DNA Profiling and Forensic Science - The Gist

Name and School: Helena Puche, Truman College.
Title: Investigating murder via paternity DNA
Time: 20-30 minute class
Application: Heredity
Target Audience: College non-majors in biology
Misconceptions addressed: http://evolution.berkeley.edu/evolibrary/misconceptions_faq.php
Each trait is influenced by one Mendelian locus. Before learning about complex or quantitative traits, students are usually taught about simple Mendelian traits controlled by a single locus — for example, round or wrinkled peas, purple or white flowers, green or yellow pods, etc. Unfortunately, students may assume that all traits follow this simple model, and that is not the case. Both quantitative (e.g., height) and qualitative (e.g., eye color) traits may be influenced by multiple loci and these loci may interact with one another and may not follow the simple rules of Mendelian dominance. In terms of evolution, this misconception can be problematic when students are learning about Hardy-Weinberg equilibrium and population genetics. Students may need frequent reminders that traits may be influenced by more than one locus and that these loci may not involve simple dominance.
Each locus has only two alleles. Before learning about complex traits, students are usually taught about simple genetic systems in which only two alleles influence a phenotype. Because students may not have made connections between Mendelian genetics and the molecular structure of DNA, they may not realize that many different alleles may be present at a locus and so may assume that all traits are influenced by only two alleles. This misconception may be reinforced by the fact that students usually focus on diploid genetic systems and by the use of upper and lowercase letters to represent alleles. The use of subscripts to denote different alleles at a locus (as well as frequent reminders that loci may have more than two alleles) can help correct this misconception.

State Standards:

- In grades 9-12, expand students' understanding of biology by incorporating more abstract knowledge, such as the structure and function of DNA, and the theory of evolution.
- 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.

Benchmark

- Grade 2: There is variation among individuals of one kind within a population. 5B/P1. Offspring are very much, but not exactly, like their parents and like one another. 5B/P2. Grade 5-8: Some likenesses between children and parents are inherited. Other likenesses are learned. 5B/E1.
- For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. 5B/E2.
- Grade 9-12: The information passed from parents to offspring is coded in DNA molecules, long chains linking just four kinds of smaller molecules, whose precise sequence encodes genetic information. 5B/H3.

Prior knowledge: DNA structure and function need to be understood before this plug-in is used. Students should know that DNA consists of nucleotides and understand genetic mutations.

What students will learn: DNA and RNA are nucleic acids consisting of long chains of chemical units (monomers) called nucleotides. The four different types of nucleotide (A, C, T, and G) that make up DNA are Adenine, Cytosine, Thymine and Guanine. Because the information coded in the DNA is passed from parents to offspring, two individuals that are related could be identified by testing their DNAs. This is the same principle that can be used to infer the degree of relatedness between two species and a common ancestor. The students should understand that at some genes, the exact sequence can be used to deduce the extent of relatedness to a common predecessor. The students will also use cladograms which are graphical representations that show relationships among taxa. In this plug-in, the cladogram will be used to infer the relationship between the "Cheddar Man, " a 9,000-year-old skeleton found in 1903 in Gough's Cave in Cheddar Gorge, Somerset, England, and the villagers using the Haplogroup U5 (Bramanti 2009).

How this applies to evolution: This plug-in introduces the concept of genetic transfer which is evidence of evolution.

Instructions: Students will compare and contrast DNA profiles of sample DNA and a suspect that is accused of committing a murder. For crime scene investigations using DNA profiling
1) DNA samples from the crime scene, suspects, victims or other evidence are isolated
2) The selected markers from each DNA sample are amplified (copied many times) to produce a large sample of DNA fragments
3) The amplified DNA markers are compared, proving which samples are from the same individual and which samples are unique. By comparing genetic markers, students will see how sequences in the genome carry from person to person.

Keywords: nucleotides, genetic markers, DNA profiling, forensics.

Specific concepts: genome, PCR, genetic markers.

References:

Bramanti et al. (2009). Genetic Discontinuity Between Local Hunter-Gatherers and Central Europe's First Farmers. Science 326: 137.

Kashyap, V. K. , T. Sitalaximi, ., P. Chattopadhyay and R. Trivedi. (2004). DNA Profiling Technologies in Forensic Analysis. Int J Hum Genet. 4(1): 11-30.

Lyall, S. (1997). "Tracing Your Family Tree to Cheddar Man's Mum", *New York Times*, 24 Mar 1997, http://www.nytimes.com/1997/03/24/world/tracing-your-family-tree-to-cheddar-man-s-mum.html?pagewanted=1

Summerset villager names: http://www.loxtonsomerset.org.uk/pictures/photoalbum-1-3.html

Inheritance

1. Heritable Variation and patterns of inheritance
   - Mendel's Law of Segregation and law of independent Assortment
   - Test-Cross to determine an unknown Genotype
   - Family Pedigrees, ABO Blood Groups, The Role of Environment
2. DNA Structure and Replication
   - DNA and RNA Structure
   - Watson and Cricks' Discovery of the Double Helix
   - Chromosomal Basis of Inheritance
   - Mutations
3. The Flow of Genetic Information from DNA to RNA to Protein
   - How an Organism's Genotype determines Its Phenotype
   - From Nucleotides to Amino acids
   - The Genetic Code
   - Transcription: From DNA to RNA
4. DNA Technology
   - Recombinant DNA Technology

************EVOLUTION PLUG IN *****************

- Genomics Proteomics
- The human Genome Project
- Genome-Mapping Techniques

Name _____ **Due Date** _____

Evolution Plug-ins
A Collaborative project between Miami University - Oxford & the University of Missouri - St. Louis

DNA Profiling and Forensic Science

Since its introduction in 1986, DNA profiling has provided crucial evidence in many famous cases. DNA evidence can prove innocence as well as guilt, to identify crime victims, to determine paternity or to protect endangered species by conclusively proving the origin of contraband animal products.

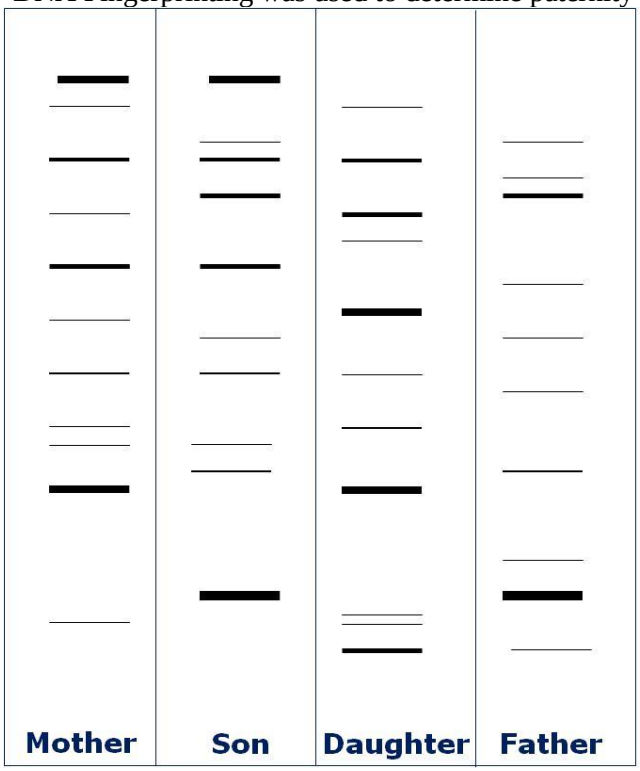
1) What are the four main nucleotides of DNA (deoxyribonucleic acid)?

2) How many chromosomes do humans have?

3) How many chromosomes does each offspring gets from each parent?

4) What is polymerase chain reaction PCR?

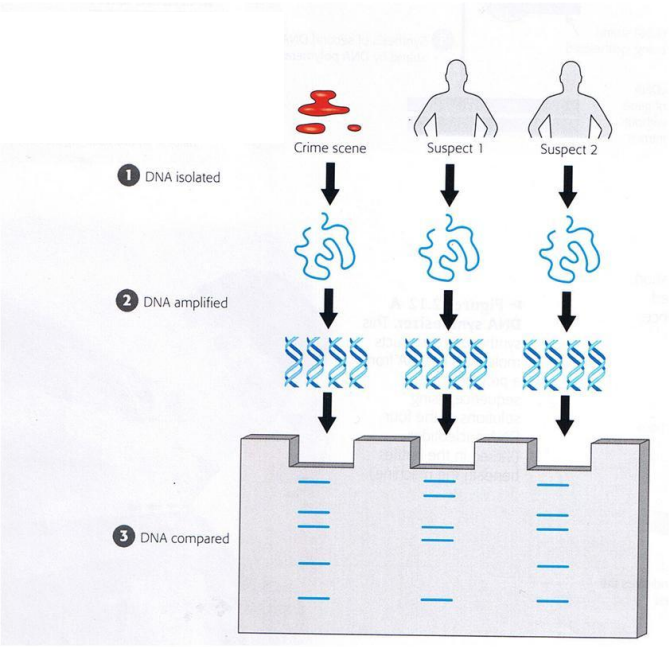
5) DNA Fingerprinting was used to determine paternity and maternity of these two children.



Family B

What do the results show?

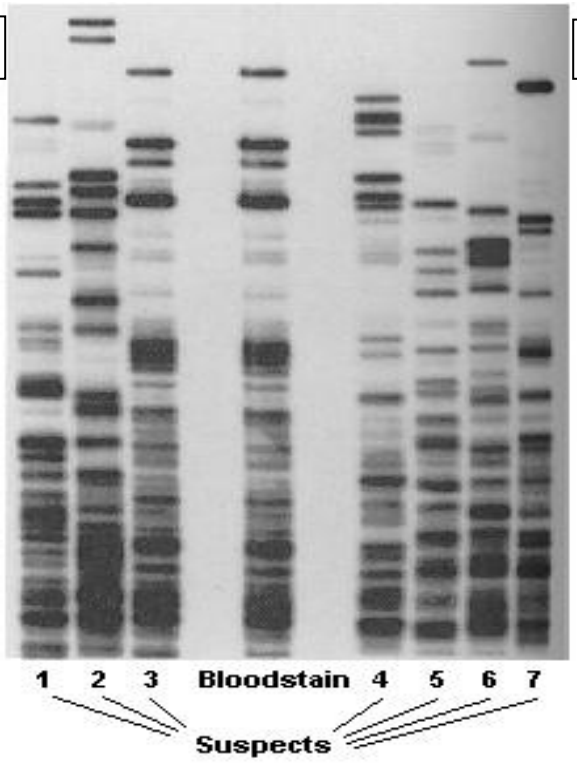
6) In DNA Profiling, PCR makes many copies of a specific segment of DNA, doubling the quantity of DNA in each round (DNA is amplified). In the following example, which suspect,1 or 2, matches the DNA found at a crime scene?



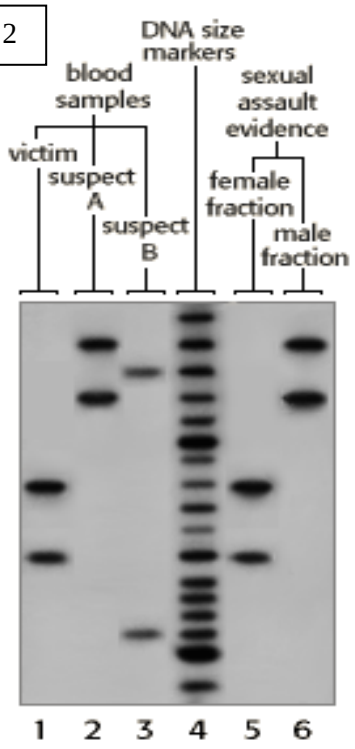
7) Based on statistical results from allele frequency databases, as a DNA investigator, what is the likelihood that a suspect's DNA profile will randomly match an evidentiary sample?

Is any of the suspects for the crime responsible for it? Circle which one.

1



2



8) The sequences of the Haplogroup U5 of different villagers and the "Cheddar Man, " a 9,000-year-old skeleton found in 1903 in Gough's Cave in Cheddar Gorge, Somerset, England, are shown below. Circle each nucleotide pair that is the same and record the total in the space provided, as in the circled example.

Cheddar Man (CM) and Louise Stark (LS)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
LS	C	T	T	C	C	A	G	T	T	T	T	A	A	A	G	C	A	G	A	G	T	G	T	C	C	A	C	T

Number of similarities between Cheddar Man and Louise Stark _____

Cheddar Man (CM) and Adrian Targett (AT)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
AT	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	T	T	T	C	C	G

Number of similarities between Cheddar Man and Adrian Targett _____

Cheddar man (CM) and Hazel Hudson (HH)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
HH	G	T	T	G	C	T	G	T	G	T	T	G	A	T	A	C	G	C	T	A	A	G	A	C	C	A	C	T

Number of similarities between Cheddar Man and Hazel Hudson _____

Cheddar man (CM) and Charles Stark (CS)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
CS	C	T	T	C	G	A	G	T	T	T	T	A	A	A	A	C	A	G	A	G	T	G	T	C	C	A	C	T

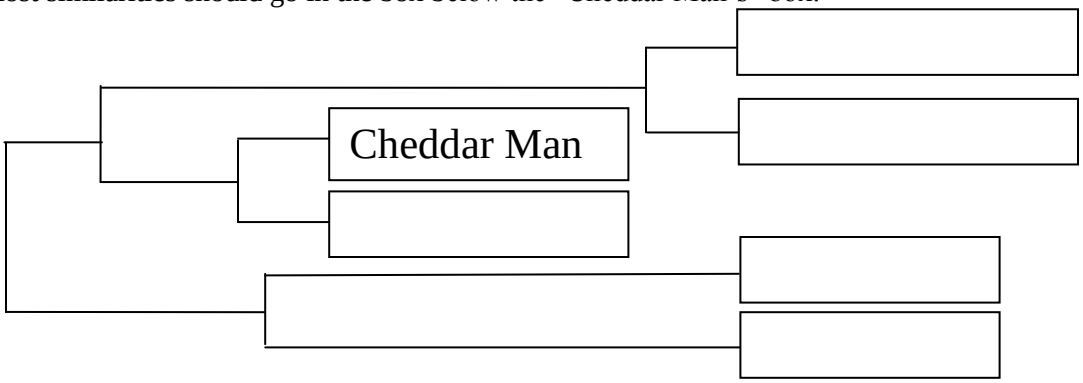
Number of similarities between Cheddar Man and Charles Stark _____

Cheddar man (CM) and William Edmond Ham (WH)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
WH	G	T	T	C	C	T	G	T	T	T	T	A	A	T	G	C	A	C	A	G	T	A	T	C	C	A	C	T

Number of similarities between Cheddar Man and William Edmond Ham _____

9) Cladograms or phylogenetic trees, are graphical representations that show relationships among groups. Use the data from question 7) to make a cladogram to show the similarities among villagers and the Cheddar Man. The more similarities with the Cheddar man, the closer they should be in the cladogram. Villager names should be written in the boxes. The villager with the most similarities should go in the box below the "Cheddar Man's" box.



10) Who has the most similarities with the "Cheddar Man"?

11) Which groups are more closely related or biologically more alike?

12) Which villagers have less in common with the "Cheddar Man"?

Name _____ **Due Date** _____

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DNA Profiling and Forensic Science - Teacher's Edition

Since its introduction in 1986, DNA profiling has provided crucial evidence in many famous cases. DNA evidence can prove innocence as well as guilt, to identify crime victims or to determine paternity or to protect endangered species by conclusively proving the origin of contraband animal products.

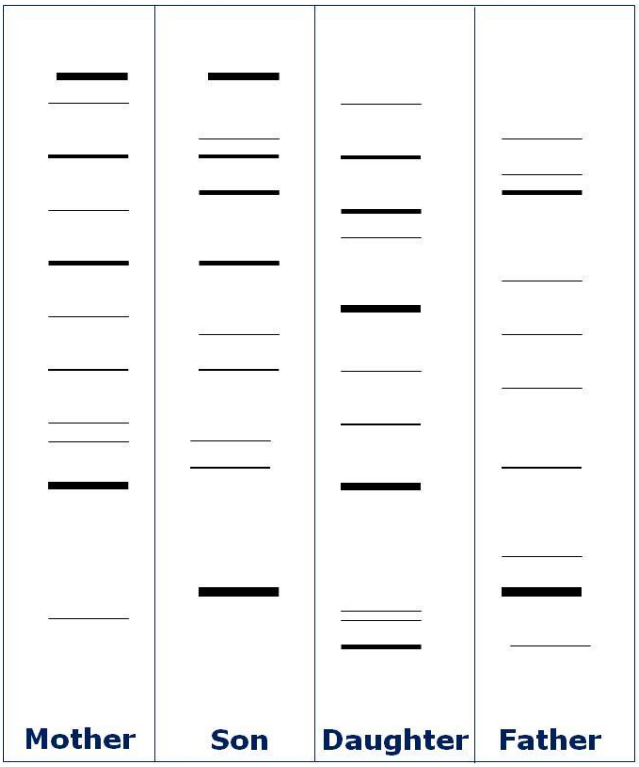
1) What are the four main nucleotides of DNA (deoxyribonucleic acid)? A, T, G, C.

2) How may chromosomes do humans have? 22

3) How many chromosomes does each offspring gets from each parent? 2

4) What is polymerase chain reaction PCR? A procedure that generates millions of copies of template DNA in a short duration.

5) DNA Fingerprinting was used to determine paternity and maternity of these two children.

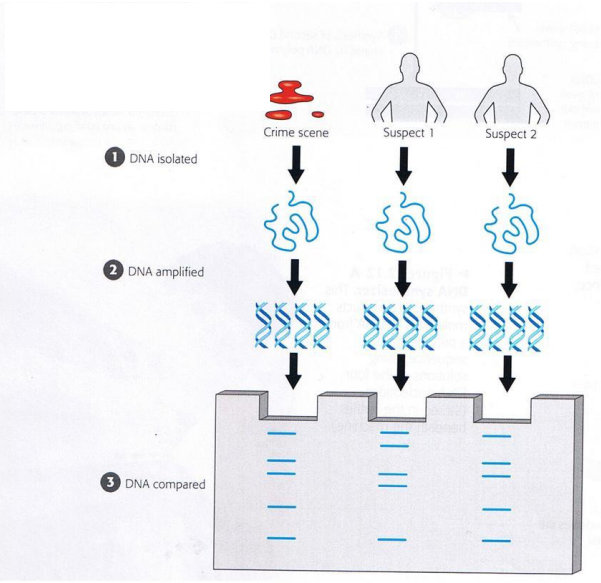


Family B

What do the results show?

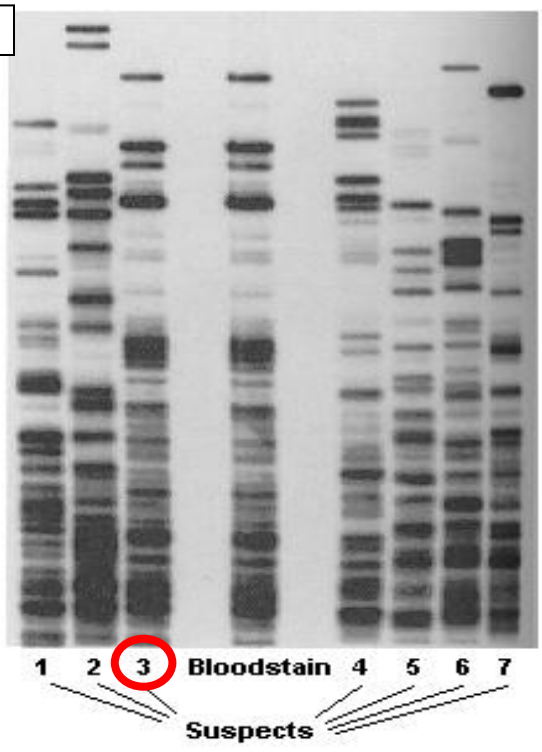
The girl is not the father's daughter.

6) In DNA Profiling, PCR makes many copies of a specific segment of DNA, doubling the quantity of DNA in each round (DNA is amplified). In the following example, which suspect,1 or 2, matches the DNA found at a crime scene? Suspect 2

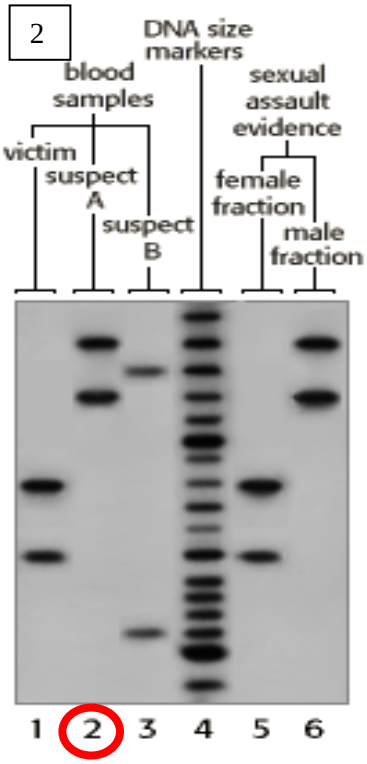


7) Based on statistical results from allele frequency databases, as a DNA investigator, what is the likelihood that a suspect's DNA profile will randomly match an evidentiary sample? The average random match probability for unrelated individuals is less than one in a trillion (DPS 2011).
Is any of the suspects for the crime responsible for it? Circle which one. 1) Suspect 3. 2) A2

1



2



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Number of similarities between Cheddar Man and Louise Stark _____4_____

Cheddar Man (CM) and Adrian Targett (AT)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	T	C	C	C	C
AT	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	T	T	C	C	G

Number of similarities between Cheddar Man and Adrian Targett _____25_____

Cheddar man (CM) and Hazel Hudson (HH)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
HH	G	T	T	G	C	T	G	T	G	T	T	G	A	T	A	C	G	C	T	A	A	G	A	C	C	A	C	T

Number of similarities between Cheddar Man and Hazel Hudson _____18_____

Cheddar man (CM) and Charles Stark (CS)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
CS	C	T	T	C	G	A	G	T	T	T	T	A	A	A	A	C	A	G	A	G	T	G	T	C	C	A	C	T

Number of similarities between Cheddar Man and Charles Stark _____8_____

Cheddar man (CM) and William Edmond Ham (WH)

CM	G	T	A	G	G	T	T	T	G	T	T	G	G	T	A	T	C	C	T	A	A	A	A	T	C	C	C	C
WH	G	T	T	C	C	T	G	T	T	T	T	A	A	T	G	C	A	C	A	G	T	A	T	C	C	A	C	T

Number of similarities between Cheddar Man and William Edmond Ham _____11_____

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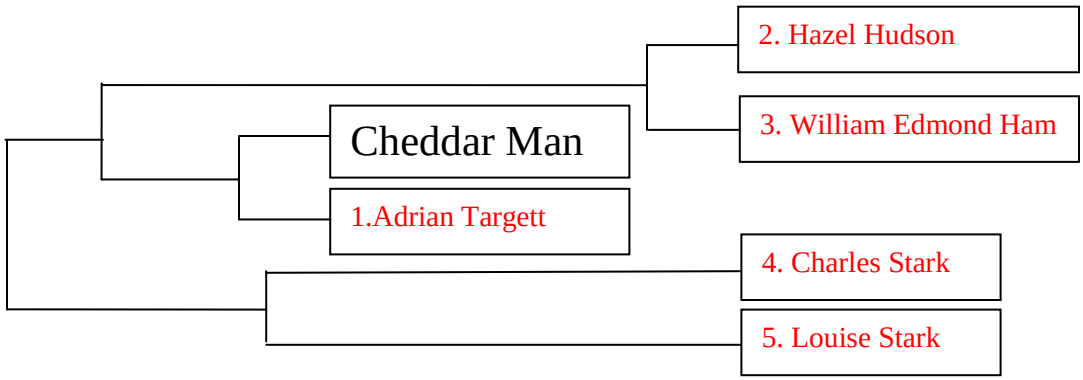

10) Who has the most similarities with the "Cheddar Man"? Adrian Targett

11) Which groups are more closely related or biologically more alike? Cheddar Man, Adrian Targett, Hazel Hudson and William Edmond Ham.

12) Which villagers have less in common with the "Cheddar Man"? Charles, Stark, Louise Stark and William Robert.

Reflection on lesson implementation:

In this Plug-In, the students will be looking at DNA and differences between individuals using PCR. These students are non-biology majors (or upper level high-school students). Therefore, it will be enough to mention the techniques and the basics for the procedures. Students will answer the questions on the worksheet. The small space provided will lead them to realize that a short answer is expected. A power point was added to introduce relatedness and promote discussion about evolution.

PLEASE GIVE US YOUR FEEDBACK		
Evolution Plug-In Feedback Form		
Name: **School:** **State:** **Country:**	**Title of Plug-In:**	
Unit and Subject:	**Grade and class size:**	**Length of time:** _____ minutes

Did you modify the Plug-In before the lesson?	o **Yes** o **No**
If Yes, please explain.	
How did students respond to activity?	o **Very well** o **So-so** o **Not well**
Please explain.	
Would you use this Plug-In again?	o **Yes** o **No**
What modifications would you suggest?	