Handout 3-A
Creating a DNA Fingerprint: Student Lab Investigation

Name _____ Date _____

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Your Job

To re-create the procedures used in a real forensic lab for making a DNA fingerprint, you will use paper, scissors, and graph paper.

Your Steps

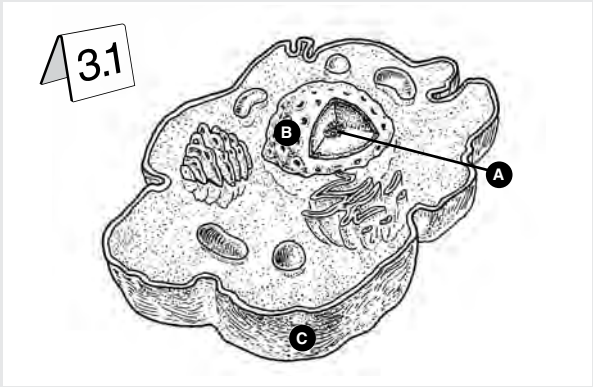
1. Getting the DNA From the Cells

   In a Real Forensic Lab

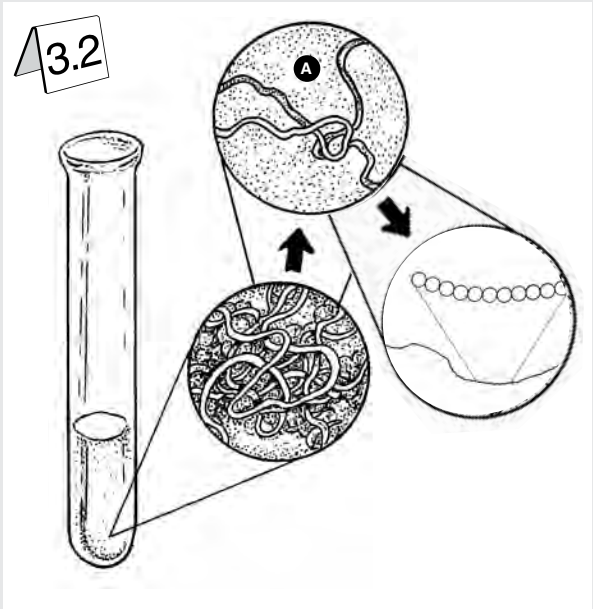
   DNA can be isolated from small pieces of hair, skin, blood, saliva, or other body tissue or fluid. In plants, animals, fungi, and protists, DNA is found in the cell nucleus (Figure 3.1). The first step in the procedure is to destroy the cellular and nuclear membranes so that the heavy DNA molecules can be separated from the rest of the cellular material (Figure 3.2).

   Your Re-Creation

   Cut apart the columns of DNA nucleotide base pairs on "Your DNA Strand." Then randomly tape them together end-to-end to form one long continuous strand. There should be no gap between nucleotides when taped together. Read "DNA: The Golden Key of Forensic Evidence," compare the information to your DNA strand, and discuss these questions.



A: DNA
B: Nuclear membrane
C: Cell membrane



Test Tube With DNA in Liquid.
A: Extracted DNA

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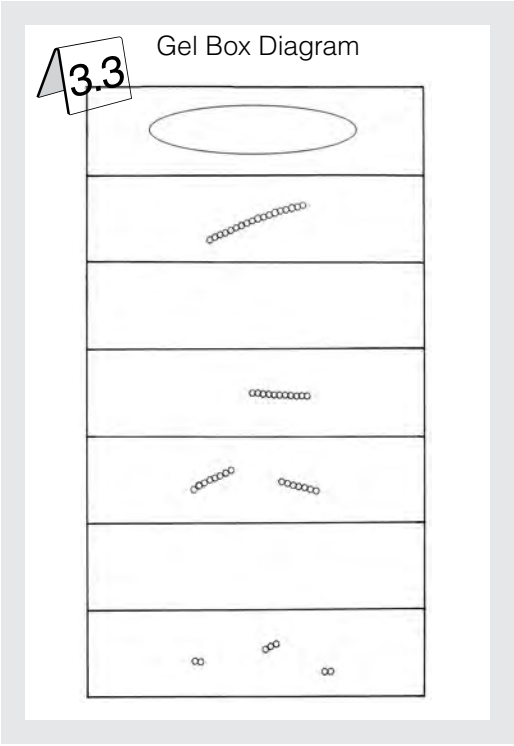
- What does each letter represent?
- What are the four combinations of letters?
- Where can DNA evidence be found?
- Do you need to look at all the DNA to tell individuals apart? Explain your response.

2. Making the DNA Fingerprint



In a Real Forensic Lab: Cutting DNA with Enzymes

In the lab, scientists use restriction enzymes to cut the DNA strands in very specific ways. When a restriction enzyme is mixed with the DNA, it targets and cuts the double strand at specific nucleotide base pairs. The resulting "breakdown" will have DNA fragments of differing lengths (Figure 3.3).

Your Re-Creation

Scissors take on the role of the restriction enzyme. Starting at the top of "Your DNA Strand," cut the paper after every **GC** pair. Do this for the entire strand. When done, you will have a pile of different-sized DNA pieces.

In a Real Forensic Lab: Sorting DNA Segments in the Gel Box

The DNA breakdown is put into the starting well of a gel box. When an electrical current is applied, the pieces move across the gel toward the far end of the box. The smaller pieces will move quickly through the gel, traveling a greater distance than the longer, heavier pieces. Some pieces might be so large that they do not move out of the starting well.

Your Re-Creation

Set all DNA pieces at the starting well of the gel box diagram (Figure 3.4). Count the nucleotide base pairs for each DNA piece and move it into the corresponding gel box section. For instance, pieces with 1 to 3 pairs are light

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and move to the end of the gel box. Pieces 19 or more pairs long are too heavy to move out of the starting well.

In a Real Forensics Lab: Creating the DNA Fingerprint "Photograph"

Once all of the pieces are separated, the gel is stained and "photographed," showing a pattern (Figure 3.5). The DNA pieces are seen as dark bands of different sizes in each section of the gel. Parts of the banding pattern are the same for all individuals of one species, while other parts are different for every individual.

Your Re-Creation

After all DNA pieces have been moved to their correct location in the gel box, count the number of pieces in each section. Record your data in the gel box summary, showing the number of nucleotide base pairs in a gel box section and the number of DNA pieces in each section.

Gel Box Summary

# nucleotide pairs	# DNA pieces
19+	_____
16-18	_____
13-15	_____
10-12	_____
7-9	_____
4-6	_____
1-3	_____

Gel Plate for DNA Electrophoresis* 3.4

12+ cm (19+ pairs)	Starting Well
10–12 cm (16–18 pairs)	
8–10 cm (13–15 pairs)	
6–8 cm (10–12 pairs)	
4–6 cm (7–9 pairs)	
2–4 cm (4–6 pairs)	
0–2 cm (0–3 pairs)	

* This is a sample diagram. Teachers will have to re-create it at approximately 8 1/2" × 11" for student use.

(Arrow = Electric current moves DNA pieces across gel lane.)

3.5 DNA Fingerprints

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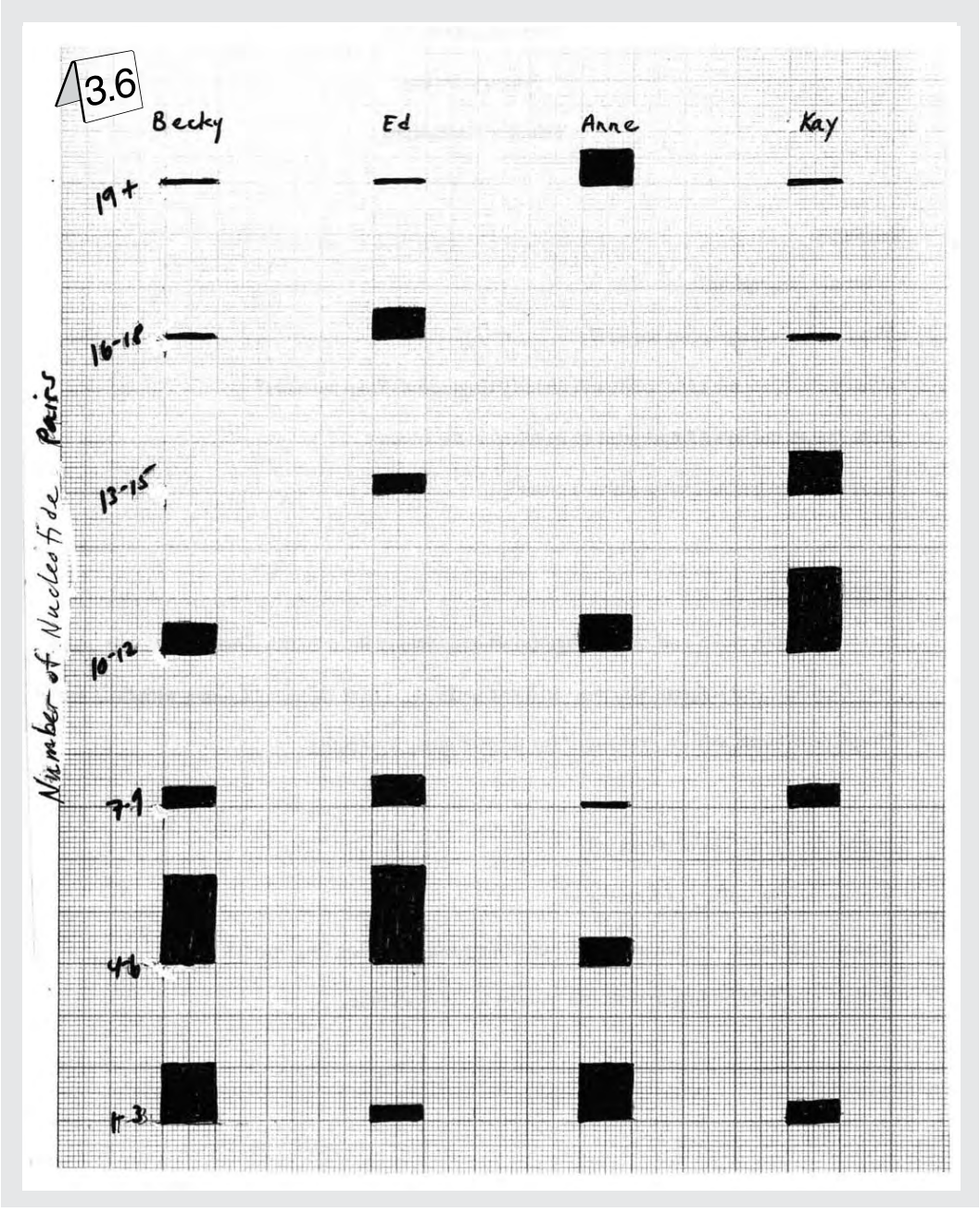

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Creating a DNA Fingerprint: Student Lab Investigation

Make a "photograph" of the DNA fingerprint shown on your gel box by using graph paper to draw a graph that looks like the bands (see Figure 3.6). For each section, draw a band that matches the number of DNA pieces.

3. Identifying an Individual by a DNA Fingerprint

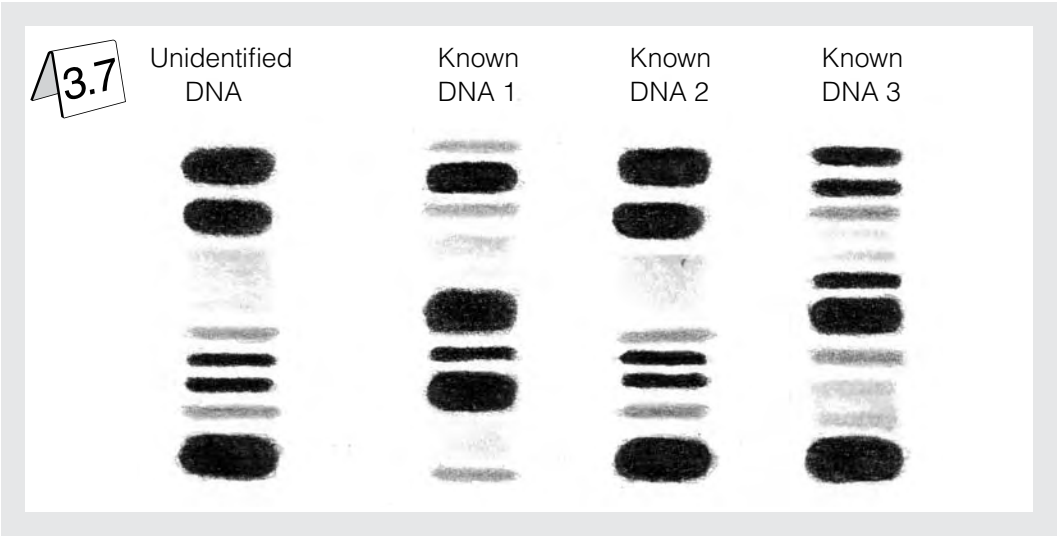
In a Real Forensic Lab

The result of this procedure is called a DNA fingerprint because, like actual fingerprints, the image can be matched to only a single individual (Figure 3.7). If similar or identical images are obtained from different samples, the DNA came from the same individual or from genetically similar individuals. Scientists can also compare DNA fingerprints of different species and identify the banding pattern that members of a species have in common.

Scientists can try to match a DNA fingerprint from blood, hair, skin, or other tissue found at the scene of a crime to a DNA fingerprint from suspects or victims. They can also match parts of a child's DNA to that of "unidentified" parent (i.e., in situations where parentage is uncertain) or other potential relatives. Still another use for this procedure is classifying organisms into species and subspecies.

Your Re-Creation

Post your DNA fingerprint "photographs" alongside those of others in the class. Compare and search for matches. Discuss the significance of finding matches or no matches.



Handout 3-A
Creating a DNA Fingerprint: Student Lab Investigation

What Did You Discover About Creating a DNA Fingerprint?

1. Why is DNA considered the golden key of forensic evidence?

2. If 96% of a chimpanzee's DNA is the same as human DNA, how much human DNA could determine individual characteristics?

3. Which DNA fingerprint image would look more similar:

   a. That of an Asian elephant and red-tailed hawk or an Asian elephant and African elephant? Explain.

   b. That of a child and his mother, or a child and a neighbor? Explain.

4. Read your comments on DNA fingerprints in your Investigator Notebook (*What do I know…. What do I want to know…*). Now answer this question: *What have I learned about DNA fingerprints?*

STUDENTS: TAKE A CLOSER LOOK

- How can DNA from blood be unique to an individual, while blood type is only unique to a large group of people?
- If the banding pattern of a DNA fingerprint can identify a species, how can it also identify an individual?
- Why do scientists only look at certain sections of DNA and not all of it?
- DNA is commonly taken from blood, but a red blood cell does not have a nucleus. Where is the DNA in blood?
- How is the restriction enzyme responsible for making the individualized banding pattern of a DNA fingerprint?
- How has the ability to create a DNA fingerprint changed criminal investigations from the 1980s and before?

Handout 3-B
Your DNA Strand

Name _____ Date _____

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TA	AT	GC	CG	GC	AT
GC	CG	AT	AT	AT	CG
AT	CG	CG	CG	TA	CG
CG	GC	TA	AT	TA	CG
TA	AT	CG	TA	TA	CG
AT	TA	CG	GC	AT	CG
TA	TA	CG	TA	CG	AT
CG	AT	TA	TA	GC	GC
CG	AT	GC	AT	CG	CG
GC	AT	AT	AT	CG	TA
AT	CG	AT	AT	AT	CG
TA	TA	TA	TA	CG	TA
GC	CG	AT	AT	GC	AT
AT	CG	CG	CG	CG	TA
CG	TA	AT	CG	TA	CG
AT	AT	TA	CG	AT	CG
TA	AT	GC	TA	AT	CG
TA	GC	TA	AT	AT	AT
AT	TA	CG	TA	CG	CG
CG	TA	GC	CG	AT	CG
AT	CG	AT	GC	TA	GC
TA	AT	CG	CG	TA	TA
CG	TA	TA	TA	TA	TA
CG	TA	AT	AT	TA	TA
CG	CG	AT	CG	AT	AT
TA	CG	CG	TA	AT	AT
TA	GC	CG	TA	CG	TA
AT	AT	CG	TA	CG	CG
CG	AT	TA	AT	TA	TA
GC	AT	AT	AT	CG	AT
AT	TA	TA	CG	CG	AT
AT	CG	TA	CG	GC	AT
CG	CG	CG	GC	CG	CG
CG	AT	AT	AT	TA	TA
TA	TA	TA	AT	CG	TA
AT	TA	CG	AT	TA	AT
TA	TA	AT	TA	AT	CG

Handout 3-C
DNA: The Golden Key of Forensic Evidence

Name _____ Date _____

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DNA (deoxyribonucleic acid) can be taken from hair, bones, blood plasma, skin, saliva, and other cellular tissue or body fluids. Since the mid-1980s, DNA fingerprinting has become the strongest evidence used to connect a person to a crime scene, to trace family relationships, and to identify species and relationships among species.

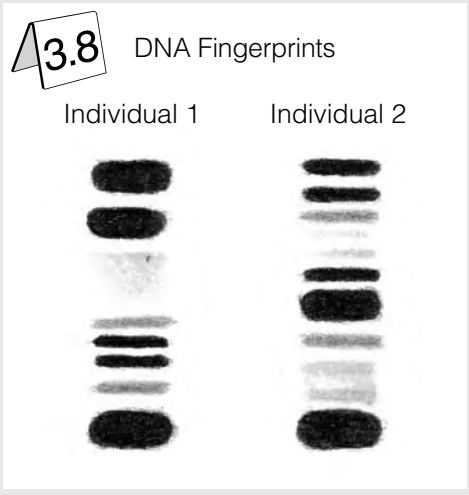
What Do Forensic Scientists Need to Know?

Scientists complete the lab procedures for making a clear DNA fingerprint from DNA evidence. Because they have a thorough understanding of the structure of DNA and its unique features among species and individuals, they can interpret the fingerprints. When scientists match DNA fingerprints from evidence with those obtained from the suspect's DNA, this evidence often becomes the pivotal proof of a person's guilt. In contrast, a lack of a DNA match has reversed court decisions by supporting a person's innocence.

What Is DNA Fingerprinting?

DNA holds the genetic instructions for all traits of an individual, from eye color to disease susceptibility. Found in the cells of every living organism, it is unique for each species and for each individual. Most DNA is the same in individuals of the same species, including humans. This lets forensic scientists who are investigating wildlife crimes match DNA evidence to a particular species or related species. In contrast, other sections of DNA are different for each individual. Scientists examine these unique sections to find a one-to-one match between evidence and a suspect, victim, or witness.

Scientists can take the DNA from evidence and make a picture, or "fingerprint," of the individual it belongs to. Then they can compare it to DNA fingerprints of suspects, victims, or witnesses (Figure 3.8).

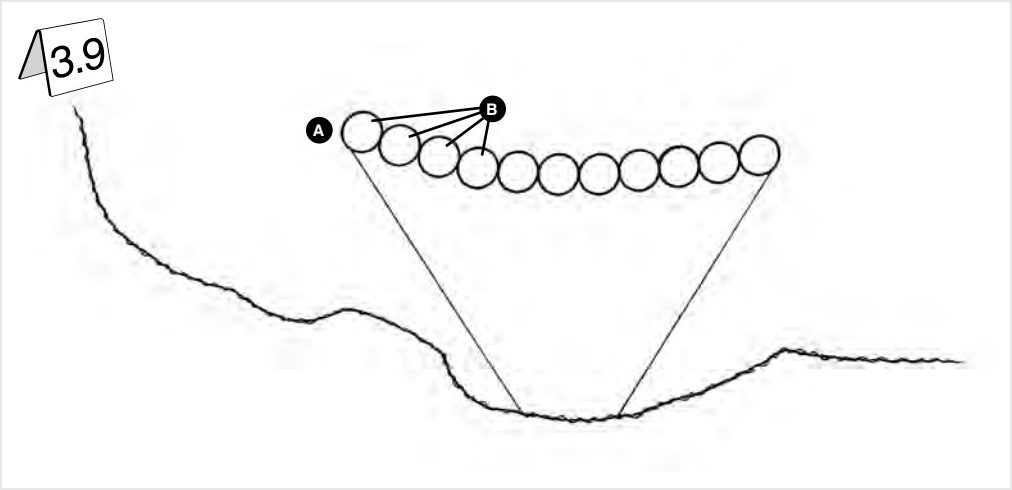


Handout 3-C

DNA: The Golden Key of Forensic Evidence

Why Is a Person's DNA Unique?

DNA is a unique sequence of nucleotides that come from mom and dad. The sequence of the nucleotides carries messages, or codes, for the traits of a particular species and individual. A DNA sequence has a four-letter alphabet of nucleotide bases—guanine, thymine, cytosine, adenine—that is written like this: AATCGTTTGACCTCTAGG. When in the double helix shape, the nucleotide bases are organized in a string of nucleotide base pairs: A-T, T-A, G-C, C-G (Figure 3.9). Adenine only pairs with thymine, and cytosine only pairs with guanine.



A: DNA (enlarged section)
B: AT, CG, CG, TA, etc.

The Latest in DNA Fingerprinting Methods

The method you have demonstrated in this lesson is the original lab technique for creating a DNA fingerprint. The problem with using this method on crime evidence is that it requires a large amount of high-quality DNA. If there is too little evidence, or the evidence is damaged or contaminated, this method may not work well.

(Continued on p. 82)

Handout 3-C
DNA: The Golden Key of Forensic Evidence

This problem was solved by the development of PCR (Polymerase Chain Reaction), a method using an enzyme that will make many copies of one small section of DNA.

Scientists focus on a locus (location) of DNA that they know varies greatly among individuals. These sections do not code for a trait, but repeat a pattern of 2–10 nucleotide base pairs. If the number of repeats in two DNA samples is different, the scientists can conclude that the samples came from two different people.

Person 1

——— CACACACA ———

OR

Person 2

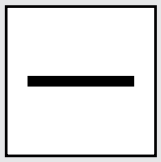
CACACACACACACA ———

After using PCR to make enough copies of this section to make a visible image, scientists put the DNA in a gel electrophoresis box (as you did in the lab) to separate and identify it.

Many copies of the section made:

CACACACA
CACACACA
CACACACA
CACACACA
CACACACA, etc.

Gel image may be only one or two bands. The width and location of the band in the box determines a match.



REFERENCE

Schefter, J. 1994. DNA fingerprints on trial. *Popular Science* (Nov.): 60–64.