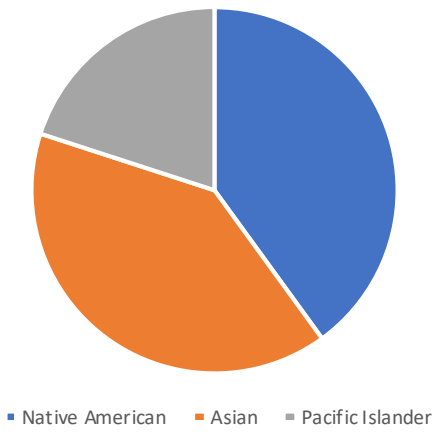
STUDENT ACTIVITY - ANSWER KEYS

Company A

Sam's Information:

	DNA variant detected	Most likely ancestry
DNA site 46754	a	**Native American**
DNA site 53134	a	**Asian**
DNA site 18034	c	**Native American**
DNA site 95005	c	**Pacific Islander**
DNA site 123030	c	**Asian**

Pie Chart:

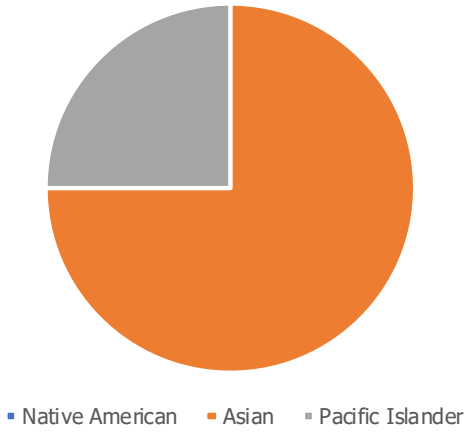


Company B

Sam's Information:

	DNA variant detected	Most likely ancestry
DNA site 53134	a	**Asian**
DNA site 18034	b	**Asian**
DNA site 95005	c	**Pacific Islander**
DNA site 123030	c	**Asian**

Pie Chart:

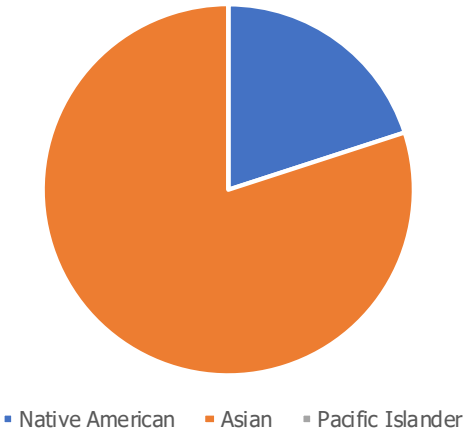


Company C

Sam's Information:

	DNA variant detected	Most likely ancestry
DNA site 46754	a	**Native American**
DNA site 53134	a	**Asian**
DNA site 18034	b	**Asian**
DNA site 95005	c	**Asian**
DNA site 123030	c	**Asian**

Pie Chart:



How Does Ancestry Testing Work? Exploring Admixture Testing

STUDENT QUESTIONS – ANSWER KEY

1. Answer key (in order): DNA, variants, reference, mathematical formulas, estimate

2. A) Based only on the data provided, it is most likely that Sam shares ancestry with the Asian reference population.

   B) No, it is not certain that Sam shares ancestry with Asian people. Variant 'a' has also been found in the Native American and European reference populations. Therefore, based on the data, it is also possible that Sam might share ancestry with these groups. This is why companies need to look at hundreds of thousands of DNA sites to make a statistical estimate of a person's probable ancestry.

   (Note, if the company were to add DNA samples from additional people to their African reference population, it is possible that they might detect variant 'a' for DNA site 26948 in this population. If this were to happen, then it is possible for Sam to share ancestry with any of the four reference populations, based on the data from this DNA site alone.)