

UCLA
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HC70A: Genetic Engineering in Medicine,
Agriculture & Law

An Introduction to Forensic DNA Analysis

Presented by
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What is a criminalist?

A criminalist is a forensic scientist who applies scientific methods and techniques to examine and analyze physical evidence and testifies in court as to his or her findings.

What does a criminalist do at LAPD?

1. Crime scene investigation

A criminalist searches for, collects and preserves physical evidence as part of criminal investigations.

2. Laboratory work

CSI, Toxicology/Blood Alcohol, Narcotics, Trace, Serology/DNA, and Firearms.

Criminalists analyze physical evidence and prepare written reports regarding their findings.

3. Courtroom testimony

Federal court, Superior court, Juvenile court, Grand Jury. City commissions.



City of LA Personnel

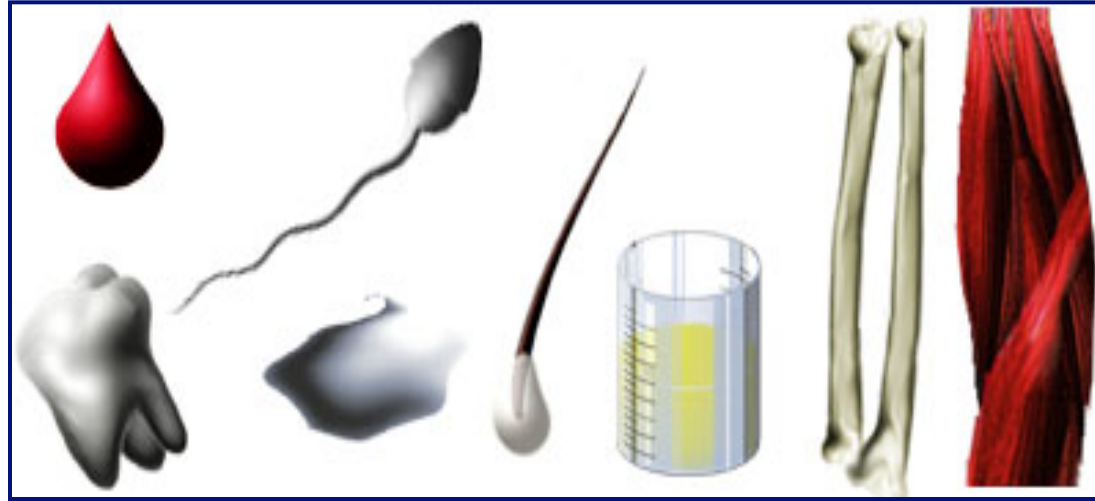
- **Criminalist:**
 - \$64,937.00 - \$110,873.00 annually
- **Requirements:**
 - Graduation from a recognized four-year college or university with a major in a physical or natural science and successful completion of 8 semester or 12 quarter units in general chemistry; and
 - A qualifying score on the 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.

Objectives of forensic DNA analysis

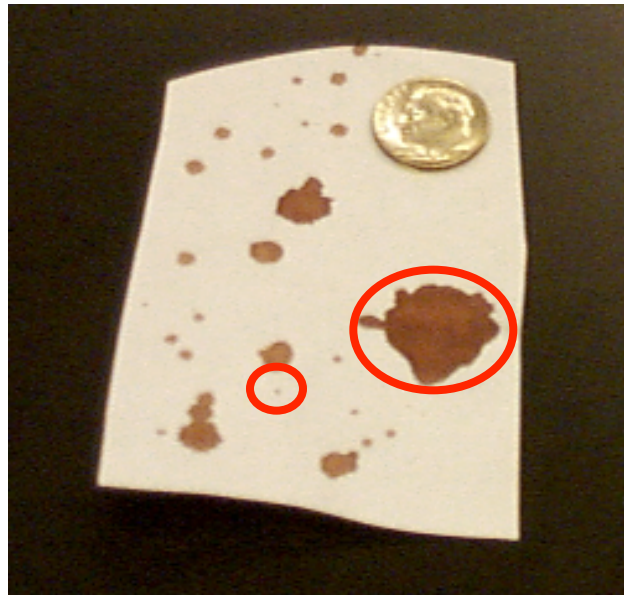
- To link an individual to a crime scene or criminal act.
 - Ex. Bloodstain at a burglary crime scene
- To exclude suspects, persons of interest or consensual partners.
 - Ex. Sexual assault, obtain husband's DNA sample for exclusionary purposes
- Other uses:
 - Identify human remains from mass disasters, unidentified bodies and missing persons
 - Paternity testing

Common sources of DNA

- Blood
- Semen
- Saliva
- Hair



- Teeth
- Bone
- Tissue

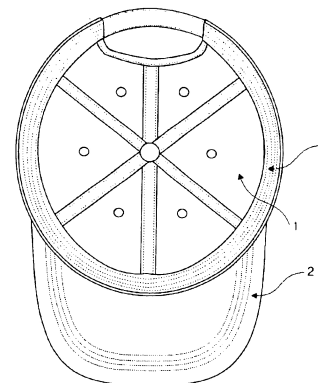
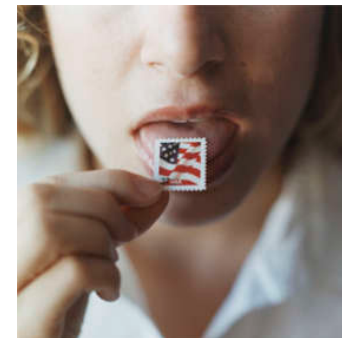


Bloodstain

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

DNA can also be recovered from...

- **Saliva:** Envelopes, stamps, stocking masks, ski masks, bite marks or body surfaces (from licking, sucking, etc.).
- **Clothing:** Obvious body fluid stains and areas in contact with skin (neckline, underarm, wrist and waist areas). Hat sweatbands and inside gloves. “*Wearer’s DNA*”.
- **Personal items:** Jewelry, eyeglasses, and wristwatches.
- **Cigarette butts**



“Touch” DNA

- Humans shed tens of thousands of skin cells each day, and these cells may be transferred to surfaces we touch.
- Touch DNA has been successfully sampled (by swabbing) items such as
 - door knobs
 - steering wheels
 - gun grips
 - eating utensils



Other types of physical evidence bearing biological material

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



iClicker question

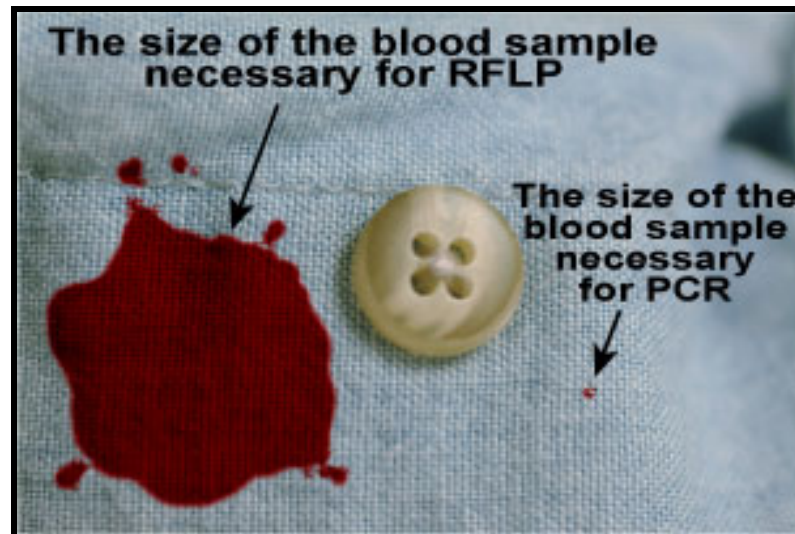
- What is type of biological evidence is commonly encountered at a burglary crime scene?
 - A. Urine.
 - B. Touch DNA.
 - C. Human bone.
 - D. Canine DNA.

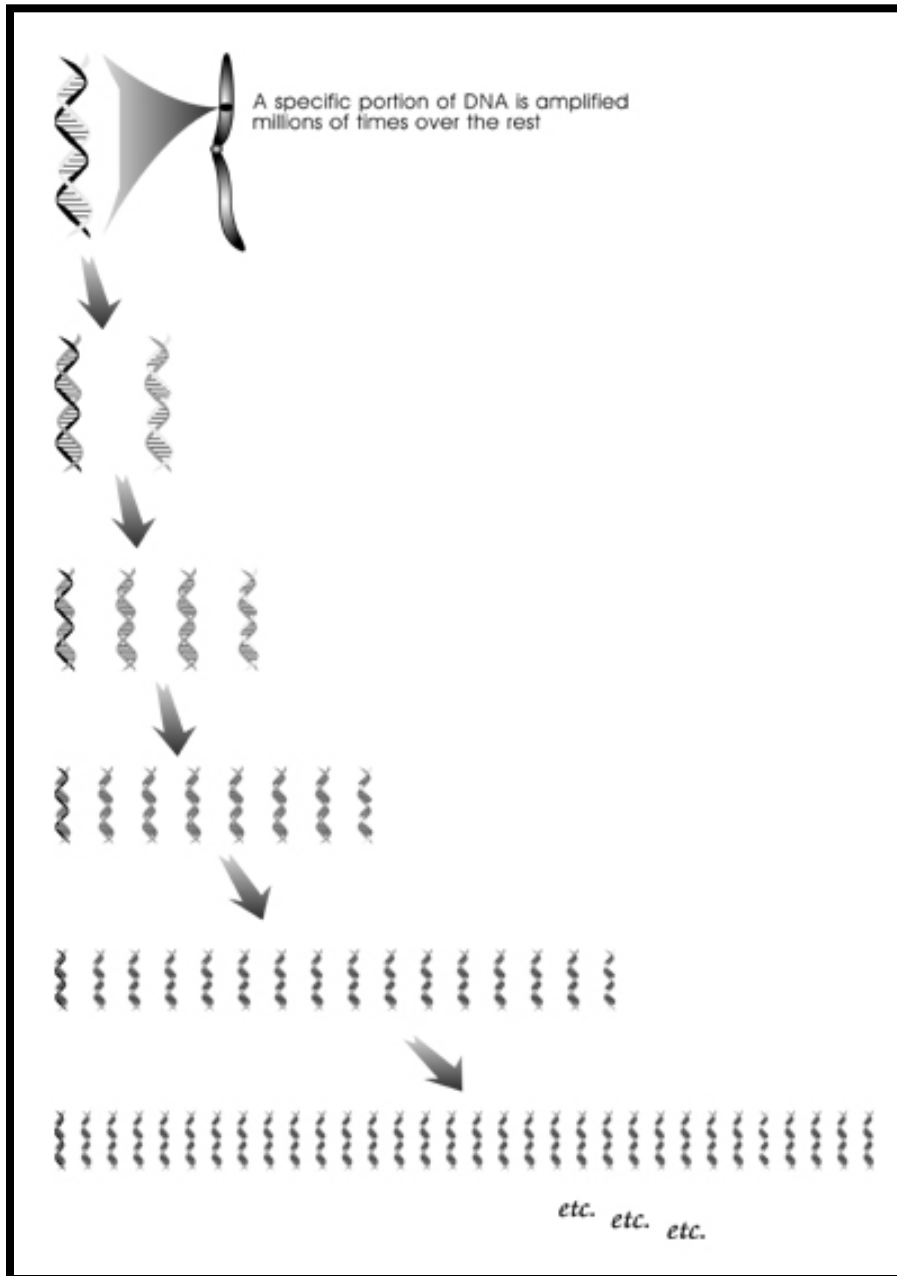
PCR



Dr. Kary Mullis
Nobel Laureate

- **Polymerase Chain Reaction**
 - “molecular Xeroxing”
 - Three temperature phases, carried out in a thermal cycler instrument, replicate or “amplify” the desired DNA fragments.





PCR Polymerase Chain Reaction

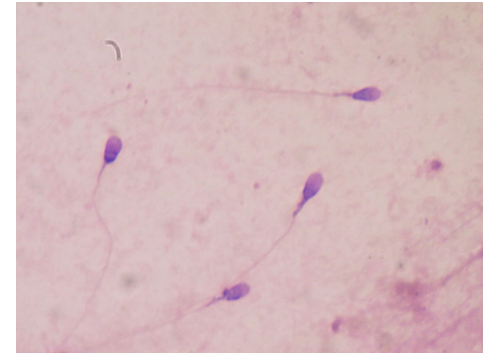
Twenty-eight PCR cycles,
exponential increase.

Starting with
two DNA fragments, the
product is:

$2^{28} \approx 270$ million amplicons!

The current method of choice: autosomal Short Tandem Repeats (STRs)

- Non-coding, tetra-nucleotide DNA sequences.
 - AGTC-AGTC-AGTC-AGTC-AGTC-AGTC-AGTC
- Requires 500 picograms of DNA to type 15 STR loci (markers).
 - ~75 epithelial cells (6.6-pg/cell)
 - ~150 sperm cells (3.3-pg/cell)
- The loci we test are polymorphic.
- Random Match Probability ranges from 10^{14} - 10^{23} (100 trillion to 100 sextillion)
 - As Larry David would say, “*Pretty, pretty, pretty rare.*”
 - World population, est. 7 billion



Steps in STR DNA typing

“Why does it take so long? On “CSI” they can do it in an hour!”

- The process:

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

Total Time: 5-6 days

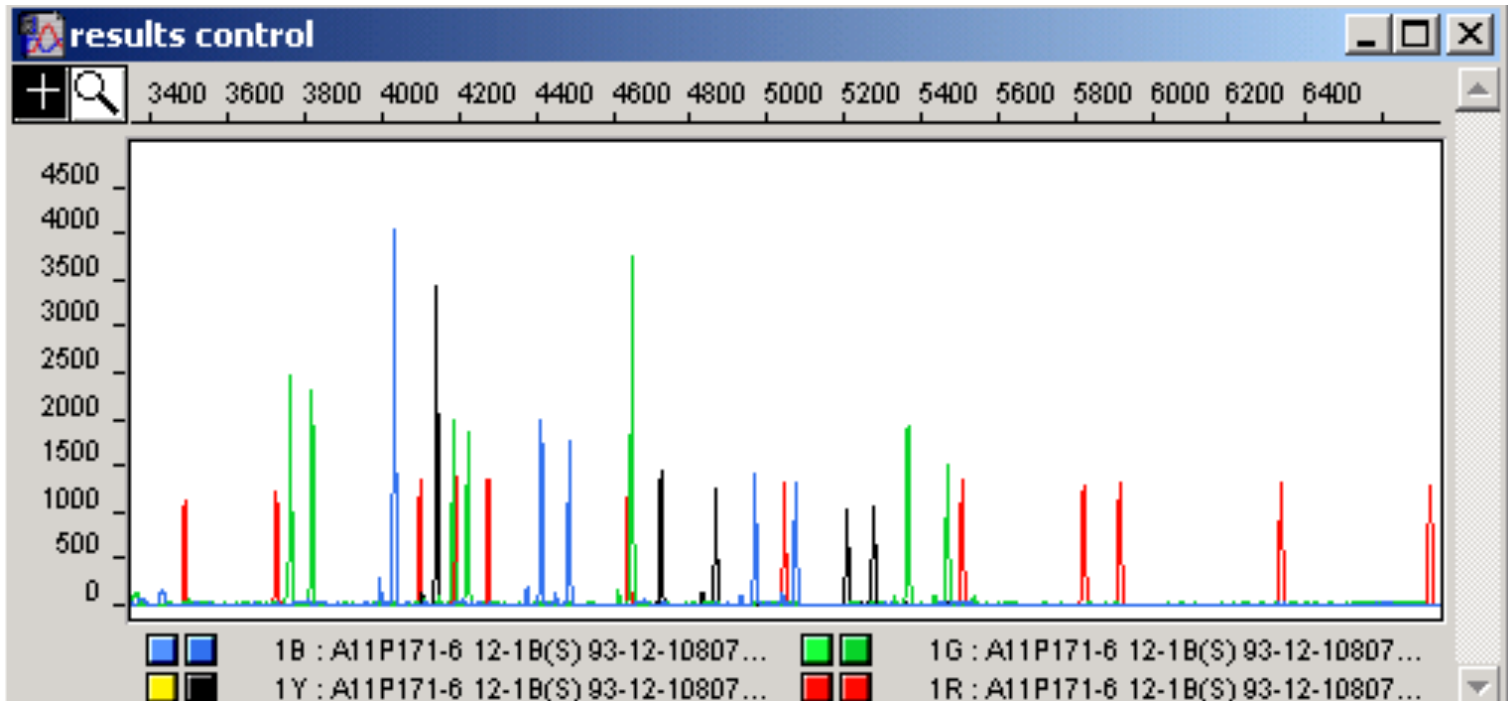
Applied Biosystems 3130 Genetic Analyzer



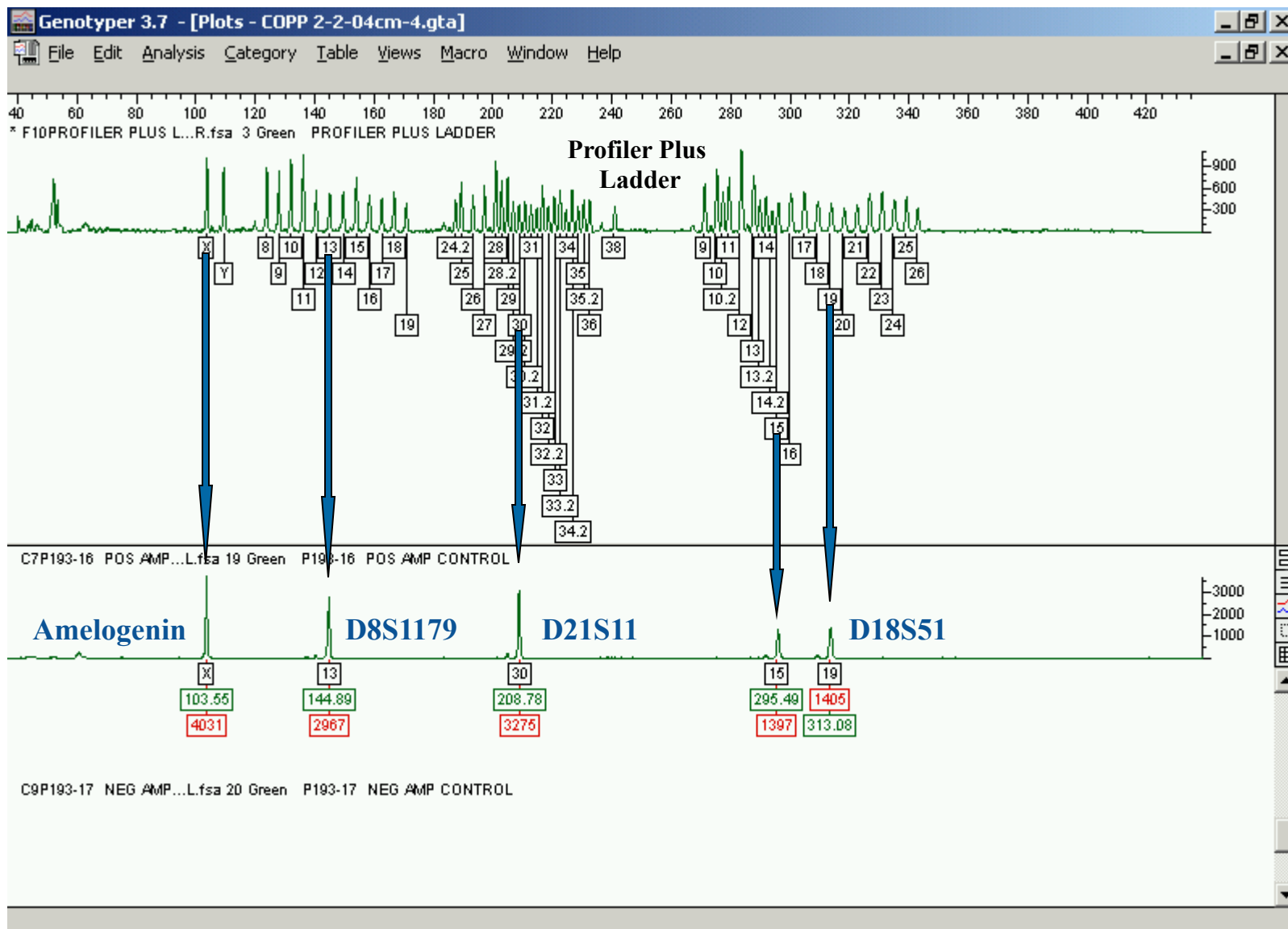
iClicker question

- Which of the following is an advantage of Short Tandem Repeat (STR) DNA typing?
 - A. A 15-locus STR profile is rare.
 - B. Requires a small test sample.
 - C. Polymorphic loci.
 - D. All of the above.

STR raw data



STR typed data



Item #25 – vaginal swab**S – sperm fraction****E – epithelial fraction**

STR profiles

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.”

iClicker question

- The profile matching the suspect occurs in approximately 1 in 100 quadrillion (10^{17}) unrelated individuals. Do you think this indicates identity? (i.e. *The semen came from the suspect and only the suspect.*)
 - A. Yes.
 - B. No.
 - C. What does Nancy Grace say?
 - D. I don't know.



COmbined DNA Index System (CODIS)

- Own and operated by the FBI.
 - All 50 states, the District of Columbia, the federal government, the U.S. Army Criminal Investigation Laboratory, and Puerto Rico participate in NDIS
- Convicted offender and forensic databases are maintained.
- Three tiers:
 - National (NDIS) – FBI
 - State (SDIS) – ex. CA DOJ
 - Local (LDIS) – ex. LAPD, LASD
- Laws concerning who is eligible for the database vary from state to state.

CODIS

National DNA Index System (NDIS)

(Stats Dec. 2012)

- **NDIS contains**
 - 10,086,400 offender profiles,
 - 1,332,700 arrestee profiles and
 - 466,800 forensic profiles
- **Investigations aided (metric)**
 - 198,400 hits assisting in more than 190,500 investigations.

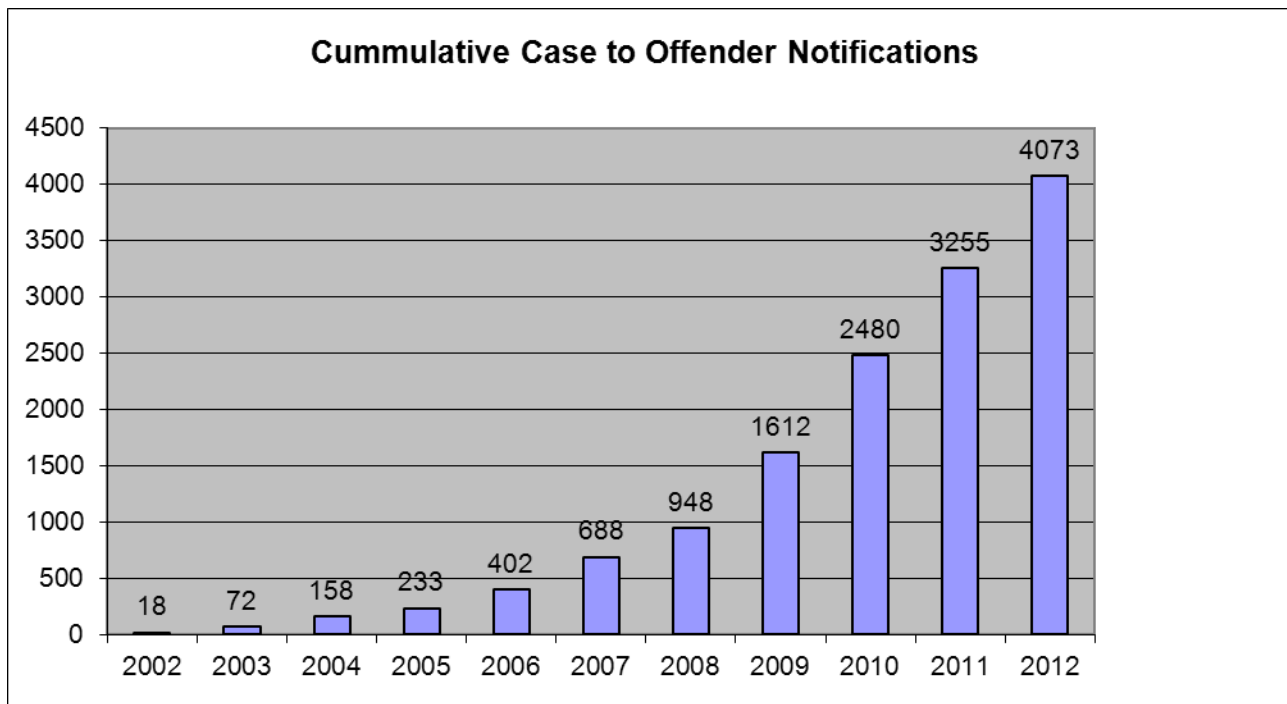
CODIS

State DNA Index System (SDIS)

(Stats for California, Dec. 2012)

- 22 participating CA law enforcement crime labs
- 1,419,913 offender profiles
- 558,535 arrestee profiles and
- 46,172 forensic profiles
- 24,553 investigations aided

LAPD CODIS stats



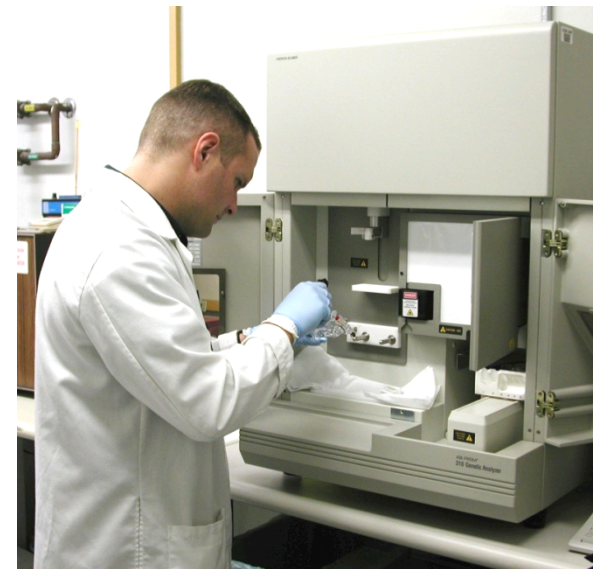
iClicker question

- Proposition 69 permits the collection of DNA samples from adults and juveniles arrested for any felony offense. Are you in favor of DNA collection on all arrested individuals?
 - A. Yes.
 - B. No.
 - C. The jury is out until 1:30 PM.
 - D. The government always knows what's best for me.

Other technologies and methods

- Mitochondrial DNA typing
 - This high copy number increases the likelihood of recovering sufficient DNA from compromised DNA samples, and for this reason, mtDNA can play an important role in missing persons investigations, mass disasters, and other forensic investigations involving samples with limited biological material.
- Y-chromosome STR typing
 - Y-STR data may augment autosomal STR results. In some circumstances, Y-STR data might be the only data that can be obtained. It is important to note that a Y-STR haplotype is shared by males from the same paternal lineage.
- GlobalFiler (Life Technologies)
 - Reduced amplification time with maximum data recovery power at 24-loci.
- Rapid DNA instruments
 - Lockheed Martin's advanced micro-fluidics based platform allows for rapid identification of human DNA in a portable package.
 - <http://www.lockheedmartin.com/us/products/dna-identification-platform.html>
- Familial Search Protocol
 - a deliberate search of a DNA database conducted for the intended purpose of potentially identifying close biological relatives to the unknown forensic profile obtained from crime scene evidence.

Questions?



References

- Wickenheiser RA. Trace DNA: a review, discussion of theory, and application of the transfer of trace quantities of DNA through skin contact. *J Forensic Sci* 2002;47(3):442–450.
- Touch DNA. What is it? Where is it? How much can be found? And, how can it impact my case? *A question and answer guide to all things touch DNA* by Suzanna R. Ryan, MS, Ryan Forensic DNA Consulting, January, 2012.
- Criminalist position
 - <http://agency.governmentjobs.com/lacity/default.cfm>
- FBI CODIS
 - <http://www.fbi.gov/about-us/lab/biometric-analysis/codis>