Name _____ Date _____ Class _____

Real-World Biology: Analysis

CHAPTER 13

DNA Fingerprinting

"Genetic Prints Help Solve Mystery of Girls Switched at Birth." "Murder Conviction Overturned by DNA Testing: Prisoner Released." Headlines such as these have become commonplace in recent years due to the forensic method of DNA fingerprinting, originally developed in Britain in the early 1980s. DNA fingerprinting is a method for visualizing sequences of DNA. Every person (except identical twins) has a unique sequence of base pairs. In DNA fingerprinting, scientists analyze a small number of DNA sequences that are known to vary a great deal among individuals. DNA fingerprinting has become an important tool in investigating criminal cases, identifying bodily remains, tracing heritage, and studying genetic disorders. In this activity, you will investigate the technique of DNA fingerprinting and learn how this science of identity is used to solve problems of family heritage and criminal justice.

Part A: How to Make a DNA Fingerprint

Step 1: DNA is extracted from cells and cut into fragments by restriction enzymes.

Step 2: The DNA fragments are placed on an electrophoresis gel, and electric current is applied. DNA, being negatively charged, moves through the gel to the positively charged electrode. The fragments spread out according to size.

Step 3: DNA fragments are separated by chemicals into single strands. Because the strands will disintegrate after a day or two, they are transferred from the gel onto a sheet of nylon. DNA probes, which are synthetic DNA segments with known sequences, are labeled with radioactive compounds. The probes are then applied to the nylon, and complementary sequences on the DNA fragments being tested attach to the probes by base pairing.

Step 4: The nylon sheet is exposed to X-ray film, and dark bands appear wherever the fragment DNA (from the sample) has attached to the probe.

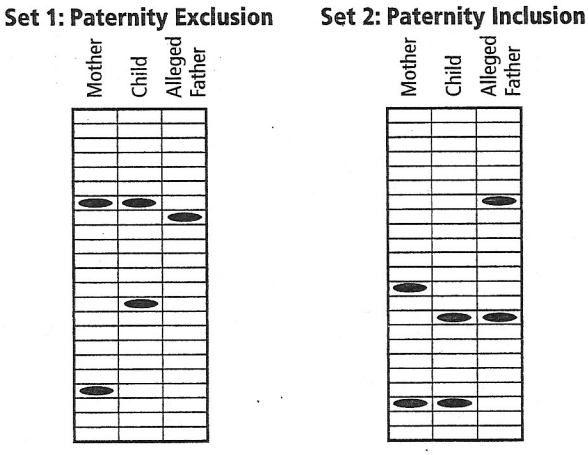


Figure 1

The DNA fingerprints in **Figure 1** can be used to determine the paternity of a child. In Set 1 of the DNA fingerprints, one of the bands in the child's DNA fingerprint is also present in the mother's DNA fingerprint. Because none of the bands in the alleged father's DNA fingerprint matches the child's bands, he cannot be the father.

Analyze and Conclude

Respond to each question.

1. **Identify** In Set 2 of the DNA fingerprints, do any of the bands in the alleged father's DNA fingerprint match a band in the child's DNA fingerprint?

_____

2. **Theorize** What does this result indicate?

_____

_____

Part B: Applications of DNA Fingerprinting

DNA fingerprinting is useful for solving crimes and analyzing kinship relationships. Read the following problems, and analyze the DNA fingerprints to answer the questions.

Analyze and Conclude

Respond to each question and statement.

1. **Analyze** DNA is isolated from a hair found in a knit hat that was recovered from the scene of a bank robbery. DNA fingerprints are derived from the hair sample (labeled *H*) and from samples obtained from seven suspects (labeled *1* through *7*). Analyze the DNA fingerprints in **Figure 2.** To which suspect might the hair belong? Explain.

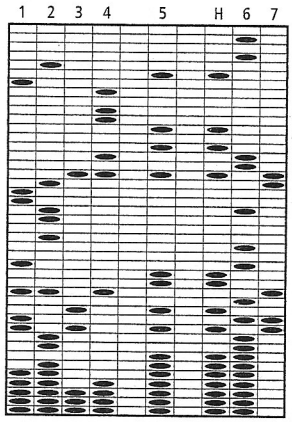


Figure 2

2. **Compare** **Figure 3** shows DNA fingerprints of a blood sample taken from a crime scene and samples taken from seven suspects. Compare the DNA fingerprints. Which suspect could have committed the crime? Explain.

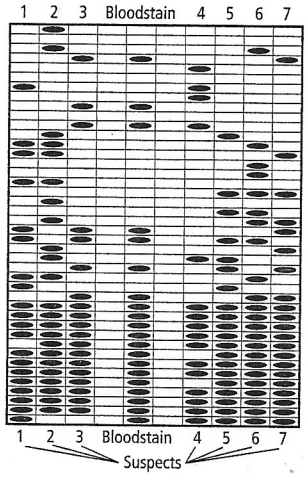


Figure 3

3. **Apply** The DNA fingerprints in **Figure 4** are those of members of three generations of a family, as well as those of some unrelated individuals.
   a. DNA fingerprint 7 is that of a son of two other family members. Which DNA fingerprints are those of his parents?

   b. DNA fingerprint 10 is that of the grandmother. Which DNA fingerprints are those of her daughter and of her daughter's father? Explain.

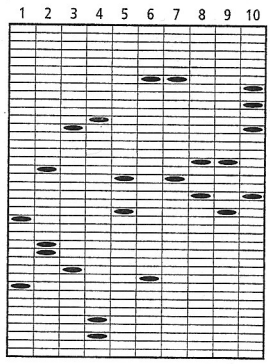


Figure 4

CAREERS IN BIOLOGY

DNA Biology Visit biologygmh.com for information on biological technicians. What are the responsibilities of a biological technician?

Name Period Date

CHAPTER 9

DNA FORENSICS: SOLVING A ROYAL MYSTERY

Pre-AP Activity

You have learned in Chapter 9 how repeat sequences in DNA can yield a DNA fingerprint that can be used to identify people. These fingerprints can be generated from nuclear DNA or mitochondrial DNA (mtDNA). One advantage of mtDNA is its maternal pattern of inheritance—because it is passed directly from mothers to offspring of both sexes, it does not undergo recombination. This keeps mtDNA sequences constant over many generations. Brothers and sisters have the same mtDNA as their mother and all maternal relatives and ancestors, allowing relatedness to be traced along distant branches of the maternal family tree.

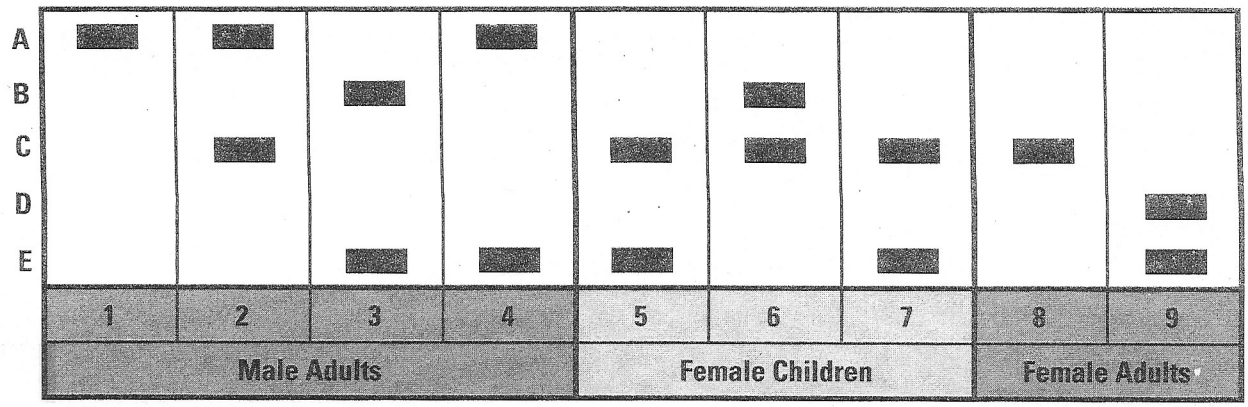
Evidence from one of the most infamous events of the 20th century—the secret 1918 execution and burial of Tsar Nicholas II of Russia and his household—is presented below. Analyze the evidence presented here to determine the identity of a group of skeletons exhumed in 1991 from a shallow grave in Russia.

IDENTIFYING THE REMAINS

On July 16, 1918, members of the Romanov royal household—Tsar Nicholas II of Russia, his wife, the Tsarina Alexandra, their five children, their family doctor, and three servants—were secretly executed by a Bolshevik firing squad and buried in an undisclosed location. Eyewitness accounts by members of the firing squad later noted that shortly thereafter, the bodies of two of the children were removed from the burial site and cremated.

In 1991, nine skeletons were exhumed from a shallow grave near Ekaterinburg, Russia. Physical characteristics of the skeletons revealed that three of the skeletons belonged to female children; two were from adult females; and four were from adult males. Nuclear DNA samples from the skeletons were taken and compared to determine relatedness among them. The table below shows the five genetic markers that were analyzed for comparison.

Test 1



Name Period Date

Answer the following questions on a separate sheet of paper.

1. Look at the DNA markers of the children and compare them to those of the adults. Remembering that offspring get half their DNA from their mother and half from their father, and assuming that the three children share the same parents, determine which two adults could have been the parents of the children. Explain your conclusions. (Hint: Look first at the adult females.)

2. Investigators hypothesized that the remains of five individuals were those of the royal family, while the rest belonged to the doctor and servants. To support their hypothesis, mitchondrial DNA from each female skeleton was compared with that of the Tsarina Alexandra's closest living maternal relative—Prince Philip, the Duke of Edinburgh, whose grandmother was the tsarina's sister. At the same time, mtDNA from the male skeletons was compared with that of Tsar Nicholas II's closest living relative—his great grandnephew James, the Duke of Fife.
Compare the simulated DNA sequences in both tests, looking for differences in bases. Do they support the hypothesis that skeletons 3 and 8 are from the tsar and his wife? Explain your answer.

Test 2: Identifying the Tsarina

mtDNA Donor–maternal lineage	Simulated Test Sequence
Skeleton 5	GTACATT...CAGT
Skeleton 6	GTACATT...CAGT
Skeleton 7	GTACATT...CAGT
Skeleton 8	GTACATT...CAGT
Skeleton 9	GTACATT...CAGC
Prince Philip	GTACATT...CAGT

Test 3: Identifying the Tsar

mtDNA Donor–paternal lineage	Simulated Test Sequence
Skeleton 1	CTTAAGCAC...AT
Skeleton 2	CTTAAGTAC...AT
Skeleton 3	TTTAAGTAC...AT
Skeleton 4	CTTAAGTAC...AC
James of Fife	TTTAAGTAC...AT

3. To further confirm the identity of skeleton 3, the body of the tsar's brother Georgij Romanov was exhumed and mtDNA was sampled. As expected, Georgij's mtDNA was a match. Consider the four tests that were performed and summarize how the evidence suggests that the skeletal remains found at Ekaterinburg belong to the murdered Romanovs.

4. Anna Demidova, Tsarina Alexandra's lady-in-waiting, was among those household members murdered in 1918. Can we presume that skeleton 9 is hers? Explain what type of testing would be needed to provide conclusive evidence.