



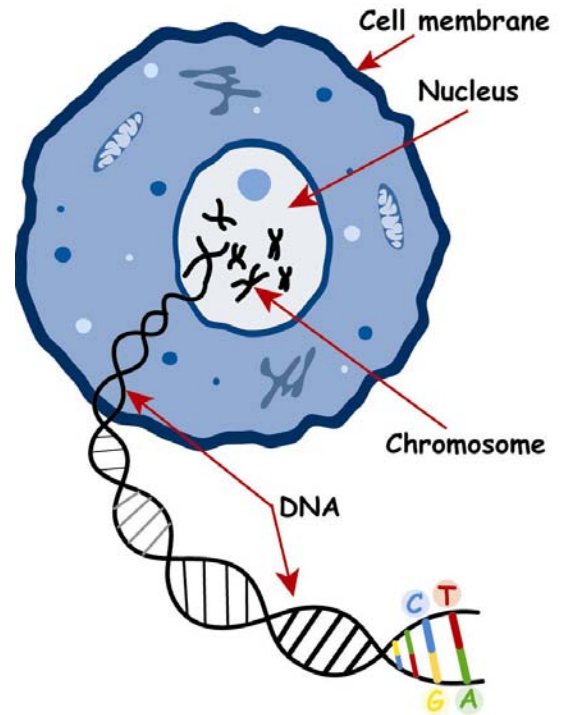
This DNA extraction laboratory is an activity to facilitate learning about cells and the structures inside of them. All living things are made of cells. Inside cells are smaller structures called organelles that work to perform different functions, or jobs, within the cell. Included are a pre-laboratory activity to aid in understanding organelle functions and a laboratory activity in which students will isolate and observe DNA from two types of cells.

## Background Information

All living things are made of cells. Cells are the basic unit of life and make up all plants, animals and bacteria. In plants and animals, cells often work together to form tissues; groups of these tissues are called organs. For example, heart cells make up heart tissue, which in turn makes up the organ called the heart. The cells in your heart work together to push red blood cells through your body. Red blood cells carry oxygen to all parts of your body and oxygen is used to produce energy so your body can survive.

Inside cells are smaller structures called organelles. These tiny structures act like factories that help the cell perform certain tasks such as general repairs, removing waste, and reproduction.

The three main parts of the cell are the **nucleus**, which holds **DNA**, the **cell membrane**, which surrounds and protects the cell, and the **cytoplasm**, which is the jelly-like part of the cell between the membrane and the nucleus. All of the smaller organelles, such as **mitochondria**, are found in the cytoplasm.



2002 Mary S. Gibbs

Cell Part	Function in the Cell
Cell Membrane	Security guard: checks what goes in and out of the cell
Mitochondria	Powerhouses: generates energy for the cell
Membrane Receptors	Gather information and deliver it to the nucleus
Nucleus	The “brain” or control center for the cell
DNA	Contains instructions for the cell, found in the nucleus



**Deoxyribonucleic acid** or **DNA** is the molecule that controls everything that happens in the cell. DNA contains the genetic code or commands that direct the activities of cells and ultimately, the body. DNA is present in all living things from bacteria to animals. In animals, it is found in almost all cell types except for usually in red blood cells.

DNA is made of two spiral strands that wind around each other like a twisted ladder. The rungs of the ladder are made up of nucleotides: **adenine (A)**, **thymine (T)**, **cytosine (C)**, and **guanine (G)**. These nucleotides pair together: adenine with thymine and cytosine with guanine. These A-T and C-G pairs make up the rungs of the ladder. The different nucleotides are like a four-letter alphabet and can spell out different words or codes. A **gene** is a long series of the four letters (nucleotides) that contains instructions for the cell to make a particular protein.

DNA is the largest known molecule. A single unbroken strand can contain millions of atoms. When DNA is released from a cell it typically breaks up into tiny fragments. These tiny fragments have a slightly negative electric charge. Salt ions, common in many solutions, are attracted to the negative charges on the DNA fragments and prevent them from adhering to one another. By controlling the salt concentration of the solution containing the DNA fragments, DNA can remain fragmented or become very “sticky” and form large globs of molecular material.

Since DNA is an essential molecule to all living things (with the exception of some viruses), it is not surprising that elaborate mechanisms to protect it have evolved. In order to extract DNA successfully, it is helpful to understand these protective mechanisms.

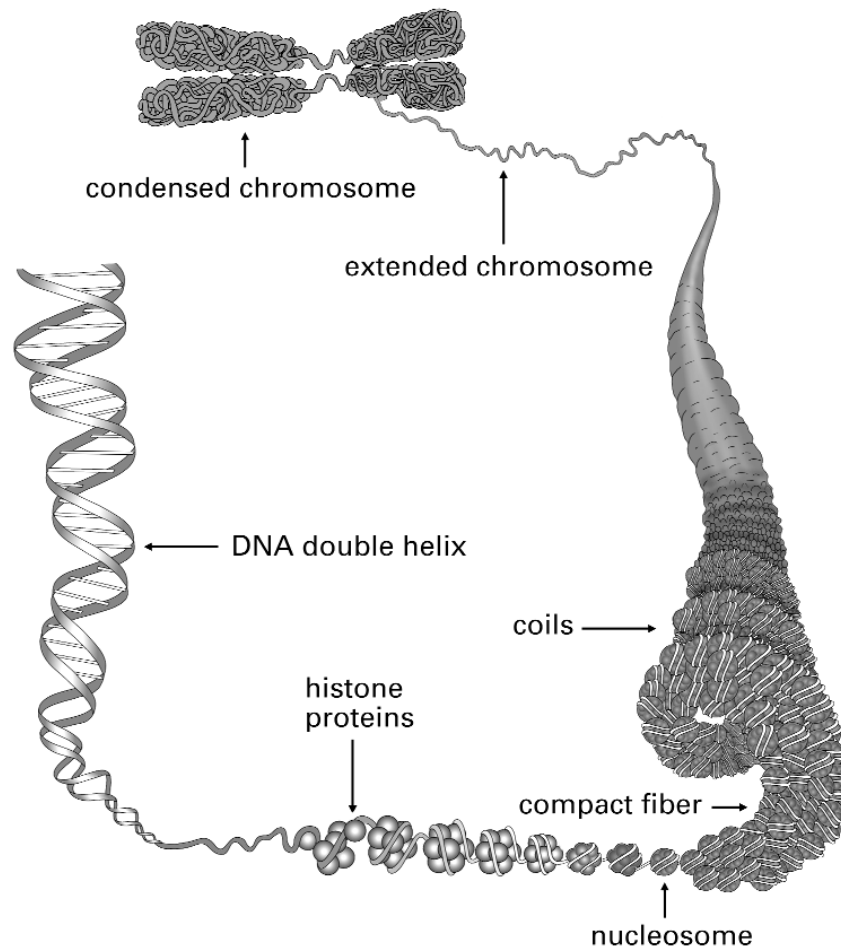
The simplest organisms do not have the protection of a nucleus; this group of organisms is called **prokaryotes**. Common prokaryotes are bacteria. The DNA of bacteria floats around in the cytoplasm and is protected from invading viral DNA by **restriction enzymes** that can cut foreign DNA into small pieces. So how do the bacteria prevent their own DNA from being digested by these enzymes? The bacterial DNA has chemical groups called **methyl groups** attached to it which prevents the restriction enzymes from cutting it. Bacteria have a relatively simple protection mechanism. As organisms get more complex, so does the protection of their own DNA.

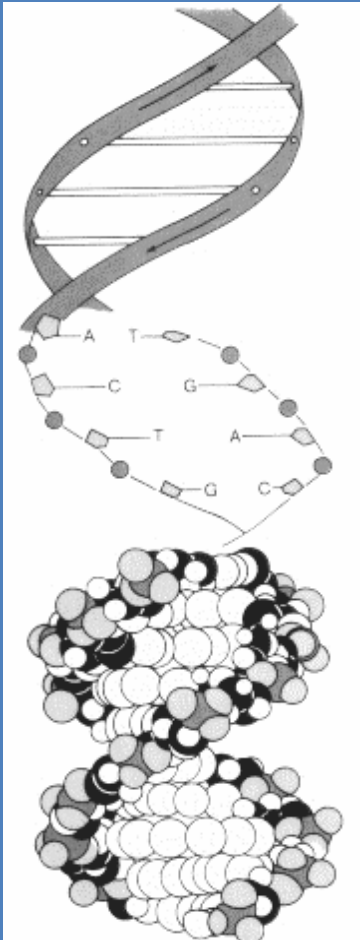
**Eukaryotic** organisms keep their DNA contained within a nucleus, protecting it from activities going on in the cytoplasm. Plants have the extra protection of a cell wall. All eukaryotes have DNase enzymes floating around in their cytoplasm that can cut DNA. In order to extract spoolable DNA, it is necessary to denature, or breakdown, these enzymes before rupturing the nucleus. Heat or pH changes are often used to denature proteins and enzymes. DNA is a relatively sturdy molecule but it is very long and can break when it is removed from the nucleus. If the DNA is broken or sheared in too many places, it won't spool and is harder to capture effectively. It is important to be relatively gentle in the last steps of DNA extraction and to avoid violent shaking or mixing that would shear the DNA.



The process of isolating DNA requires that it be released from a cell whether it is a plant (which has extra protection with a cell wall), animal, fungi, or bacterium. Detergents and soaps breakdown cell membranes and proteins so that the DNA can be released. Protein enzymes or **proteases**, like those in contact lens cleaner or “Ultra” forms of laundry detergent, can be used to further this process of breaking down proteins.

Once the DNA fragments are released into solution, the DNA can be spooled together by using ice-cold alcohol. A small layer of alcohol is added to the top of the solution containing the cellular fragments. The DNA will collect at the interface between the alcohol and the cell solution. The DNA can then be captured, or spooled, onto a wooden stick or glass rod. The alcohol allows the DNA fragments to stick together once again and you have a blob of DNA to examine. Although this method is effective at isolating DNA, the DNA is by no means pure. Other materials like protein and cell fragments are carried along. Additional steps can be completed to remove proteins and cellular debris, thereby purifying the isolated DNA.





#### The structure of DNA.

DNA is composed of a series of nucleotides which bind to each other through hydrogen bonding. In DNA, adenine always pairs with thymine and cytosine always pairs with guanine. The joining of the two DNA strands by hydrogen bonding forms the characteristic double helix structure of DNA.

Photo source:

<http://academy.d20.co.edu/kadets/lundberg/images/biology/dna71.gif>

## DNA PROFILING

In 1984, a British geneticist named Alec Jeffreys developed a technique that utilized variation in DNA sequences to identify individuals. This technique was called **DNA fingerprinting**. Since then, DNA fingerprinting, now often called **DNA profiling**, has been used in forensic and legal cases around the world. Although employed in less than 1% of criminal cases today, DNA evidence has become invaluable in courtrooms and in situations where relatedness or identity is in question.

Every cell in the human body, with the exception of gametes and mature red blood cells, contains the same complete set of genetic information. Humans have about three billion base pairs of DNA in their genome, but only about three million bases, or **about 0.1% of the genome, vary between individuals**. This means that for any two random individuals, about 99.9% of their genetic sequence is exactly the same. The exceptions to this are related individuals, who are more genetically similar, and identical twins, whom theoretically have exactly the same genetic code (given no mutations). Despite this striking level of similarity, individuals will have unique sequences within this 0.1% variation that can identify them from any other individual in the world. Since the development of DNA profiling, several methods for identification have been

employed. Each method begins with the collection of DNA. DNA is commonly collected from sources such as blood, saliva, and hair follicles, but almost any cell type can be used. Listed are common DNA profiling techniques. Keep in mind however,



that certain aspects of some techniques are often applied to and used with others, and there are many technique variations possible when performing DNA profiling.

## PCR ANALYSIS

This technique allows scientists to analyze much smaller samples of DNA. The **Polymerase Chain Reaction (PCR)** technique is used to make millions of copies of a particular DNA sequence. PCR can be used to amplify sections of DNA that scientists have identified as being highly variable amongst individuals. One example is **Variable Number Tandem Repeats (VNTRs)**. VNTRs are sequences of DNA, nine to eighty nucleotides in length, that repeat, in tandem, one after another. Individuals vary in the number of repeats of a given VNTR. By analyzing many VNTRs, scientists can produce a highly unique DNA profile for the individual.

## RESTRICTION ENZYMES

DNA restriction analysis is based on two assumptions:

- DNA molecules can be identified by a difference in the sequence of bases
- Enzymes, produced naturally by bacteria, cut DNA molecules at *specific* sites identified by the difference in the sequence of bases.

When a restriction enzyme is used to cut *different* DNA samples, the size and number of the fragments generated will be *unique* to each molecule. In the example below, both DNA1 and DNA2 are cut with the same enzyme, HaeIII. Note that the enzyme cuts only at its particular recognition site (GGCC). A one base pair substitution (a point mutation) leading to GTCC for example, would result in no cutting. After the DNA is “digested” by restriction enzymes, the fragments remain mixed in solution and indistinguishable from one another. In order to separate and visualize the resulting DNA bands, **agarose gel electrophoresis** is performed.

### Restriction Enzyme

(ri-strik-shn en-zIm) – A tool scientists use to “digest or cut” DNA at a particular sequence.

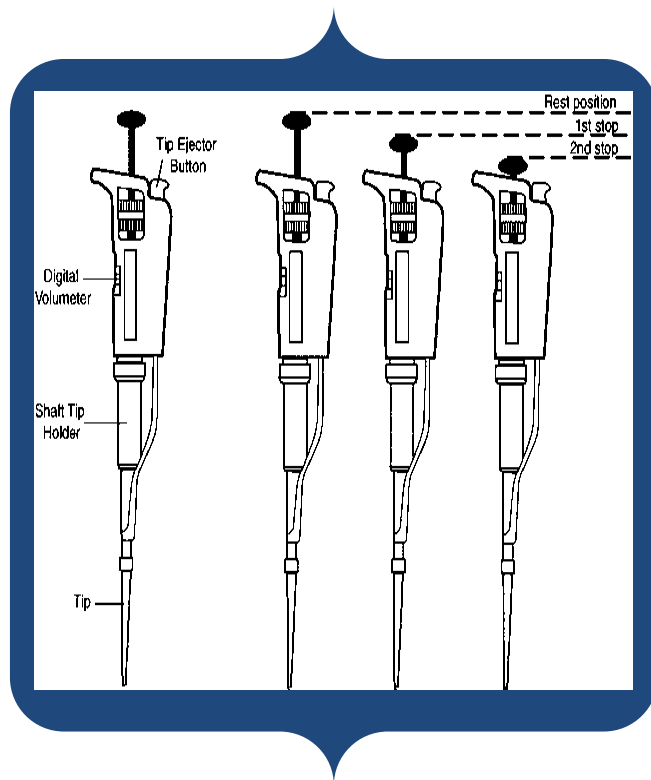
## Micropipette Explanation

$$1 \text{ L} = 1,000 \text{ mL}$$

$$1 \text{ mL} = 1,000 \mu\text{L}$$

### Micropipette Procedure

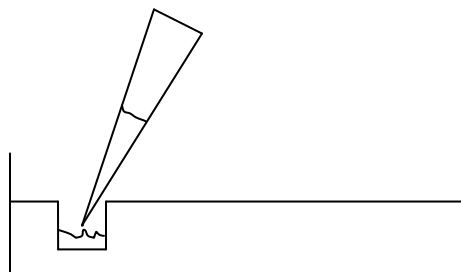
1. Adjust the pipette to the desired volume by turning the dial. Do not turn the dial beyond the volume range for the pipette.
2. Firmly press a new tip onto the pipette by inserting the pipette into the tip while the tip is still in the box.
3. Get tip out without touching it with your hands; this is to prevent contamination of the samples.
4. Draw up liquid from the micropipette
  - Depress the plunger to the first stop to measure the desired volume and hold the plunger in that position.
  - Holding the pipette vertically, immerse only the very end of the tip into the liquid to be transferred.
  - Slowly release the plunger to draw up the liquid.
  - Wait 1 – 2 seconds to be sure the full volume of sample is drawn up into the tip.
5. Dispense the liquid
  - Place the tip into the container where the liquid is to be released.
  - Slowly depress the plunger to the second stop to blow out all of the liquid in the tip.
  - Remove tip out of liquid.
  - Release plunger carefully.
  - Eject tip into a waste container.





## Practice Gel Loading Exercise

1. Set the micropipette to 10  $\mu\text{L}$
2. Add a tip on the end of the micropipette.
3. Remove the lid of the practice agarose gel
4. Make sure you can clearly see the wells.
5. Microcentrifuge the practice loading dye.
6. Select a well to pipette the dye into.
7. Draw up 10  $\mu\text{L}$  of loading dye.
8. Lower the tip filled with the dye into a well to be filled.
9. Carefully dispense all of the 10  $\mu\text{L}$  of dye into the well.
10. Examine your practice gel to make sure that the tip did not poke through the bottom of the well or rip between the wells.
11. Repeat steps 1 – 10 until you are comfortable with loading samples onto a gel.





*Lab associates,*

*This past week I have made an amazing discovery – inside of different cells I have found a material I have never seen before! Unlike the proteins that we have found in cells, this new substance comes from the nucleus of the cell and is not damaged by protease enzymes. Thus, it cannot possibly be anything we already know of. I have been calling it nuclein.*

*It is very interesting to try different cells and materials to see what contains nuclein. Through my experiments, I have found nuclein in both cells from a cow and from salmon, but have not been able to find any in water.*

*I am very interested to see if nuclein is also in plants and would like for you to set-up an experiment using a fruit or vegetable.*

*Good luck!*

*Johann Meischer*



## DNA Extraction PART I:

1. Identify the samples you will use in your experiment today:

**Positive Control:** \_\_\_\_\_  
This is the sample expected to contain DNA.

**Negative Control:** \_\_\_\_\_  
This is the sample not expected contain DNA.

**Experimental S:** \_\_\_\_\_  
You will determine if the sample contains DNA.

**Experimental K:** \_\_\_\_\_  
You will determine if the sample contains DNA.

**Experimental B:** \_\_\_\_\_  
You will determine if the sample contains DNA.

2. Write a hypothesis about your experimental sample, using an "if/then" statement.

Make sure your hypothesis includes:

- whether the experimental sample will or will not contain DNA
- a comparison to the (positive or negative) control you believe the experimental samples will resemble

**Experimental Sample S (Strawberry):**

\_\_\_\_\_  
\_\_\_\_\_

**Experimental Sample K (Kiwi):**

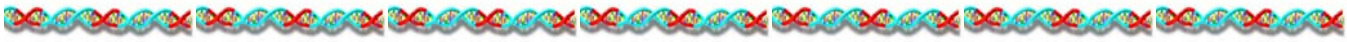
\_\_\_\_\_  
\_\_\_\_\_

**Experimental Sample B (Banana):**

\_\_\_\_\_  
\_\_\_\_\_

3. Be sure you have five capped test tubes:

- (-) for negative control which contains 2 mL of distilled water
- (+) positive control tube which contains 2 mL of salmon cells
- (B) for experimental sample banana
- (K) for the experimental sample kiwi
- (S) for experimental sample strawberry
- Be sure you have eight labeled plastic pipettes:  
**S, K, B, dH<sub>2</sub>O, DNA Buffer, 3% SDS Buffer, NaCl, and Ethanol.**



4. Take the experimental Samples:
  - **S (strawberry)**
  - **K (kiwi)**
  - **B (banana)**
  
5. Using the plastic pipettes labeled **dH<sub>2</sub>O**, add 7 mL of distilled water (dH<sub>2</sub>O) to each zip-lock bag:
  - **S (strawberry)**
  - **K (kiwi)**
  - **B (banana)**
  
- 6. Seal the bag.**
  
7. Using the plastic pipettes labeled **DNA Buffer**, add 3 mL of DNA buffer to each zip-lock bag:
  - **S (strawberry)**
  - **K (kiwi)**
  - **B (banana)**
  
- 8. Remove the air from the zip-lock bag.**
  
- 9. Seal the bag.**
  
10. Gently mash up the experimental sample within the zip lock bag:
  - **S (strawberry)**
  - **K (kiwi)**
  - **B (banana)**
  
11. Identify the beaker labeled **S** with the cheesecloth over the top of the beaker.
  
12. Carefully open the bag and pour off all of the liquid experimental mixture (avoid solid chunks) into the beaker.
  
13. Squeeze the cheesecloth to make sure all liquids are within the beaker.
  
14. Identify the beaker labeled **K** with the cheesecloth over the top of the beaker.
  
15. Carefully open the bag and pour off all of the liquid experimental mixture (avoid solid chunks) into the beaker.
  
16. Squeeze the cheesecloth to make sure all liquids are within the beaker.
  
17. Identify the beaker labeled **B** with the cheesecloth over the top of the beaker.



18. Carefully open the bag and pour off all of the liquid experimental mixture (avoid solid chunks) into the beaker.
19. Squeeze the cheesecloth to make sure all liquids are within the beaker.
20. Use the plastic pipette labeled **dH<sub>2</sub>O** to add 2 mL of distilled water into the tube labeled — which represents the negative control.
21. Examine the + (**positive control**) test tube in the test tube rack.
22. Make sure there is 2 mL of liquid solution in the test tube labeled +.
23. Use the plastic pipette labeled **S** to add 2 mL of the liquid experimental sample into the tube labeled **S**.
24. Use the plastic pipette labeled **K** to add 2 mL of the liquid experimental sample into the tube labeled **K**.
25. Use the plastic pipette labeled **B** to add 2 mL of the liquid experimental sample into the tube labeled **B**.
26. **Add 1 mL of DNA buffer** (using the **DNA Buffer** pipette) to each of the white capped test tubes.

**Be careful not to touch the tip of the pipette to the inside of the test tubes or your samples may become contaminated.**

27. Re-cap the tubes and mix well by inverting.
28. Allow the tubes to sit in the rack for at least **5 minutes** (the longer you wait, the better your results).
29. **Add 2 mL of ethanol** (using the **Ethanol** pipette) slowly down the side of each of the white capped tubes to form a layer that floats on top of each sample. **DO NOT MIX THE SAMPLE.**

**If DNA is present it should precipitate out in white or clear clumps that may also look like cobwebs or gooey strands.**



30. Which samples contained DNA? Circle your answers:
- |                          |     |    |
|--------------------------|-----|----|
| <b>Positive Control:</b> | YES | NO |
| <b>Negative Control:</b> | YES | NO |
| <b>Experimental S:</b>   | YES | NO |
| <b>Experimental K:</b>   | YES | NO |
| <b>Experimental B:</b>   | YES | NO |

**What is the purpose of the DNA buffer?**

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**Did you notice white particles in your sample? \_\_\_\_\_**

**What are the white particles floating around in your sample?**

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**Were the hypotheses supported by the data you observed?**

**Experimental S (strawberry):**

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**Experimental K (Kiwi):**

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**Experimental B (banana):**

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# CITY POLICE DEPARTMENT

CONFIDENTIAL

## INCIDENT DATA

<b>Incident Type:</b>	Museum Theft	<b>Complaint Status:</b>	Pending DNA Results
<b>Processed by:</b>	Officer Joe Friday	<b>Other Officers:</b>	Officer Dee Enae Officer Ligase

## PROPERTY

<b>Property Code:</b>	Jewelry/Precious Metal	<b>Owner's Name:</b>	City Museum
<b>Name:</b>	Crown Jewels	<b>Value:</b>	\$1,000,000

## BURGLARY DATA

**Method of Entry:** Unlawful Entry through broken window

**Narrative:** The crown jewels were allegedly stolen from the City Museum. Once on the scene, I noted that the only window in the room was broken. Officer Ligase approached me and said that there were no prints or any apparent evidence left at the crime scene. However, upon further inspection of the window, my partner, Dee Enae, noticed that there was some blood on the window sill. The thief had cut himself on the broken glass. The blood sample was collected and sent to the crime lab via the messenger, R. Renee, who gave the package to the technician Edna N. Zime.

## SUSPECT DATA

**Suspect Number:** 1

**Name:** Pockets Peterson

**Brief Description of Suspicion:** A widely known and successful crime thief. Peterson has been known to brag that he could get by any security system. He said he would prove it by someday taking the crown jewels. No stone has been known to have higher security.

**Suspect Number:** 2

**Name:** Cruella "The Cat" Blanchard

**Brief Description of Suspicion:** Owns the largest private collection of precious stones in the world. She has offered millions of dollars for them. Having been a member of the prestigious ninja swat team, she has the talent and guts to pull off such a crime.

**Suspect Number:** 3

**Name:** Professor Angstrom

**Brief Description of Suspicion:** Past curator of the museum that housed the crown jewels. He was recently fired from his job and replaced by the boss's niece. His motive may be revenge.

**Suspect Number:** 4

**Name:** The Resident Scientist

**Brief Description of Suspicion:** Credited for discovery of the crown jewels. She claims they are rightfully hers.

## CRIME LAB DATA

<b>Crime Lab Investigator:</b>	Edna N. Zime	<b>Evidence Messenger:</b>	R. Renee
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<b>List of Evidence Received:</b>	Plastic bag with Blood from crime scene DNA from four suspects	<b>List of Procedures Used:</b>	DNA Extraction  DNA restriction analysis
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**Narrative:** After receiving the package with the plastic bag marked *Crime Scene*, the crime scene DNA was extracted from the blood sample in the bag. Forensic scientists used DNA isolated from four suspects and compared them to the crime scene DNA using DNA restriction analysis.

**Results:** See the *Final Report*.



# CITY POLICE DEPARTMENT

## CRIME LAB LABORATORY PROTOCOL

There are several tubes in your Crime Scene Kit:

- Crime Scene DNA = **CS**
- Suspect 1 DNA = **S1**
- Suspect 2 DNA = **S2**
- Restriction Buffer = **RB**
- Restriction Enzyme = **RE**
- Loading Dye = **LD**

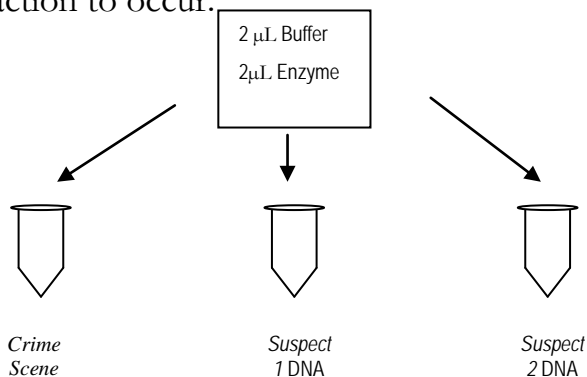
When working with micropipettes, be sure to change your pipette tip between samples. This will prevent contamination of your samples and your reagents.

**Be sure to add samples to the bottom of your tube.**

Pipette up and down once or twice to gently mix it.

1. To set up a Restriction Enzyme Digest:
  - Add 2  $\mu\text{L}$  of Restriction Buffer **RB** to each of the three samples CS, S1, and S2
  - **Remember to change your tips.**
2. Add 2  $\mu\text{L}$  of Restriction Enzyme **RE** to each of the three samples CS, S1, and S2.
 

**Remember to change your tips.**
3. Incubate the three samples at room temperature for **1 minute** for the enzymatic reaction to occur.



**Assign Gel Boxes and Sample Wells:**

CS well # \_\_\_\_\_

S1 well # \_\_\_\_\_

S2 well # \_\_\_\_\_

4. Add 3  $\mu\text{L}$  of loading dye **LD** to each of the three samples CS, S1, and S2.

**Remember to change your tips.**



5. Load 15 $\mu$ l of each of the three samples CS, S1, and S2 into the wells of the agarose gels in the gel electrophoresis box.  
**Remember to change your tips.**
6. After all samples have been loaded, your instructor will help you add electrophoresis buffer to the gel box and with the lid.
7. Your instructor will help your group connect the power supply to the gel box, plug it in, turn it on, and make sure the gel runs properly.
8. **The gel will run for approximately 30 minutes at 100 volts.**  
**WHILE WE ARE WAITING FOR OUR GELS TO RUN, WE ARE GOING TO COMPLETE ANOTHER ACTIVITY.**  
**WAIT FOR YOUR INSTRUCTORS' DIRECTIONS.**
9. After the gel is done running, your teacher will turn off the power supply and remove the cover to the gel box.
10. If the gels need to be stained to make the DNA bands darker:
  - Have your Instructor assist you in removing the agarose gel from the electrophoresis box and placing in a staining tray.
  - Identify the bottle at your station labeled Carolina Blu™ Stain
  - Pour the entire bottle over your gel.
  - Wait for 10 minutes.**Begin answering the DATA/OBSERVATION SHEET: Part I and II**
11. Pour the entire staining solution back into the bottle labeled Carolina Blu™ Stain
12. Ask your Instructor to examine the gel. They may or may not ask you to add water to the staining box. The water will remove extra stain from the gel.
13. Analyze the DNA bands for each sample:
  - **Bring the staining tray containing the gel, a pencil, and your packet to the light box.**
  - **The teacher will tell when you can place your gel on the light box.**
  - **The teacher will show you how to record your results.**
14. Remember to inspect both the number of bands and the different sizes.
15. Complete the questions on the Data/Observation Sheets and record your results on the diagram.



# CITY POLICE DEPARTMENT:

## DATA/OBSERVATION SHEETS

### I. RESTRICTION DIGEST

1. What does the restriction enzyme do to the DNA?
2. Why are the DNA samples and restriction enzyme incubated for 1 minute?
3. What will happen to the DNA if the enzyme did not find a restriction site? How many fragments will you have if the enzyme cuts the DNA two times?

### II. PREPARATION OF THE AGAROSE GEL

4. What is the function of the agarose gel?
5. What is the function of the comb?
6. Predict what would happen if you used 0.02 g of agarose instead of 0.2 g to make a gel. Would there be more or less separation of DNA fragments?

### III. PREPARATION OF THE GEL ELECTROPHORESIS BOX

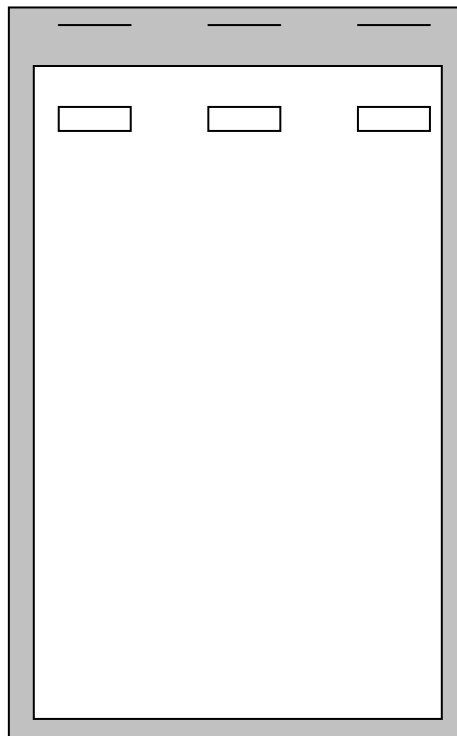


7. Why is buffer poured over the gel before the voltage on the gel box is turned on?
  
8. Describe what is occurring in the gel when the electric current is applied.
  
9. What would happen if the wells of the agarose gel were close to the positive electrode?

## VI. RESULTS

10. Use this diagram to record the sample names and where you loaded each sample; also record the results you observe after the gel finished running. Label the positive and negative electrodes and the direction the DNA traveled.

Sample Names





**CITY POLICE DEPARTMENT**  
**CONFIDENTIAL**  
**FINAL REPORT**



Identify the members of your Forensic Team:

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Were there any suspects' DNA found at the crime scene? If so, who?

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After processing the evidence, explain how your group made their conclusion.

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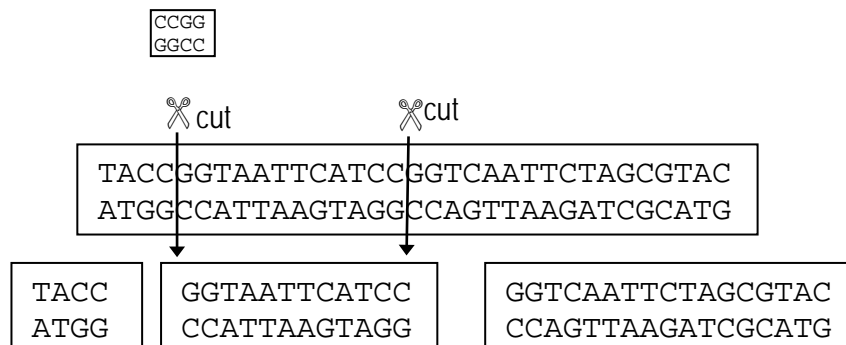
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# DNA EVIDENCE EVALUATION

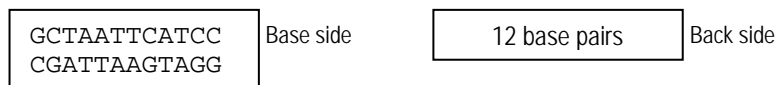
*WORK ONLY ON YOUR DNA SAMPLE*

- Each team member should have one DNA sequence strip. Use your scissors (restriction enzymes) to cut your DNA samples only where you see this base pattern: Cut between the C and G as shown in this example:



**Keep all the DNA fragments you cut from one sample together. Do not mix up with other sample fragments.**

- Count the number of base pairs (bp) in each fragment of DNA that you have cut. A base pair consists of two complementary bases.
- Record the number of base pairs in each piece on the back side of the DNA fragment.



- Tape your DNA sequences on the chart according to the number of base pairs.
- Be sure to put all the fragments from your sample in the proper column.
- Analyze the DNA fragments.
- Look at the number of fragments and sizes for all suspect and crime scene samples.
- Are there any suspects that match the crime scene DNA?
- Begin to fill out the *Final Report* sheet with your conclusions.



Crime DNA	Suspect 1	Suspect 2	Suspect 3	Suspect 4	Number of Base Pairs (bp)
					32
					31
					30
					29
					28
					27
					26
					25
					24
					23
					22
					21
					20
					19
					18
					17
					16
					15
					14
					13
				12 bp	12
					11
					10
					9
					8
					7
					6
					5
					4
					3
					2
					1



**Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA Crime DNA**  
GTCCGACCGGTGACCGTGCGTACACAGTGCTCCGGATAGCTGATAGCTCCGGTG  
CAGCTGGCCACTGGCACGCATGTGTCACGAGGCCTATCGACTATCGAGGCCAC

**Suspect 1 DNA Suspect 1 DNA Suspect 1 DNA Suspect 1 DNA Suspect 1 DNA Suspect 1 DNA Suspect 1 DNA**  
GTCCCAGCCGGACCGTACCGGTAGATCAGCCGGTAGATTGATAGCGTGATGTG  
CAGGGTCGGCCTGGCATGGCCATCTAGTCGGCCATCTAACTATCGCACTACAC

**Suspect 2 DNA Suspect 2 DNA Suspect 2 DNA Suspect 2 DNA Suspect 2 DNA Suspect 2 DNA Suspect 2 DNA**  
GTCTACGTAATCGTAGCCATCCGGACAGTGTCACGATCGTACATGCTACGTG  
CAGATGCATTAGCATCGGTAGGCCTGTCACACGTGCTAGCATGTACGATGCAC

**Suspect 3 DNA Suspect 3 DNA Suspect 3 DNA Suspect 3 DNA Suspect 3 DNA Suspect 3 DNA Suspect 3 DNA**  
GTCCGACCGGTGACCGTGCGTACACAGTGCTCCGGATAGCTGATAGCTCCGGTG  
CAGCTGGCCACTGGCACGCATGTGTCACGAGGCCTATCGACTATCGAGGCCAC

**Suspect 4 DNA Suspect 4 DNA Suspect 4 DNA Suspect 4 DNA Suspect 4 DNA Suspect 4 DNA Suspect 4 DNA**  
GTCTCCATCCGGACTACCATAACATCTGGTGTACCCGGTGATATCGTCCGGGTG  
CAGAGGTAGGCCTGATGGTATGTAGACCACATGGGCCACTATAGCAGGCCAC