Left at the Scene of the Crime:

An Introduction to Forensic Science

Brian Ell, Ph.D.
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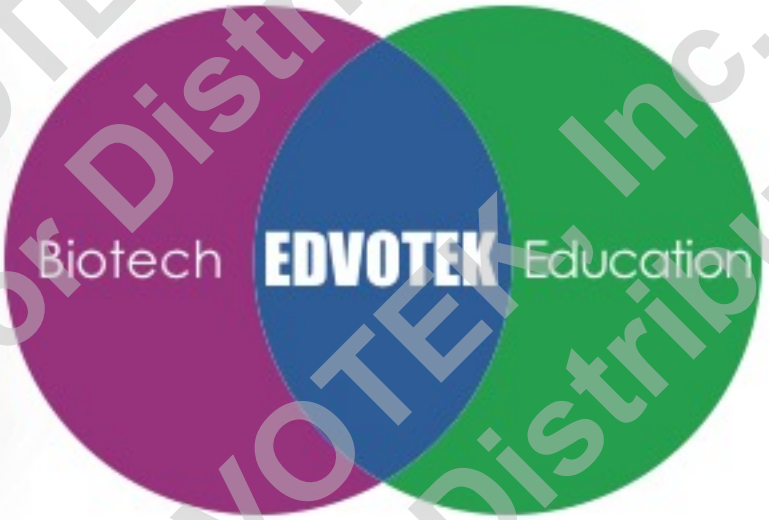

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What is Forensic Science?

- **Forensic science (or forensics)** is the application of scientific knowledge to answer questions of interest within the legal system.
- Evidence from accidents and crime scenes is collected and analyzed by forensic scientists.
- Forensic scientists act as expert witnesses.

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Forensic Scientists Use Techniques from Many Scientific Disciplines

Blood Typing

Southern Blotting

Polymerase Chain Reaction (PCR)

Clockwise from top: #140, #541, #504

- **Anthropology** – Analyze remains in advanced stages of decomposition
- **Genetics/Molecular Biology** – Uses biological material to determine serological and DNA profiles
- **Toxicology** – Identifies poisons, drugs and/or alcohol in tissues and body fluids.
- **Chemistry** – Analysis of trace physical evidence
- **Pathology** – Determine cause of death post-mortem

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A Break-in at the Lab!

- A scientist returned to her lab to find someone had broken in and stolen her research on a groundbreaking vaccine.
- Luckily, the police found some blood at the crime scene. Several suspects have been identified.
- As a forensic scientist, you have been commissioned to analyze the sample.

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Crime Scene Investigation Using Forensic Techniques

DNA Fingerprinting by PCR Amplification

(EDVO-KIT #130)

What Information Does Blood Typing Provide?

(EDVO-KIT #191)

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DNA Fingerprinting by PCR Amplification

- Simulation of DNA Fingerprinting featuring Ready-to-Load™ DNA samples
- DNA profiles for the crime scene and the suspects were created.
  - DNA was extracted from the sample, amplified by PCR and digested with restriction endonucleases.

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What Do I Need to Perform Electrophoresis Experiments?

LabStation™ #5062

- Horizontal electrophoresis apparatus
- D.C. power source
- Micropipet or transfer pipet
- Agarose
- Electrophoresis Buffer
- Samples – dye, DNA, RNA
  - PCR products
- A way to visualize samples

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Casting the Agarose Gel

1. Prepare the tray for gel casting by sealing the ends with rubber end caps.

2. Place a comb in the appropriate notches.

3. Prepare the agarose gel solution. Cool to 60°C and then pour the gel.

4. After approx. 20 min. the gel will solidify. Remove the comb from the gel tray.

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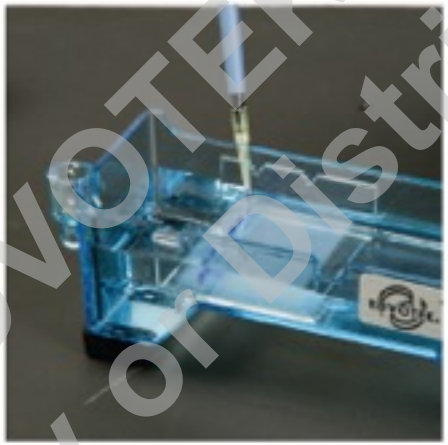
Performing Electrophoresis

5. Slowly remove the rubber end caps. Be very careful not to damage or tear the gel!

6. Place the gel (on its tray) into the electrophoresis chamber. The gel should be completely submerged under electrophoresis buffer.



7. Load samples into wells in consecutive order, starting with the first well on the left.

8. After samples are loaded, attach the safety cover, connect the leads to the D.C power source and set the power source at the required voltage.

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Let's run our gels!

Load 35 microliters of sample per well.

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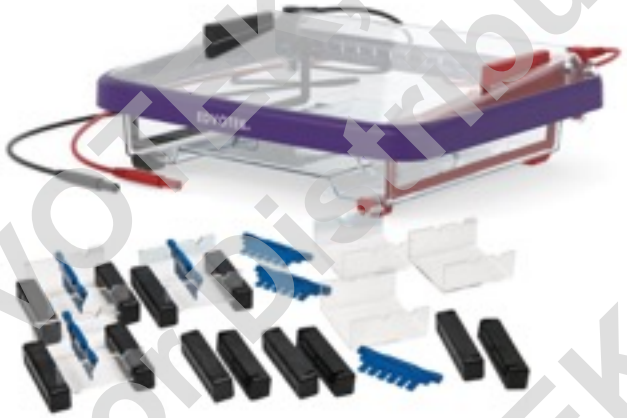
Electrophoresis Chambers for Classrooms of all Sizes

Cat. # 502
Model M12
Two gels



Cat. # 515
Model M36
Six gels

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Power Supplies Provide Current for Electrophoresis

Cat. #509
DuoSource™ 150
(75/150 V)

Cat. #5010
TetraSource™
300
(30-300V)

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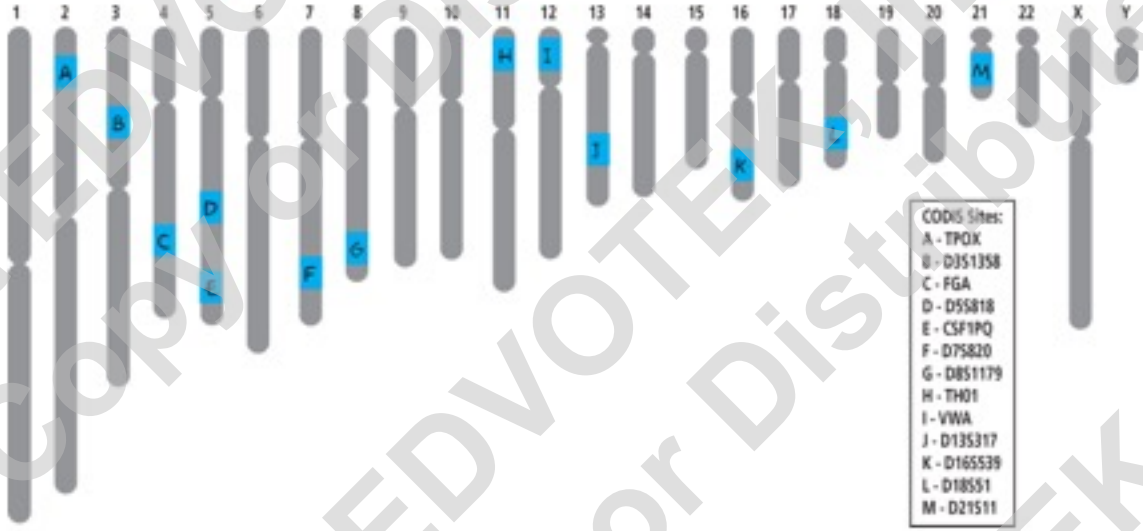
DNA Sequences are Unique

CODIS – Combined DNA Index System



- The chances of two individuals having exactly the same DNA profile is ~30 billion to one
  - Single Nucleotide Polymorphisms (SNPs)
  - Restriction Fragment Length Polymorphisms (RFLPs)
- **DNA profiling** is a forensic technique used to identify individuals by analyzing differences within DNA.

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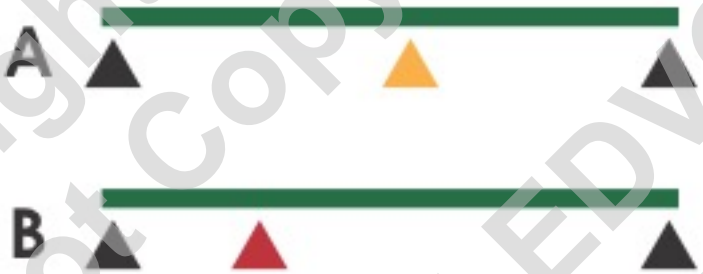
RFLPs Are Used as Landmarks for DNA Fingerprinting



Cat. # 109

- **Restriction Fragment Length Polymorphisms (or RFLPs)** are heritable differences in the nucleotide sequence.
- Some RFLPS add a restriction enzyme cut site to the DNA.

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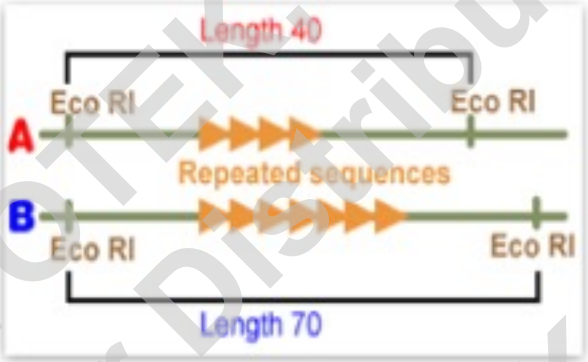
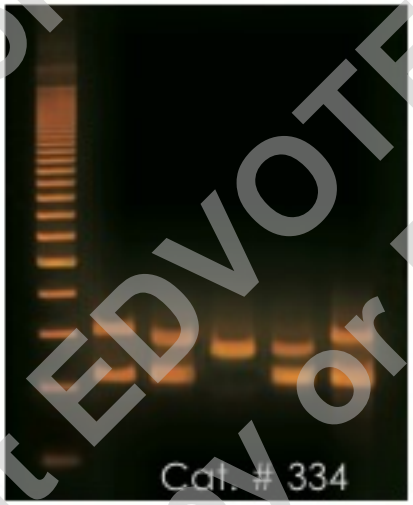
RFLPs Are Used as Landmarks for DNA Fingerprinting

- **Variable Number of Tandem Repeats (or VNTRs)** comprise short, repetitive DNA sequences present in multiple copies between two restriction sites
  - 15-35 base pair sequences
  - VNTRs appear between five and 100 times.





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DNA Fingerprinting is Used to Determine Paternity

- Parentage can be determined from a child's DNA profile.
- DNA fragments in the child's sample that are absent from the mother's DNA must be contributed by the biological father.

1 – Standard DNA Fragments
2 – Mother's DNA Digest
3 – Child's DNA Digest
4 – Father 1 DNA Digest
5 – Father 2 DNA Digest
(Cat. #114)

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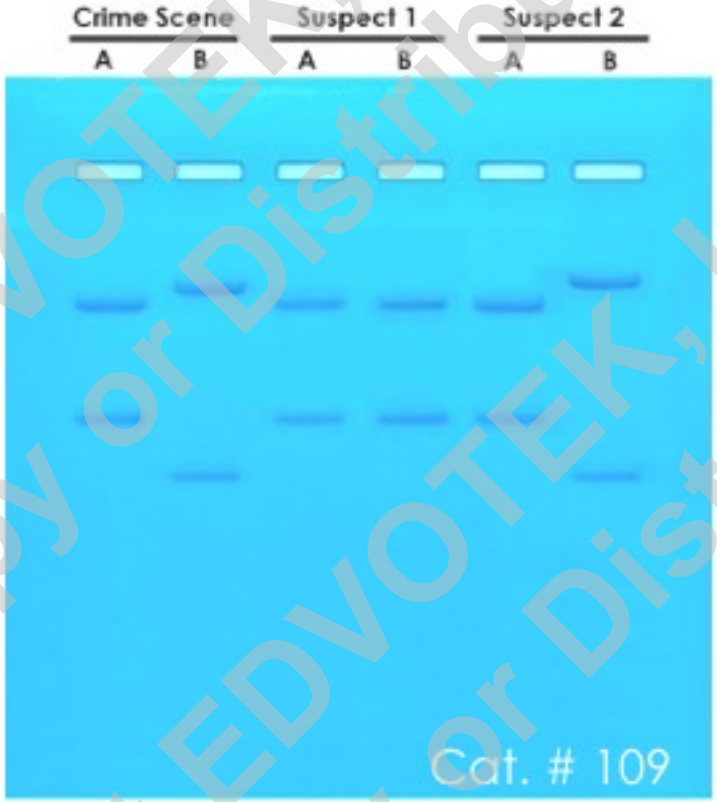
DNA Fingerprinting is Used to Solve Crimes

- Forensic scientists identified a biological sample at the scene of a crime.
- DNA was extracted from the sample, amplified by PCR and digested with restriction endonucleases to create a "DNA Fingerprint".
- A match suggests that the suspect was at the crime scene.



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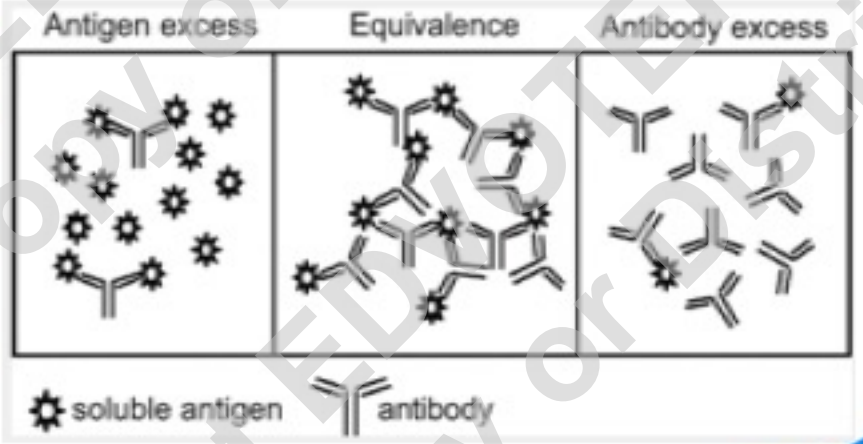
Forensic Blood Typing is a Confirmatory Test for Blood

- **Agglutination**, or the precipitation of an antigen-antibody complex, confirms the presence of blood.
- Although blood typing is easy and cost-effective, it cannot definitively link a suspect to a crime scene.

Blood Type	Antigen
A	A
B	B
AB	A and B
O	Neither A nor B



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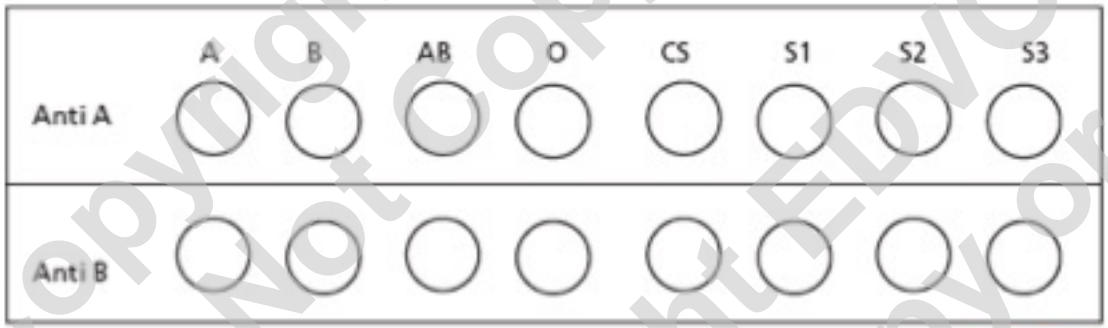
Analysis of Crime Scene Samples Using Blood Typing

1. Label the microtiter plate as shown.
2. Add 2-3 drops of control blood type samples, along with crime scene and suspect blood samples using appropriate pipets.
3. Add a drop Anti-A serum to all wells in row 1. Add a drop Anti-B serum to all wells in row 2.
4. Incubate plate at room temperature for 5-10 minutes.
5. Interpret your results.



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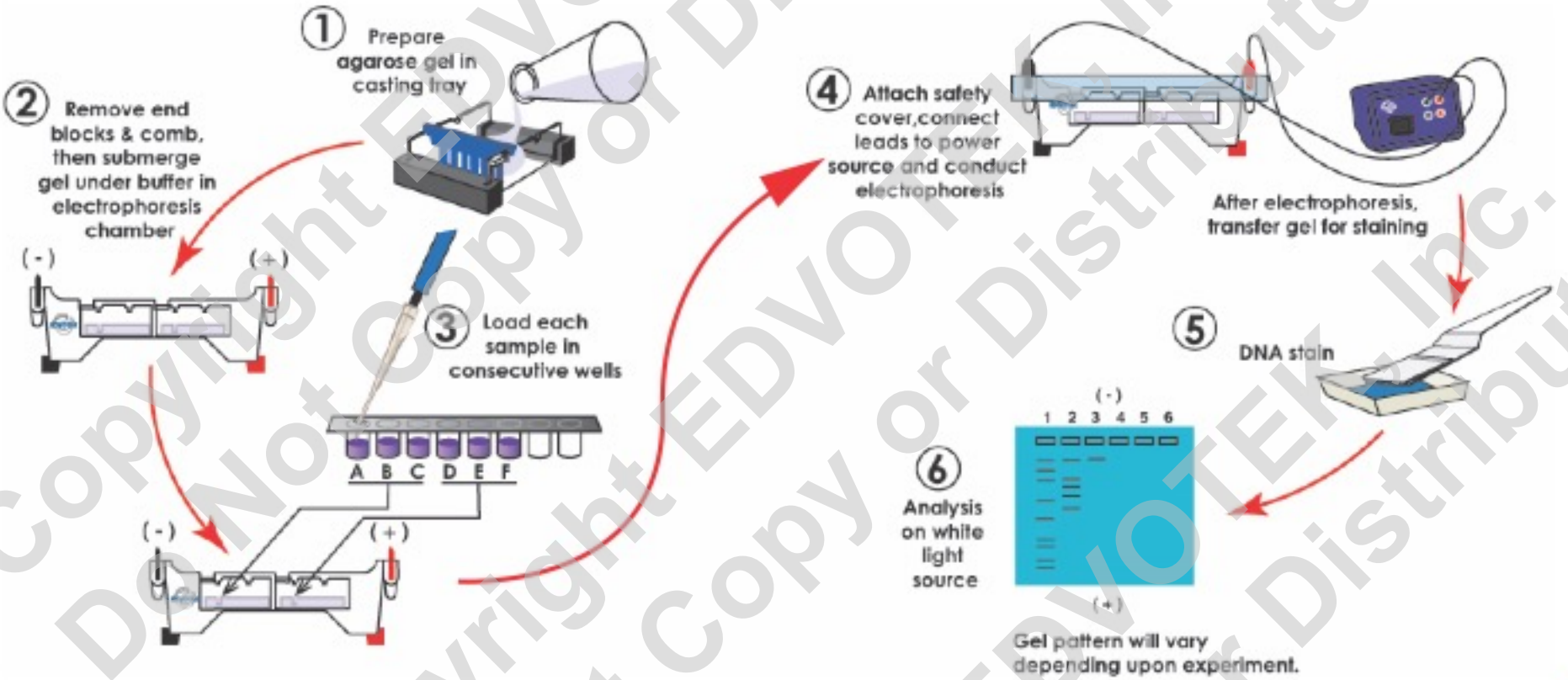
Summary of Electrophoresis



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Electrophoresis Separates DNA Fragments By Size

- The sugar-phosphate backbone of DNA has a strong negative charge.
- When an electrical current is passed through the gel, the current drives the DNA fragments through the gel towards the positive electrode.

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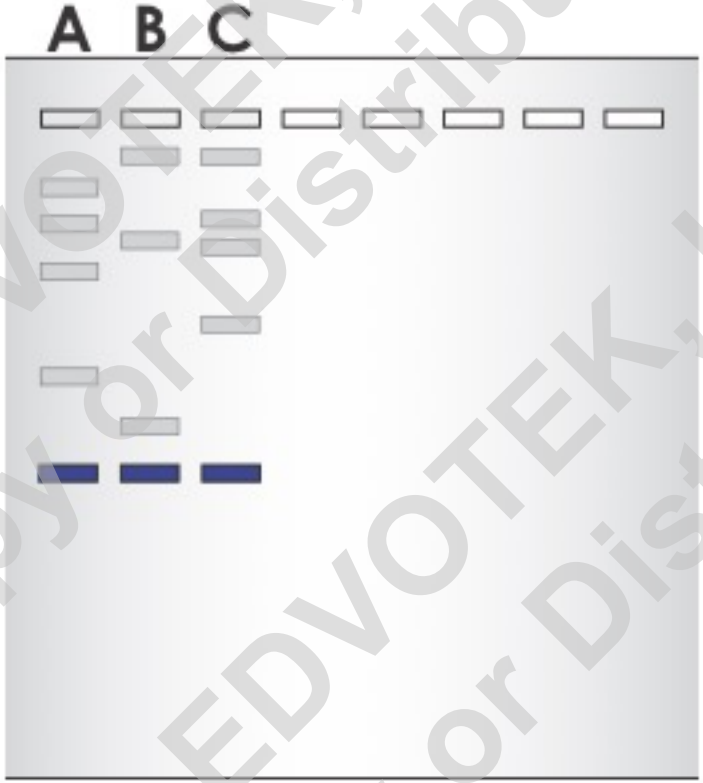
Electrophoresis Separates DNA Fragments By Size

- The gel contains small channels through which the DNA can pass.
- Small DNA fragments move through these holes easily, but large DNA fragments have a more difficult time squeezing through the tunnels.



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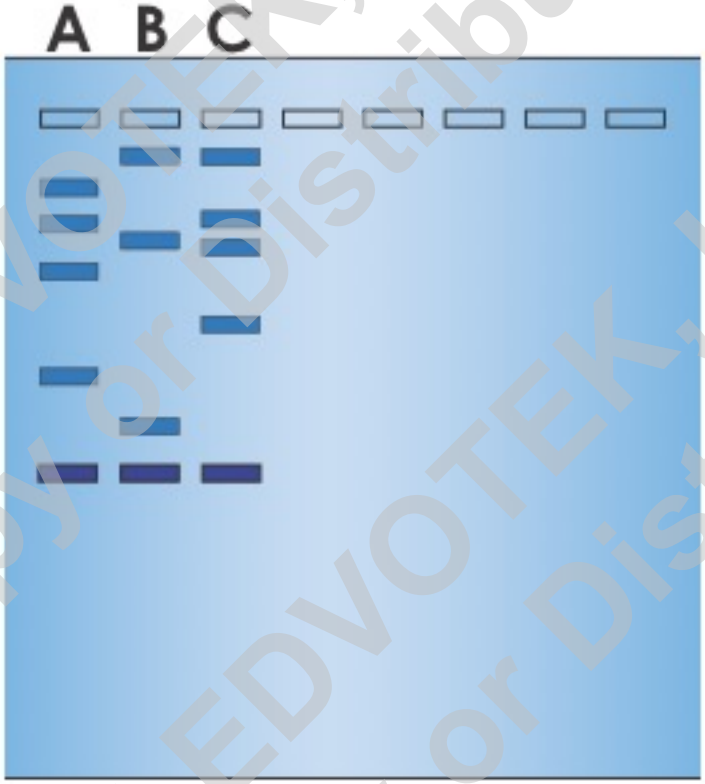
Electrophoresis Separates DNA Fragments By Size

- Because molecules of different sizes travel at different speeds, discrete bands are formed.
- After the current is stopped, the bands can be visualized using a stain that sticks to DNA.
- UV-reactive dyes simulate DNA fragments, eliminating post-staining time.



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SYBR® Safe DNA Stain

In-gel Staining

- Melt agarose and cool to 65°C.
- Add concentrated Sybr® Safe stain to the molten gel at 1:10,000 dilution (5 µL per 50 mL agarose solution).
- Run DNA samples through gel – no post staining or destaining necessary!

Post-electrophoresis Staining

- Dilute concentrated stain to 1:20,000 (5 µL per 100 mL distilled water).
- After electrophoresis, place gel in tray. Cover gel with diluted Sybr® Safe stain.
- Stain gel for 10 – 15 minutes.

Kit #109
Transilluminator #558
SybrSafe® Stain #608

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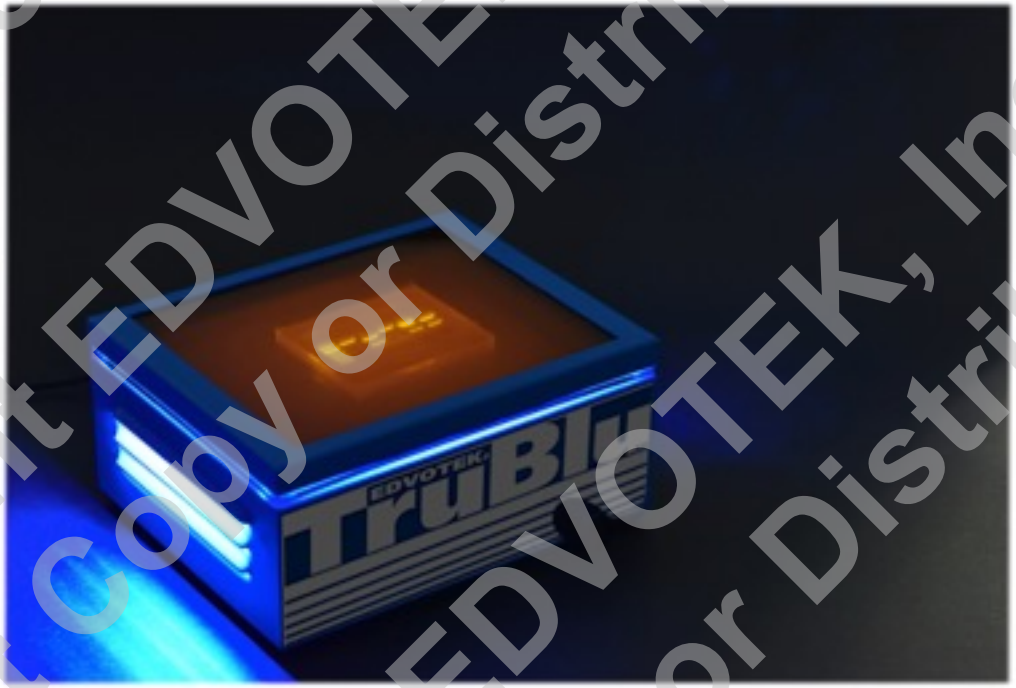
TruBlu™ Bluelight Transilluminator

Optimized for **SYBR® Safe** stained gels • Large viewing area • No harmful UV



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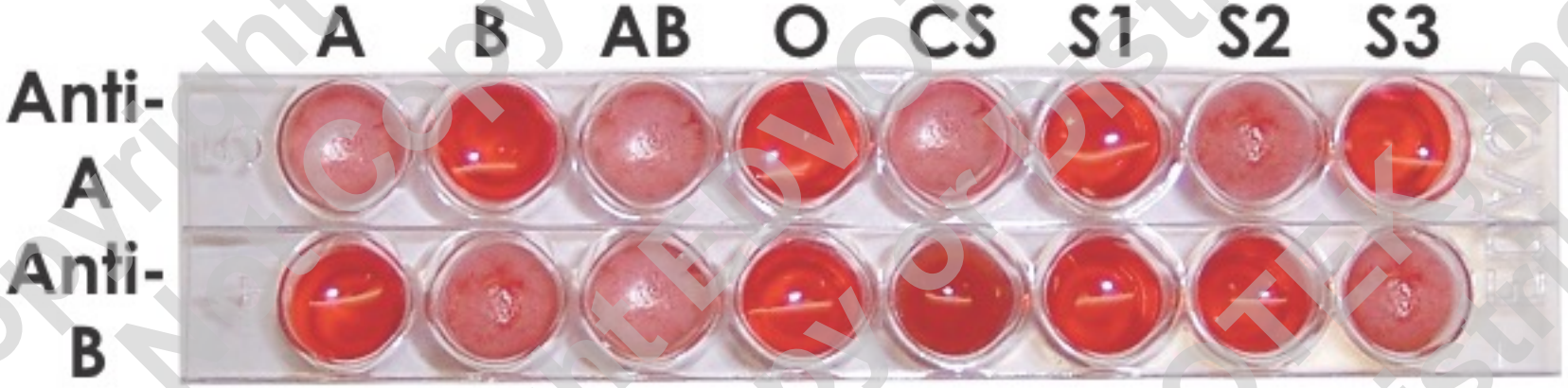
Which Suspect Was at the Crime Scene?



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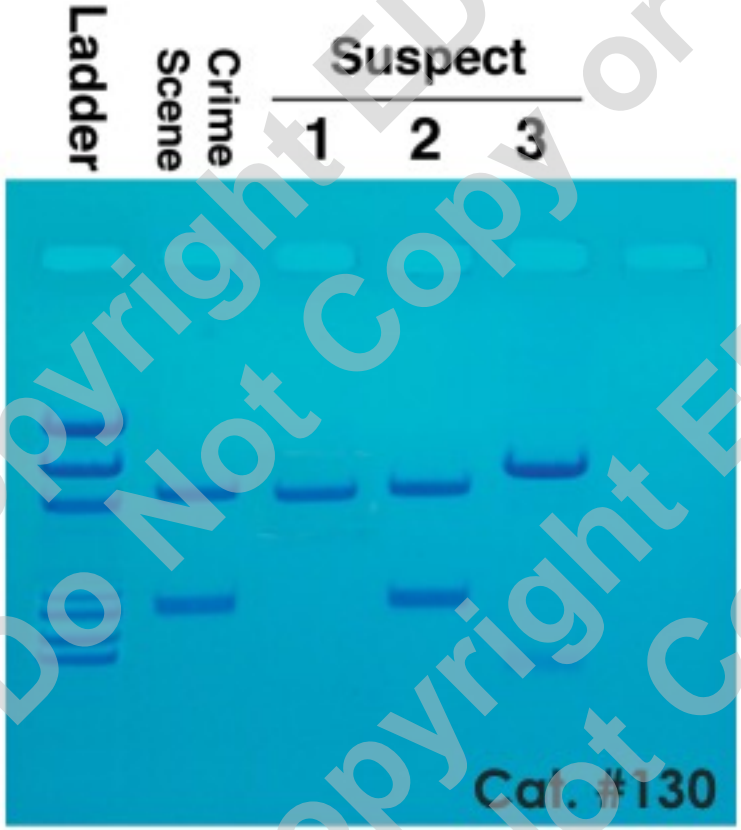
Which Suspect Was at the Crime Scene?



- A match provides strong evidence that the suspect was present at the crime scene.
  - Alone, this evidence does not **prove** the suspect committed the crime.
- If a suspect's DNA profile does not match that of the crime scene, that person may be eliminated from the inquiry.

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Crime Scene Investigation Using Forensic Techniques

- Forensic science uses scientific methodology to answer legal questions.
- Forensic Blood Typing is a confirmatory test for blood that can help rule out suspects.
- DNA Fingerprinting identifies heritable differences in an individual's DNA.
- Together, these techniques can provide evidence that a suspect was at a crime scene.
- Results are used as evidence in the court of law.

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Bring the Exciting World of Forensics to your Classroom!

DNA Fingerprinting using PCR (#371)

Forensic Blood Typing (#191)

DNA Fingerprinting by Southern Blot (#311)

Whose DNA Was Left Behind? (#S-51)

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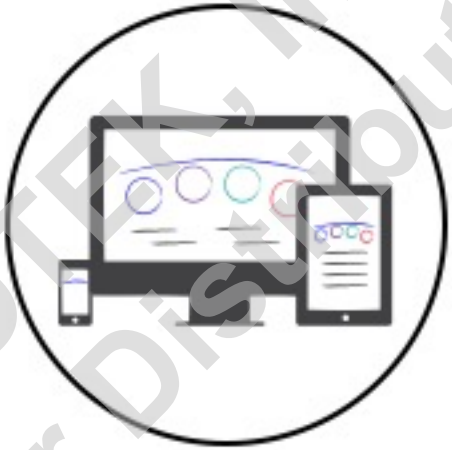

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