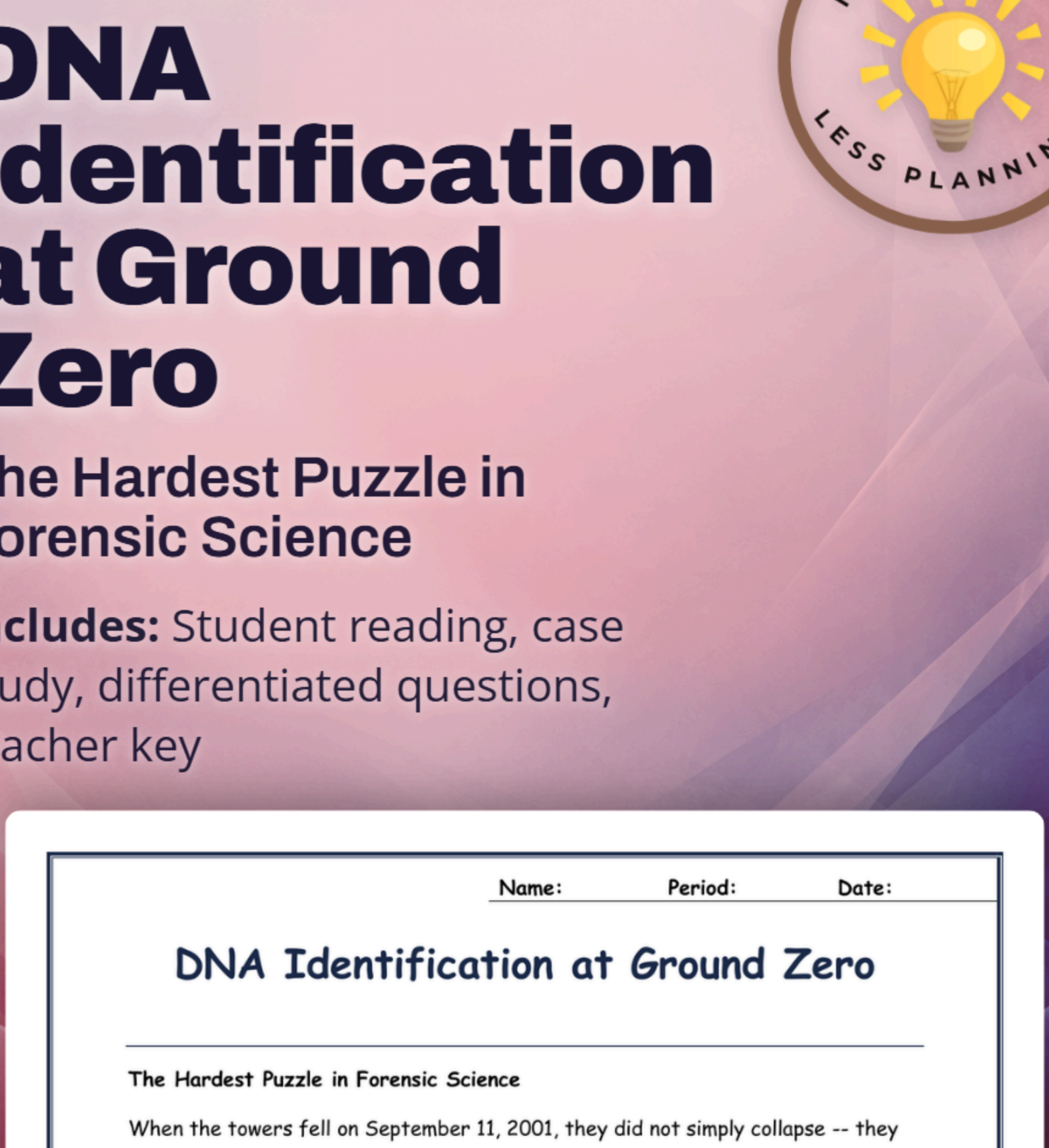
NO PREP

DNA Identification at Ground Zero

The Hardest Puzzle in Forensic Science

Includes: Student reading, case study, differentiated questions, teacher key



Name: Period: Date:

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When the towers fell on September 11, 2001, they did not simply collapse -- they pulverized. Two 110-story buildings, each weighing roughly half a million tons, came down onto themselves in about ten seconds, grinding concrete into powder and twisting steel into ribbons. Of the 2,753 people killed at the World Trade Center, only a few hundred were recovered as whole bodies. Everyone else would have to be identified from fragments. That job fell to the New York City Office of Chief Medical Examiner, the government agency responsible for investigating deaths in the five boroughs. What began that morning became the largest and longest forensic investigation in American history, and it has never officially ended. During nine months of recovery work at Ground Zero, and years of sifting debris at a Staten Island landfill, workers collected roughly 21,900 separate pieces of human remains. Many were smaller than a coin. Fingerprints were useless because there were rarely fingers. Dental records helped in some cases, but only when teeth or jaws survived. Traditional forensic tools were built to identify one body at a time, and they simply could not scale to a disaster of this shape. That left DNA. Every fragment of bone or tissue carried the complete genetic instructions of exactly one person, and if scientists could read those instructions and match them to a name, a family could finally bury someone. Dr. Charles Hirsch, the chief medical examiner in 2001, made a promise that has outlived him: his office would keep testing, keep matching, and keep calling families for as long as the work took.

What DNA Can Say About a Person

DNA is the molecule inside almost every cell that carries the instructions for building and running a living thing. Human beings share about 99.9 percent of their DNA with one another, so forensic scientists ignore the shared portion and focus on the tiny slice that varies. Their main tool is the short tandem repeat, usually shortened to STR. An STR is a short sequence of genetic code that repeats over and over at a known location on a chromosome, and the number of repeats differs from person to person. One individual might have eleven repeats at a given location while a stranger has fifteen. Scientists measure the repeat counts at about twenty different locations and combine them into an STR profile, a string of numbers so specific that the odds of two unrelated people sharing one are smaller than one in a trillion. That profile is what identification actually means in a modern forensic laboratory. There is a second kind of DNA that proved essential at Ground Zero. Mitochondria, the structures that release energy inside cells, carry their own small loop of genetic material called mitochondrial DNA. A single cell holds only one nucleus but can hold hundreds or thousands of mitochondria, so mitochondrial DNA survives in damaged samples where ordinary nuclear DNA has broken apart. It comes with a tradeoff. Mitochondrial DNA passes down almost unchanged from mother to child, which means a person shares it with siblings, cousins on the mother's side, and a maternal grandmother. It can rule a person out or narrow a search, but on its own it can rarely name one individual.

Reference Samples and Kinship Matching

A DNA profile pulled from a bone fragment is meaningless by itself. It is a lock without a key. To turn a profile into a name, scientists need something to compare it against, and that comparison sample is called a reference. The strongest kind is a direct reference: DNA that came from the missing person before the disaster. In the weeks after the attacks, families were asked to bring in toothbrushes, hairbrushes, razors, retainers, and unwashed clothing, along with any stored medical samples. A toothbrush sounds like a strange thing to hand a police officer,

but it may hold thousands of cells from the person's mouth, and those cells produce a profile that belongs to that individual and no one else. Many families had nothing like that to give. Their loved one lived alone, or the apartment had been cleaned, or the person was visiting from another country. For those cases, scientists turned to kinship analysis, which identifies someone indirectly by comparing the unknown profile to the profiles of biological relatives. Children inherit half their nuclear DNA from each parent, so a parent and child share half their markers, and full siblings share about half on average. By collecting cheek swabs from parents, children, and siblings, laboratories could calculate the statistical likelihood that a fragment belonged to a specific missing person rather than to a stranger. Kinship work demands more relatives, more math, and more caution than a direct match, and a single sample can require months of review before the office is confident enough to make a phone call.

Fire, Bacteria, and Time

The remains recovered from Ground Zero were among the most damaged samples forensic science had ever attempted to read. Fires burned in the debris pile for one hundred days, in places at temperatures above one thousand degrees Fahrenheit. Heat shatters DNA into fragments too short to measure. Jet fuel, diesel, and the chemicals released by burning building materials attacked the samples further. Rain soaked the pile, and moisture invited bacteria, which consume tissue and leave their own genetic material mixed into the sample. Bone, usually the most durable evidence a laboratory can receive, had been crushed and heated at the same time. Analysts often ran a sample, got no readable profile at all, and set the fragment aside. Those failures are the reason the work continues today. Every fragment that could not be identified was cataloged, sealed, and stored under controlled conditions rather than discarded, on the theory that technology would eventually improve enough to read it. That gamble paid off. Beginning around 2017, the medical examiner's office adopted next-generation sequencing, a family of methods that reads enormous numbers of short DNA fragments at once and

reassembles them by computer. Techniques designed for ancient bones and archaeological samples turned out to suit Ground Zero remains as well. Older extraction chemistry was replaced with gentler methods that pull usable material from powdered bone. A fragment that produced nothing in 2002 and nothing again in 2010 can produce a complete profile today, which is why new identifications still arrive more than two decades after the attacks.

A Promise Without a Deadline

Roughly 1,100 of the people killed at the World Trade Center have never been identified. That is about forty percent of the victims there, and it means many families received a death certificate but never received their relative. The unidentified remains are not in a warehouse or a cemetery. Since 2014 they have rested in a repository built behind a wall at the National September 11 Memorial and Museum, seventy feet below street level at the original site. The medical examiner's office, not the museum, controls that space. Families can visit a private reflection room beside it, and no one else may enter. The arrangement was controversial, and some families objected strongly to the location, but the underlying purpose was to keep the remains close to the scientists still working on them. That work continues on a schedule no one can predict. In September 2023 the office announced its 1,648th and 1,649th identifications, the first new names in two years, and each announcement follows the same procedure: an independent review of the match, then a call to the family. Families choose in advance how much they want to know. Some ask to be told about every new fragment. Others ask never to be called again, having decided years ago that they had grieved as much as they could. The office honors either choice, and it has committed to continuing the identification effort indefinitely, with no closing date and no point at which a victim is declared unfindable.

Key Information: DNA Identification at Ground Zero

Detail	Information
Agency in charge	New York City Office of Chief Medical Examiner
Victims at the World Trade Center	2,753 people
Remains recovered	About 21,900 separate fragments
Main technique	STR profiling of about 20 DNA locations
Backup technique	Mitochondrial DNA for badly degraded samples
Reference samples	Toothbrushes, hairbrushes, razors, or relatives' DNA
Still unidentified	About 1,100 victims, roughly 40 percent
Most recent milestone	1,648th and 1,649th identifications announced in 2023

Case Study: The Sample That Waited Nineteen Years

Naomi Ellis, 34, is a DNA analyst at the medical examiner's office. On a Tuesday in 2020 she pulls case number 24-118 from cold storage: a bone fragment the size of a thumbnail, recovered from the debris pile in March 2002 and tested unsuccessfully three times since. Naomi grinds a few milligrams into powder and runs it through the sequencing workflow her lab adopted three years earlier. Nine days later a profile appears on her screen, complete at every marker. The computer matches it to a cheek swab given in 2001 by a woman in Queens whose son, a 26-year-old line cook, never came home. Naomi does not make the call herself. The match goes to a review panel, then to a family liaison, then to a file that records what this family asked for years ago. The note reads: contact us every time. Naomi writes in her log, "Fourth attempt. Same fragment. Different decade of technology." She reshelves the tray and pulls the next one.

1. Naomi's laboratory succeeded on the fourth attempt with the same fragment. Using the reading, explain what changed between 2002 and 2020.

_____

_____

2. Why does the office record in advance whether a family wants to be contacted, and what does that policy suggest about its priorities?

_____

_____

Multiple Choice

1. Why could investigators not rely on fingerprints or dental records at the World Trade Center site?
    a) The records were destroyed in the collapse of the towers
    b) Most remains were fragments too small to carry either one
    c) Federal law barred the use of fingerprints in disaster cases
    d) Investigators lacked trained fingerprint examiners in 2001

2. What is the main advantage of mitochondrial DNA in a badly damaged sample?

a) It identifies one individual with complete and absolute certainty

b) It survives heat better than any other molecule

c) Many copies exist per cell, so some survive when nuclear DNA breaks

d) It can be read without any laboratory equipment

3. What makes a toothbrush a stronger reference sample than a sibling's cheek swab?

a) It provides a profile from the missing person, not a relative

b) It contains mitochondrial DNA and nothing else

c) It is easier for a laboratory to store long term

d) It never requires any form of statistical or mathematical analysis

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ STR profile	A) Identifying remains by comparing them to the DNA of biological relatives
2. ___ mitochondrial DNA	B) Newer method that reads huge numbers of short DNA fragments and reassembles them
3. ___ kinship analysis	C) DNA from the missing person's own belongings, such as a toothbrush or razor
4. ___ direct reference sample	D) Genetic loop found in many copies per cell and inherited from the mother
5. ___ next-generation sequencing	E) String of repeat counts measured at about 20 DNA locations, unique to one person

Fill-in-the-Blank

1. Scientists build a profile from repeat counts called _____ repeats.

2. A cell holds many copies of _____ DNA, so it survives damage.

3. Unidentified remains rest in a _____ at the 9/11 memorial site.

Short Answer

Answer each question in 2-4 complete sentences.

1. Why is DNA identification at Ground Zero still unfinished more than twenty years later?

_____

_____

_____

2. Explain why a laboratory stores a fragment that has already failed testing three times.

_____

_____

_____

3. Why does kinship analysis require more caution than a match to a direct reference sample?

_____

_____

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