

# UCLA

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HC70A - Genetic Engineering in Medicine, Agriculture and Law



## **An Introduction To Forensic DNA Analysis And Crime Scene Investigation**

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LAPD SID Criminalistics Laboratory  
UCLA, '88 - B.Sc. Microbiology  
Diplomate, American Board Of  
Criminalistics**



LOS ANGELES POLICE DEPARTMENT Scientific Investigation Division



# My career



- Criminalist, start date 1990
  - LAPD Criminalistics Laboratory
    - ✦ Serology Unit, 1990-1993 & 1995-present
      - FBI Academy, April-May 1991
    - ✦ Blood Alcohol Unit 1993-1995
    - ✦ Fellow/Diplomate, American Board of Criminalistics 1995-present
    - ✦ Forensic Accident Investigation Team 1994-2003
    - ✦ Criminalist-III, 1997-2008
    - ✦ DNA Technical Leader 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:
  - \$64,937.00 - \$110,873.00 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



- 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.



# iClick!

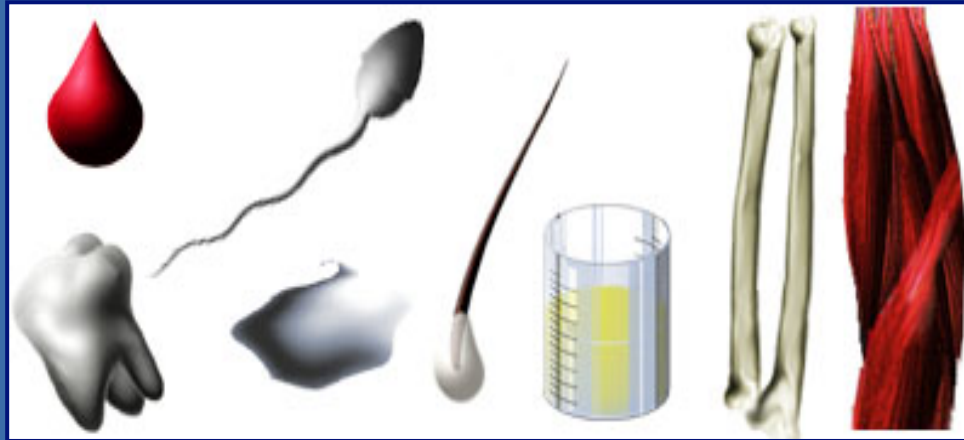


- Why should you consider a career as a Criminalist with the Los Angeles Police Department?
  - A. You'll put your UCLA education to use helping reduce the fear and incidence of crime in the City of Los Angeles.
  - B. Life-long learning opportunities.
  - C. Great pay and benefits.
  - D. All of the 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.



# 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.



# iClick!



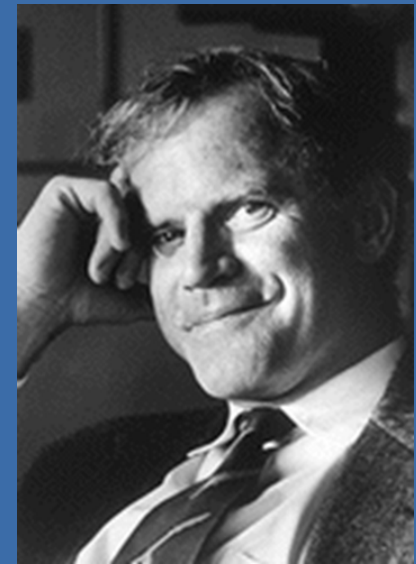
- The collection of touch DNA from a firearm can be destructive to latent (invisible) fingerprints. Which would you collect?
  - A. Touch DNA.
  - B. Latent prints.
  - C. Both types of evidence, if possible.
  - D. Let the detective decide.



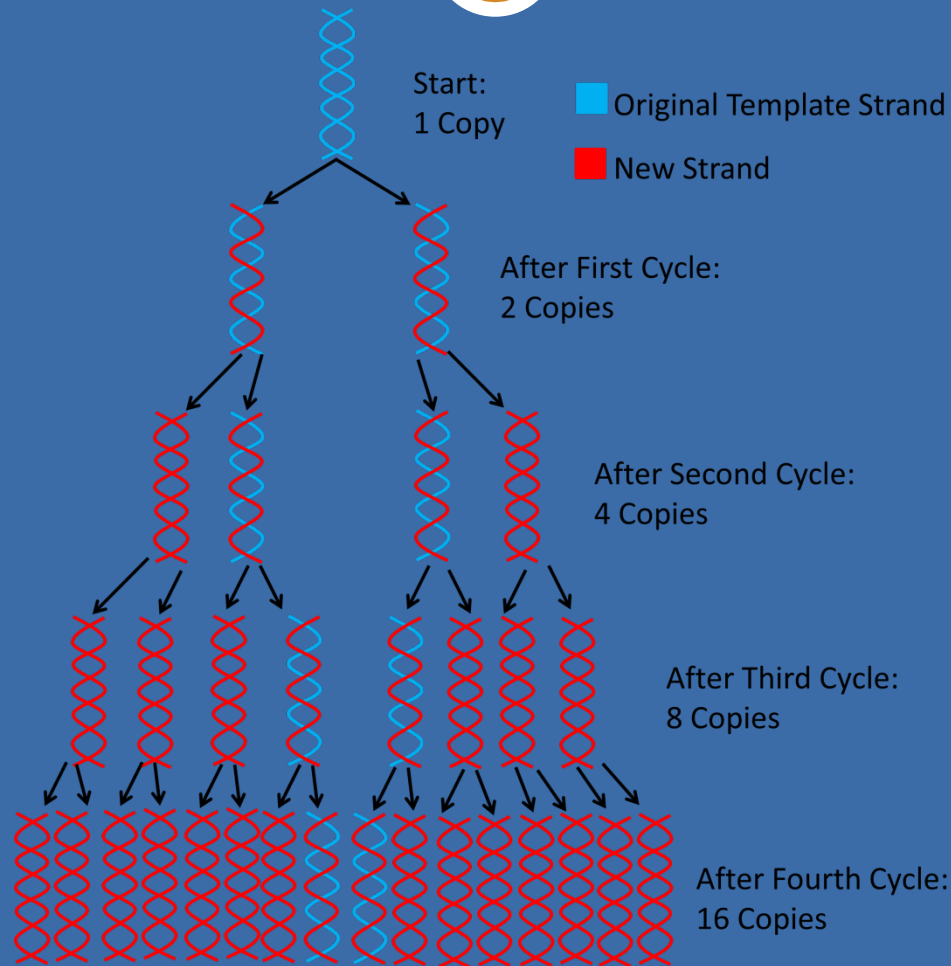
# PCR – Polymerase Chain Reaction

- “Molecular Xeroxing”
- Three temperature phases, carried out in a thermal cycler instrument, replicate or “amplify” the desired DNA fragments.

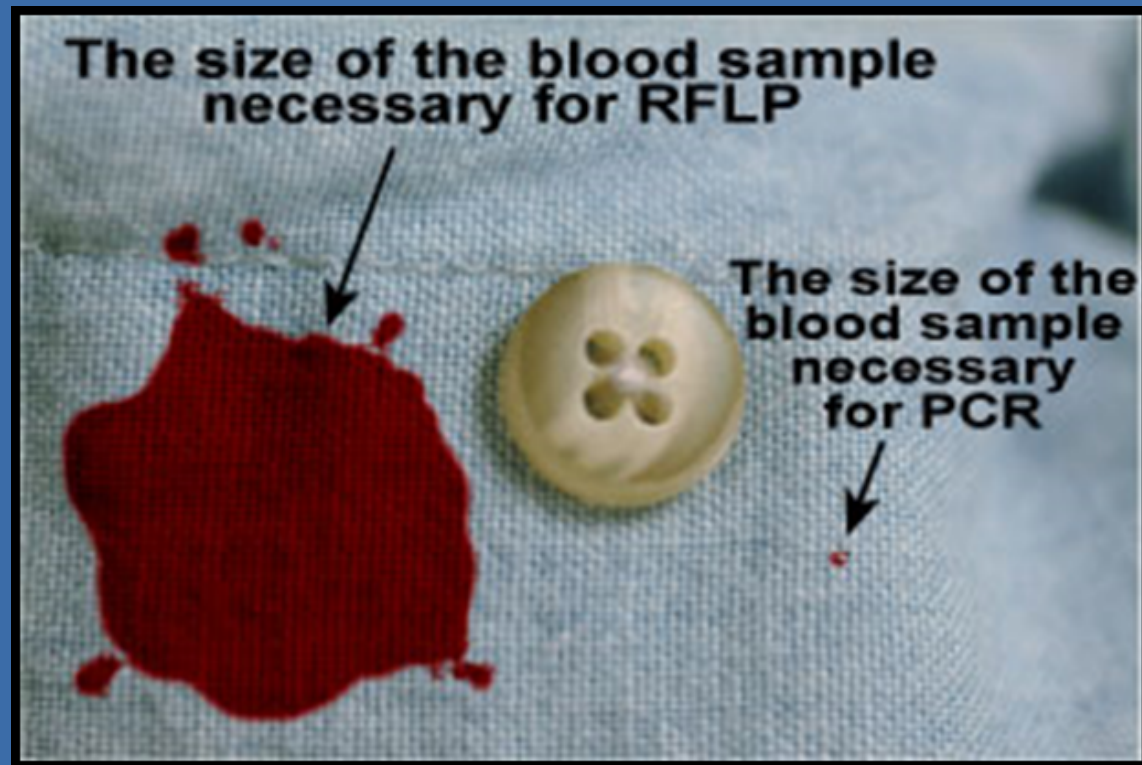
Dr. Kary Mullis  
Nobel Laureate



# PCR – Polymerase Chain Reaction



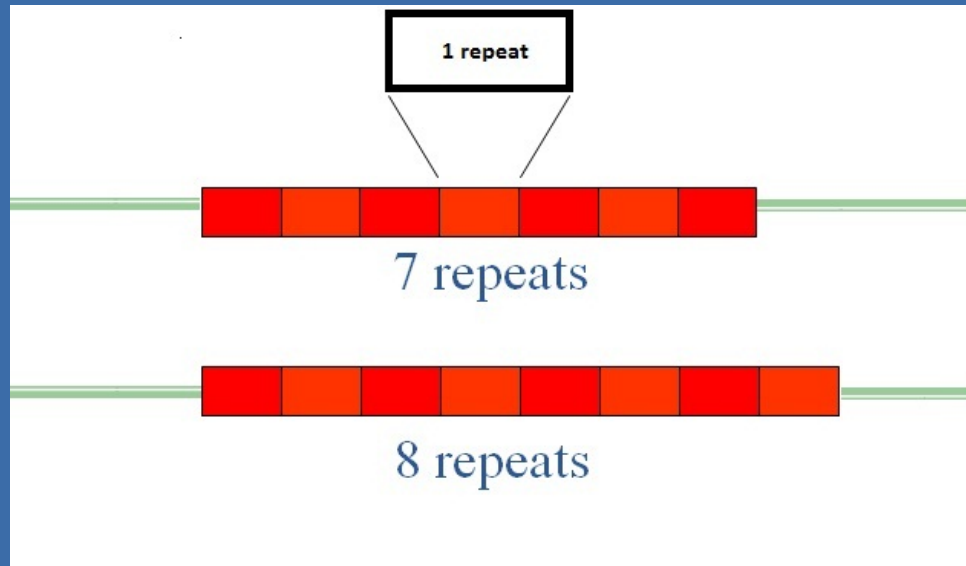
# PCR – Polymerase Chain Reaction





# Short Tandem Repeat (STR)

- Simple sequence repeats; stretches of DNA containing core repeat units of four nucleotides in length that are tandemly repeated from approximately a half dozen to several dozen times.



# STR, continued



- Identifiler® PCR Amplification Kit
  - Amplifies 15 loci and Amelogenin (multiplex reaction) .
  - Target 0.5-1.0 nanogram of DNA.
    - ✦ ~75-150 epithelial cells or ~150-300 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.  $7.2 \times 10^9$  (7.2 billion)





# Steps in STR DNA typing

- The process:
  - Select swab/stain (1 hour)
  - Extract DNA (6 hours)
  - Quantify human DNA (3 hours)
  - Amplify human DNA (PCR) (4-5 hours)
  - Prep samples for analysis; set-up instrument (1-2 hours)
  - 3130xl CE “run” (12 hours)
  - Data analysis (2-3 hours)
  - Report writing, tech and admin reviews (1-2 days)

Total Time: 5-6 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.

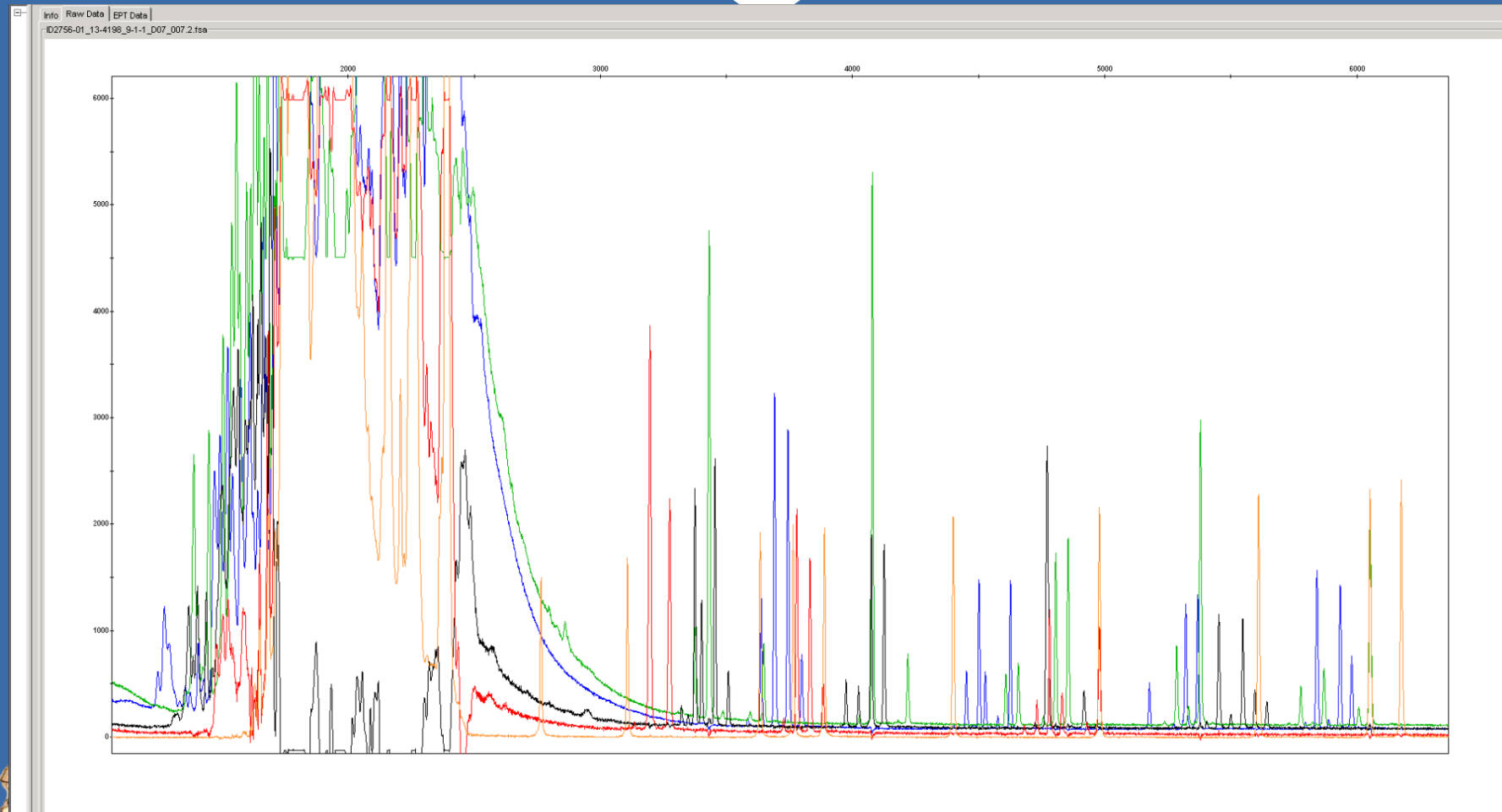


# Applied Biosystems® 3130xl Genetic Analyzer

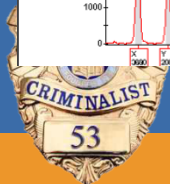
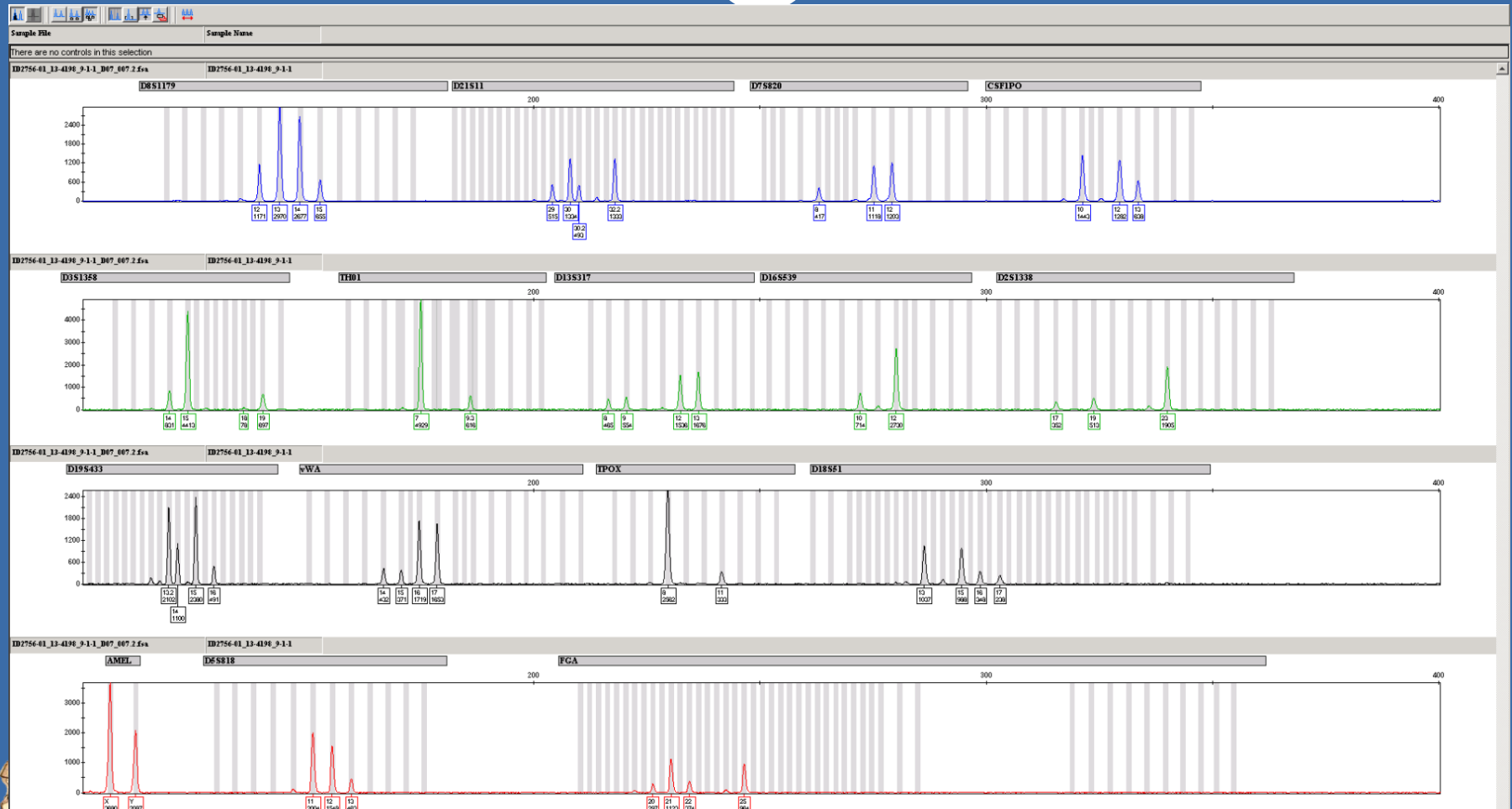


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# STR raw data



# STR typed data – 2 person mixture



# STR profiles (case example)



## STR TYPING SUMMARY SHEET

Date:			DNA Analyst / Serial #:							DR #:			
9/24/1999			MATTHIES V9780							00-00-00001			
Item #	AMEL	D3S1358	vWA	FGA	D8S1179	D21S11	D18S51	D5S818	D13S317	D7S820	D16S539	TH01	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)	X	15, 17	16, 18	19, 26	15	28, 32.2	14, 16	8, 13	12	11	11, 12	7, 8	11
	X	15, 17								11			
VICTIM	X	15, 17	16, 18	19, 26	15	28, 32.2	14, 16	8, 13	12	11	11, 12	7, 8	11
	X	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
	X, Y	17								8, 10			

*"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 ( $10^{17}$ ) 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 Feb. 2015):
  - 11,634,999 offender profiles
  - 1,911,810 arrestee profiles
  - 612,477 forensic profiles
  - 276,598 “hits”; 263,888 investigations aided
    - <http://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 am waiting for the CA Supreme Court's decision on this issue.
    - <http://www.sacbee.com/news/politics-government/capitol-alert/article10649801.html>.





# Advanced forensic DNA technologies



- Expanded loci kits
  - Life Technologies GlobalFiler™ Kit
  - Promega PowerPlex® Fusion 6C System
- Expert Systems software
  - STRmix™
    - ✦ <http://strmix.esr.cri.nz/>
  - Cybergenetics TrueAllele® Casework
    - ✦ <https://www.youtube.com/user/TrueAllele>
- Parabon Nanolabs, Snapshot
  - ✦ <http://snapshot.parabon-nanolabs.com/>
- Rapid DNA analysis
  - <http://integenx.com/>



# Life Technologies GlobalFiler™ Kit

## Maximizing Discrimination



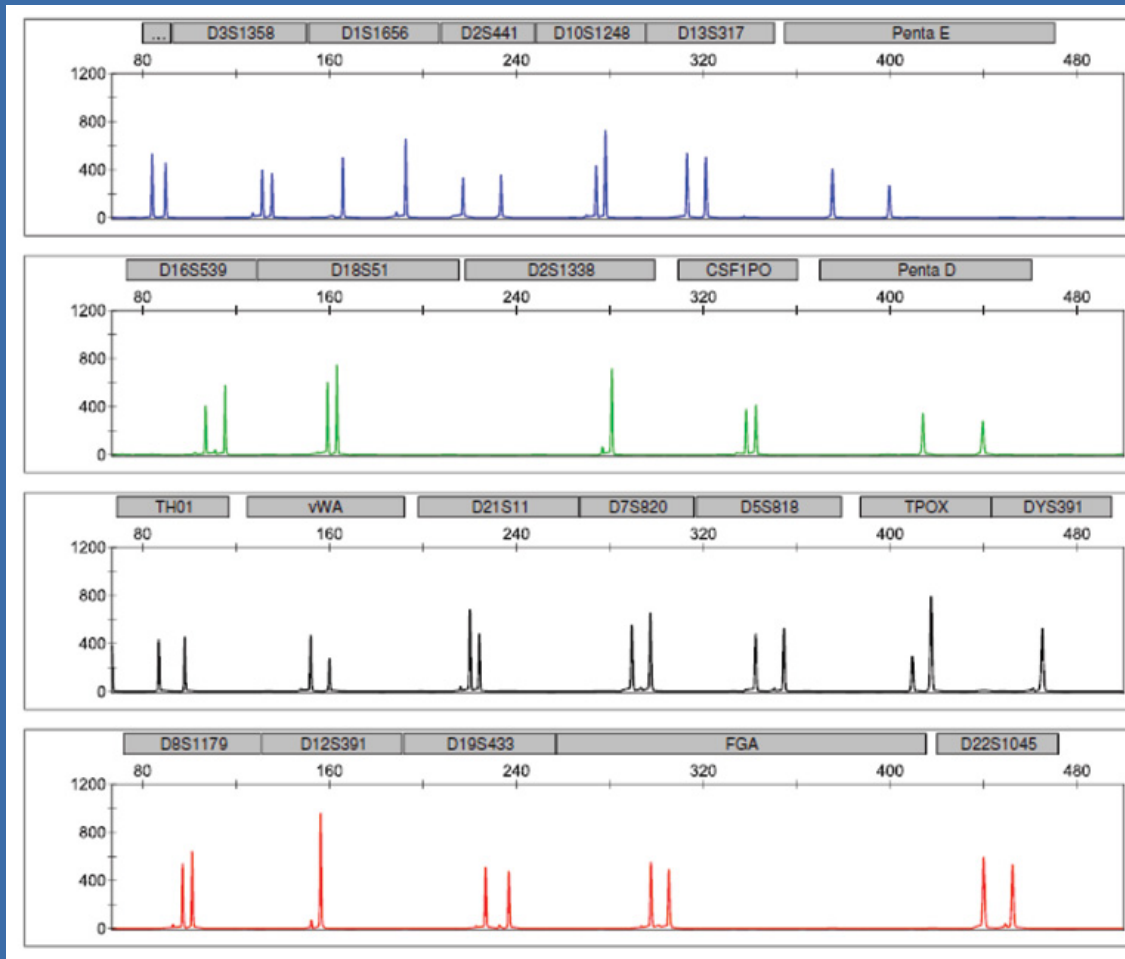
Kit	D8S1179	D21S11	D7S820	CSF1PO	D3S1358	TH01	D13S317	D16S539	D2S1338	D19S433	vWA	TPOX	D18S51	D5S818	FGA	D10S1248	D22S1045	D2S441	D1S1656	D12S391	S133	PI*
Identifiler® Kit	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							2.6 x 10 <sup>-17</sup>
NGM SElect™ Kit	x	x			x	x		x	x	x	x		x		x	x	x	x	x	x	x	1.12 x 10 <sup>-20</sup>
GlobalFiler™ Kit	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	7.12 x 10 <sup>-26</sup>

\* Preliminary calculations based on a US Caucasian Database

- The GlobalFiler™ Kits will:
  - Deliver a new level of discrimination
  - Reduce the risk of adventitious matches
  - Facilitate international DNA profile comparisons



# Promega PowerPlex® Fusion System



Amplification  
of 100  
picograms of  
human DNA  
using 30 cycles  
and the  
PowerPlex®  
Fusion System.



# STRmix™ expert forensic software



- With STRmix™ you will be able to:
  - Interpret DNA results faster.
  - Compare profiles against a person of interest and calculate a likelihood ratio.
  - Resolve previously unresolvable, complex DNA mixtures with no restriction on the number of contributors.
  - Use more of the information in a DNA profile.
  - Search complex, mixed DNA profiles against a database.



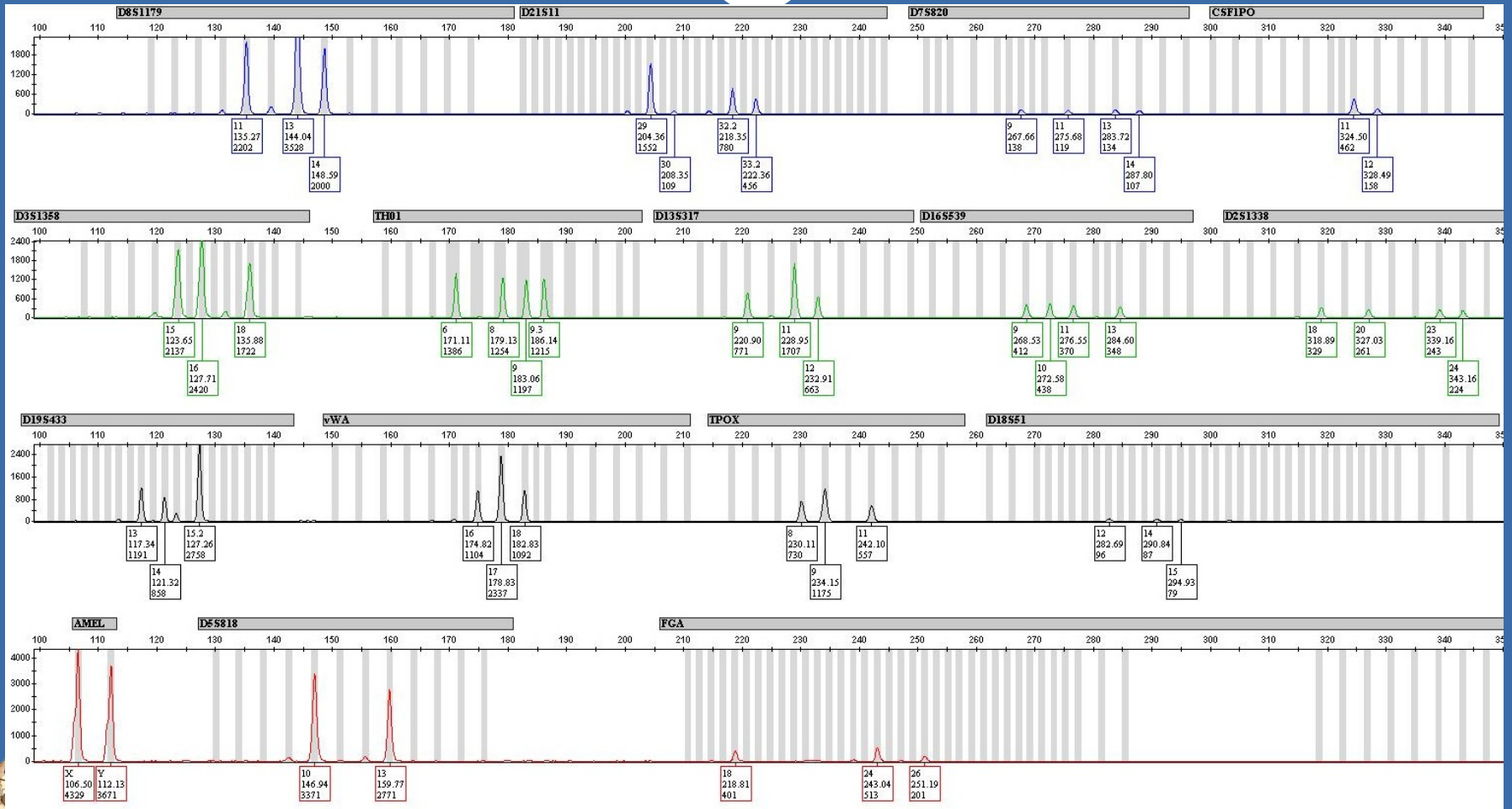
# STRmix™ - sexual assault case



- 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.



# Electropherogram – DNA mixture profile



# STRmix™ - interpretation

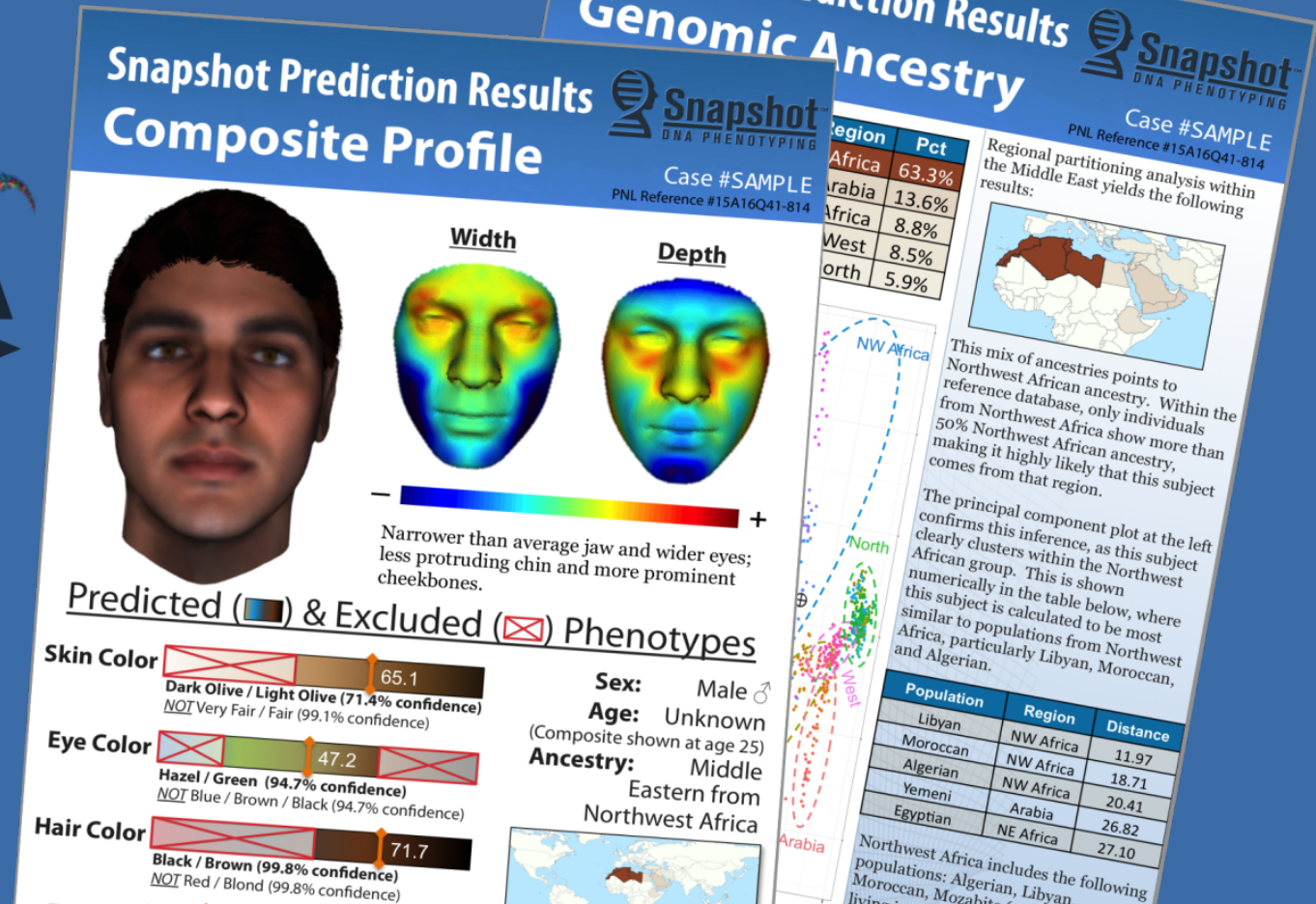


- Using STRmix™, the profile was interpreted assuming two contributors and compared against a database with over 145,000 profiles. The crime profile matched two individuals.





# Parabon Nanolabs - Snapshot™





# integenX RapidHIT<sup>®</sup> System



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# integenX RapidHIT<sup>®</sup> System



- Concordant profiles for 13 CODIS loci.
- Run 1 sample, 7 samples, or anything in between.
- 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. 5-6 days conventional lab work.



# Any questions?



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