UCLA

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An Introduction To Forensic DNA Analysis And Crime Scene Investigation

Harry Klann, Supervising Criminalist Los Angeles Police Department Forensic Science Division Serology/DNA Unit UCLA, '88 - B.Sc. Microbiology Diplomate, American Board Of Criminalistics





What keeps me awake at night??

Crime?

Bills?

Long Beach Airport?

No, none of those things...



Emmett Klann!



My career at the LAPD Crime Lab

Criminalist, start date 1990:

- Serology Unit, 1990-1993 & 1995-present
 - FBI Academy, Forensic DNA Analysis, April 1991
- Blood Alcohol Unit, 1993-1995
 - Forensic Alcohol Supervisor certification, CA DHS
- American Board of Criminalistics, 1995-present
 - Diplomate, General Criminalistics; Fellow, Molecular Biology
- Forensic Accident Investigation Team, 1994-2003
 - CHP Academy, Techniques of Accident Investigation, June 1995
- Criminalist III, 1997-2008



DNA Technical Leader (ASCLD), 2000-2011

Supervising Criminalist, December 2008-present

Criminalist

What does a Criminalist do?

- Crime scene investigation
 - A Criminalist searches for, collects and preserves physical evidence as part of criminal investigations.
- Laboratory work
 - Blood Alcohol, Field Investigations, Firearms Analysis, Narcotics, Quality Assurance, Questioned Documents, Serology/DNA, Toxicology, Trace Analysis
 - Criminalists analyze physical evidence and prepare written reports regarding their findings.

Courtroom testimony



Criminalist position – City of Los Angeles

- Criminalist I (entry level):
 - \$64,290 \$91,475 annually
- **Requirements:**
 - Graduation from a recognized four-year college or university with a major in a physical or natural science and successful completion of 8 semester or 12 quarter units in general chemistry; and
 - A qualifying score on the Criminalist qualifying written test; and
 - In addition to the regular City application, each candidate is required to complete and submit a *Criminalist Supplemental Training and Experience Questionnaire* at the time of filing.
 - A valid California driver's license is required prior to appointment.



Serology/DNA Unit (SDU)

Criminalists assigned to the SDU

- Analyze evidence for the presence of biological material to develop DNA profiles.
 - The analytical process is divided into two primary activities, screening and profiling.
 - Screening involves examination of evidence items collected from crime scenes to locate biological evidence that is probative to the resolution of the crime.
 - Once probative biological evidence is located, a DNA profile is developed to compare to a known source, such as a suspect or victim, or uploaded into the Combined DNA Index System (CODIS) for searching against State and Federal databases of known offenders.



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Why should you consider a career as a Criminalist with the Los Angeles Police Department?

- A. You will put your valuable UCLA education to use helping reduce the fear and incidence of crime in the City of Los Angeles.
- B. Life-long learning opportunities.
- C. Great pay and benefits.



D. All of the above.

Sources of DNA in biological material

- Blood
- Semen
- Saliva
- Hair
- Teeth
- Bone
 - Tissue
 - Urine??





Only a very small bloodstain is needed to obtain a DNA profile.

Locations of potential evidence

Saliva: Envelopes, stamps, stocking masks, ski masks, bite marks or other sites of oral contact (from licking, sucking, etc.)

Clothing: Obvious body fluid stains and on places of potential wear and contact (neckline, underarm area, inside of hat brims, gloves, and waist areas) Personal items: Jewelry, eyeglasses, and wristwatches

Cigarette butts









Touch DNA

- Humans shed tens of thousands of skin cells each day, and these cells are transferred to every surface our skin contacts.
- Touch DNA has been successfully sampled (by swabbing) items such as door knobs, steering wheels, gun grips, and eating utensils.







Touch DNA – What is it?

Touch DNA is simply DNA that is transferred via skin cells when an object is handled or touched.

- Shedder vs. non-shedder
- Object handled
 - Porous vs. non-porous
 - Textured vs. smooth
- Amount of time item is handled
- Possibility of transfer



DNA sources

Great

✓ Bloodstains → Saliva

- **Bottles**, cans
- **Bite marks**
- **Cigarette Butts**
- Licked envelopes
 - Masks

Semen

✓ Hair with roots

- Sexual assault kits
- ✓ Used condoms
- Soiled bedding

Clothing (Wearer's DNA)

- Hats, shirt collars
- **Eye glasses**
- Latex gloves

Touch DNA

- **Steering wheels**
- Guns
- **Cartridge cases / magazines**

Not as great

Touch DNA collection (detective training)

- Firearms *Use one swab!*
 - Grip area, trigger, hammer, safety, slide etc.



Multiple cartridges or cartridge cases - Use one swab!
Additional information needed from the I/O:
Number of suspects, location of items discovered at crime scene, etc.





Touch DNA recovery from ammunition

In-house study:

- 97 cases included in study, 2006 to present
 - 5 samples had sufficient DNA; ~5% success rate
- Combined DNA Index System (CODIS)
 - 3 profiles uploaded to CODIS
 - No hits to date
- The remaining 92 cases had insufficient DNA.



Other potential evidence

Latex gloves found near a scene may have been discarded by the perpetrator. Open beverage containers, chewed gum, or partially consumed food left at scene.







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The collection of touch DNA from a firearm can be destructive to latent (invisible) fingerprints. Which would you collect? • A. Touch DNA.

• B. Latent prints.

• C. Both types of evidence, if possible.



D. Let the detective decide.

PCR – Polymerase Chain Reaction

"Molecular Xeroxing"

Three temperature phases, carried out in a thermal cycler instrument, replicate or "amplify" the desired DNA fragments.

Dr. Kary Mullis Nobel Laureate







PCR – Polymerase Chain Reaction





Short Tandem Repeat (STR)

Simple sequence repeats; stretches of DNA containing core repeat units of four nucleotides (ex. AGTC) that are tandemly repeated from a half dozen to several dozen times.





STR, continued

AmpFlSTR® Identifiler® PCR Amplification Kit (currently in use at LAPD FSD)

- Amplifies 15 loci and Amelogenin (multiplex reaction).
- Target 1.0 nanogram DNA.
 - ~150 epithelial cells or ~300 sperm cells!

Random Match Probability ranges from 1/100 trillion to 1/100 sextillion (100,000,000,000,000,000,000,000,000)
 World population est. 7.3 x 10⁹ (7.3 billion)



Steps in forensic DNA typing

The process:

- Select swab/stain
- Extract DNA
- Quantify human DNA
- Amplify human DNA (PCR)
- Prep samples for analysis; set-up instrument (1 hour)
- 3130xl capillary electrophoresis
- Data analysis
- Report writing, tech and admin reviews

(1 hour) (2 hour) (3 hours) ment (1 hour) (overnight) (2-3 hours) (1-2 days)

(1 hour)



Total time: ~5 days

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Why is PCR the method of choice to perform DNA typing on a crime scene evidence sample? • A. PCR is a rapid testing process.

• B. A minute sample may be sufficient.

• C. Multiple STRs can be combined into a single reaction.

• D. All of the above.



Applied Biosystems 3130xl Genetic Analyzer









STR profiles (case example)

Date:			DNA Analyst / Serial #:							DR#:				
9/24/1999			MATTHI	ES			V9780				00-00-00001			
ltem#	AMEL	D3S1358	vWA	FGA	D8S1179	D21S11	D18S51	D5S818	D13S317	D7S820	D16S539	THO1	TPOX	
25(S)	X, Y	17	15, 17	23, 26	14, 15	26	12, 15	10	9, 13	8, 10	9, 10	8, 9	9, 10	
	X, Y	17								8, 10				
25(E)	Х	15, 17	16, 18	19, 26	15	28, 32.2	14, 16	8, 13	12	11	11, 12	7, 8	11	
	Х	15, 17								11				
VICTIM	Х	15, 17	16, 18	19, 26	15	28, 32.2	14, 16	8, 13	12	11	11, 12	7, 8	11	
	Х	15, 17								11				
SUSPECT	X, Y	17	15, 17	23, 26	14, 15	26	12, 15	10	9, 13	8, 10	9, 10	8, 9	9, 10	
	Χ, Υ	17								8, 10				

STR TYPING SUMMARY SHEET



"The DNA profile obtained from Item #25 (sperm fraction) matches the DNA profile of the suspect. The combination of genetic marker types exhibited by Item #25 (sperm fraction) and the suspect occurs in approximately one in one hundred quadrillion (10¹⁷) unrelated individuals in the general population."

The Combined DNA Index System (CODIS)

- Convicted Offender and Forensic databases are maintained.
 Local (LDIS), State (SDIS) and National databases (NDIS)
- Laws concerning who is eligible for the database vary from state to state.
- US National database (as of Nov. 2015):
 - 12,069,150 offender profiles
 - 2,173,094 arrestee profiles
 - 668,285 forensic profiles
 - 311,248 "hits"; 299,130 investigations aided
 - https://www.fbi.gov/about-us/lab/biometric-analysis/codis/ndis-statistics



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Anyone arrested for a felony in California can now expect both a trip to jail and a demand for a sample of their DNA. Do you agree DNA collection from arrestees? • A. Yes, it's a powerful law enforcement tool.

• B. No, this constitutes unlawful search and seizure.

• C. I'll wait for the CA supreme court decision.

• (LAC Deputy DA: The case is still pending before the CA Supreme Court. There have been several rounds of briefings and amicus briefs have been submitted. We may have a decision by June.)



Advanced forensic DNA technologies

- Expanded loci kits
 - Promega PowerPlex® Fusion 6C System
- Expert forensic software
 - STRmix[™]
 - http://strmix.esr.cri.nz/
- Parabon Nanolabs
 - Snapshot[™]
 - http://snapshot.parabon-nanolabs.com/
- Rapid DNA analysis
 - RapidHIT® System



http://integenx.com/

Promega PowerPlex Fusion 6C System

Allows co-amplification and fluorescent detection of 27 loci.
Includes all Combined DNA Index System (CODIS) Core Loci and European Standard Set (ESS) loci.

 Reliably produces complete STR profiles from as little as 125pg (18 cells!) of human DNA.

• Can successfully type inhibited samples.



Promega PowerPlex Fusion System



Amplification of 100 picograms (14 cells!) of human DNA using 30 PCR cycles.

STRmix expert forensic software

With STRmix you will be able to:

- Resolve mixed DNA profiles without reference to known contributors.
- Compare reference DNA profiles to single source and mixed DNA profiles and provide a statistical weighting.
- Interpret DNA profiling data generated by any autosomal STR profiling kit.



STRmix - sexual assault case

A mixed DNA profile was obtained from a semen stain on a carpet at the scene of an alleged sexual assault involving two male offenders.

DNA from two individuals was detected, present in approximately equal proportions. This profile was unsuitable for database searching using traditional DNA interpretation methods.





STRmix - interpretation

Using STRmix,

• The profile was interpreted assuming two contributors and compared against a database with over 145,000 profiles.

The crime profile matched two individuals.





Snapshot report

DNA Phenotyping with Parabon[®] Snapshot[™]

Customer Case # D06A19B74E



Predicted (
) & Excluded (
) Phenotypes







integenX RapidHIT System

- Concordant profiles for 13 CODIS loci
- Run 1-7 samples
- Process any swab type or crime scene samples directly in the cartridge
- Requires on ~3 minutes of hands-on time, less than
 2 hours time to results
 - Compare vs. several days conventional lab work



Any questions?

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