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Forensic DNA Analysis



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Forensic BIOLOGY



➤ Screening

- Examination of exhibits and identification of biological fluids
- Blood, semen, saliva

➤ Forensic DNA analysis

- Development of DNA profiles from crime stains
- Development of DNA profiles from reference samples
- Comparison



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Screening

- Growing list of biological substrates tested for DNA
 - traditionally blood, semen, saliva
 - more and more commonly trace DNA; contact DNA
- Examples of unusual substrates
 - (ear wax, contact lenses)
- Anything in contact with biological fluids
- Shedders vs. non-shedders



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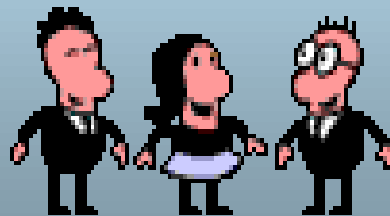
DNA Molecule and Structure

- DNA: DeoxyriboNucleicAcid
- Genetic material of most living organisms, genetic blueprint
- Inherited from our parents
- Stores information which determines

our physical features

AND

other attributes



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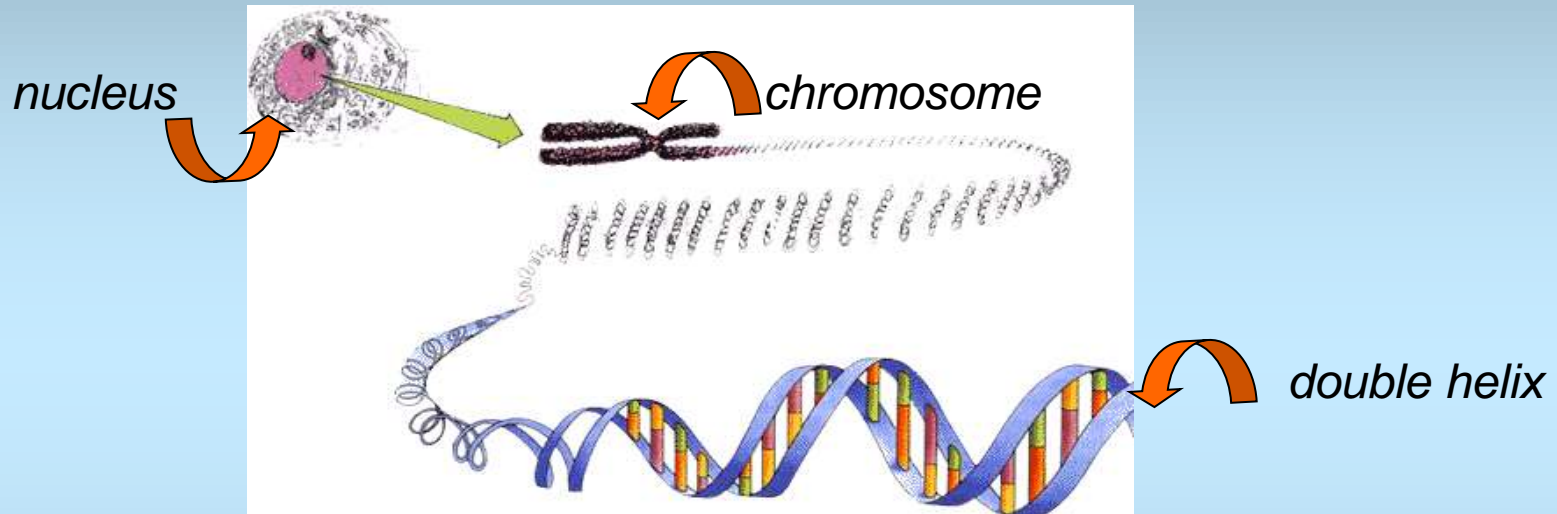
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DNA Molecule and Structure



- Found in every cell of our body
 - exception: red blood cells
- DNA is 99.7% identical between any two people
 - ONLY 0.3% variation
- Unique to an individual
 - exception: identical twins



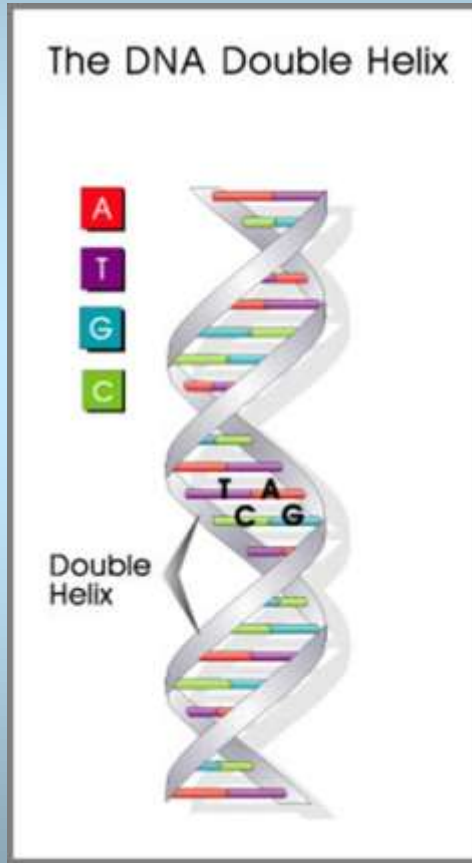
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DNA Molecule and Structure



- DNA is composed of nucleotides; interlocking building blocks
- Nucleotides characterized by a base present (Adenine, Cytosine, Thymine or Guanine)
 - complementary pairing (A-T, C-G)
- Human genome contains 3 billion base pairs
 - onion genome 17 billion base pairs



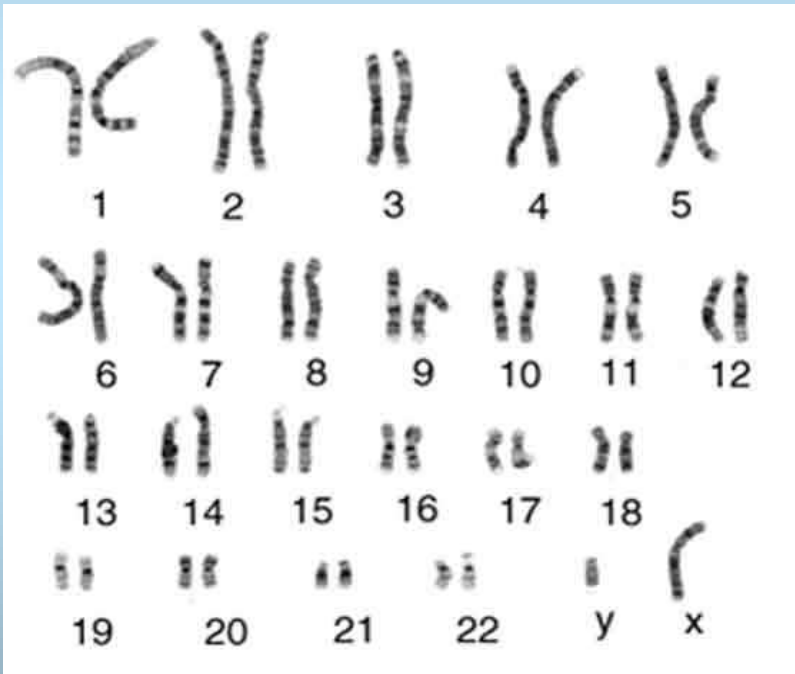
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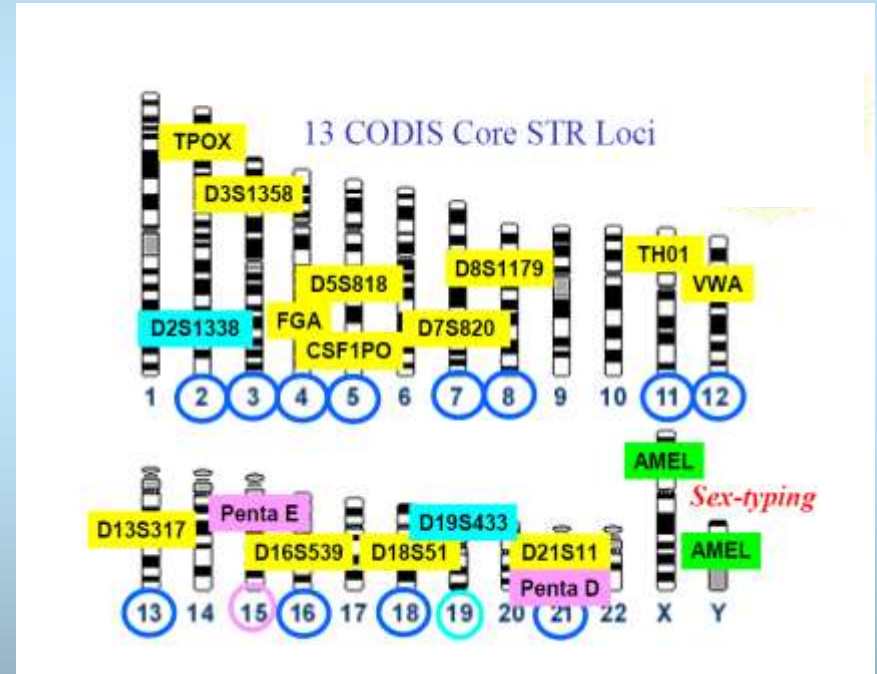
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DNA Molecule and Structure



HUMAN CHROMOSOMES



LOCATION OF FORENSIC LOCI ON HUMAN CHROMOSOMES



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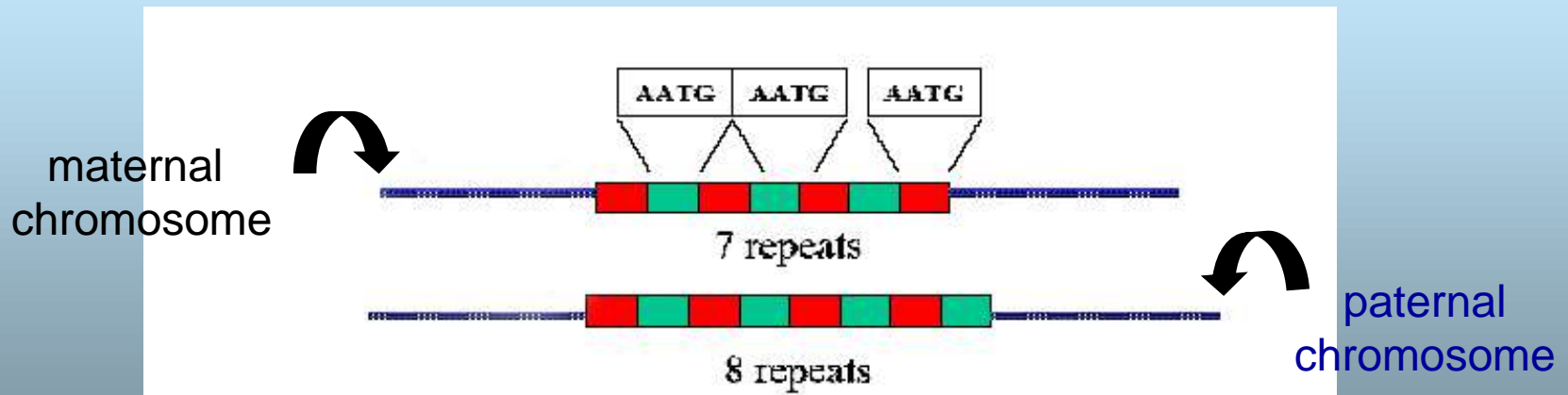
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Short Tandem Repeats (STR)

- Basis of forensic DNA testing
- Short stretches of DNA characterized by a repeat unit
- Repeats present in variable numbers in individuals
- Number of repeats distinguishes one person from another
- Forensic DNA analysis designed to isolate, count and compare STR's between individuals



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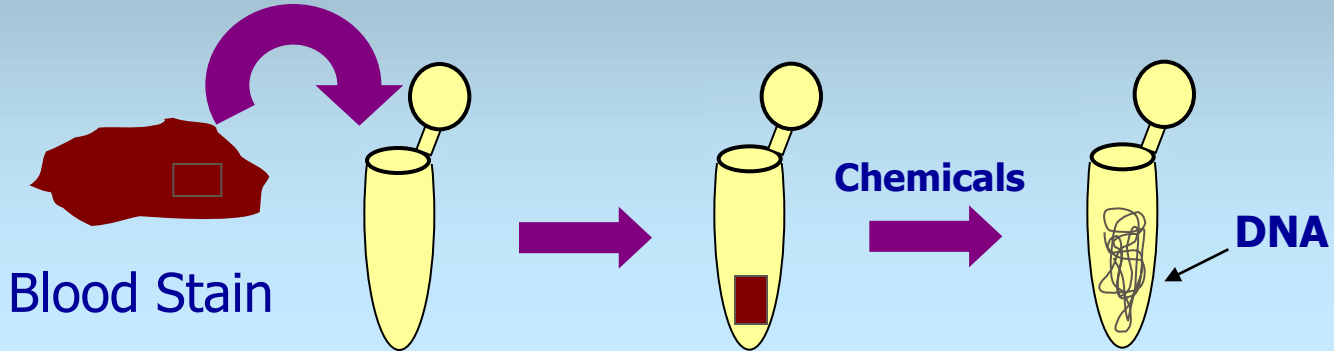
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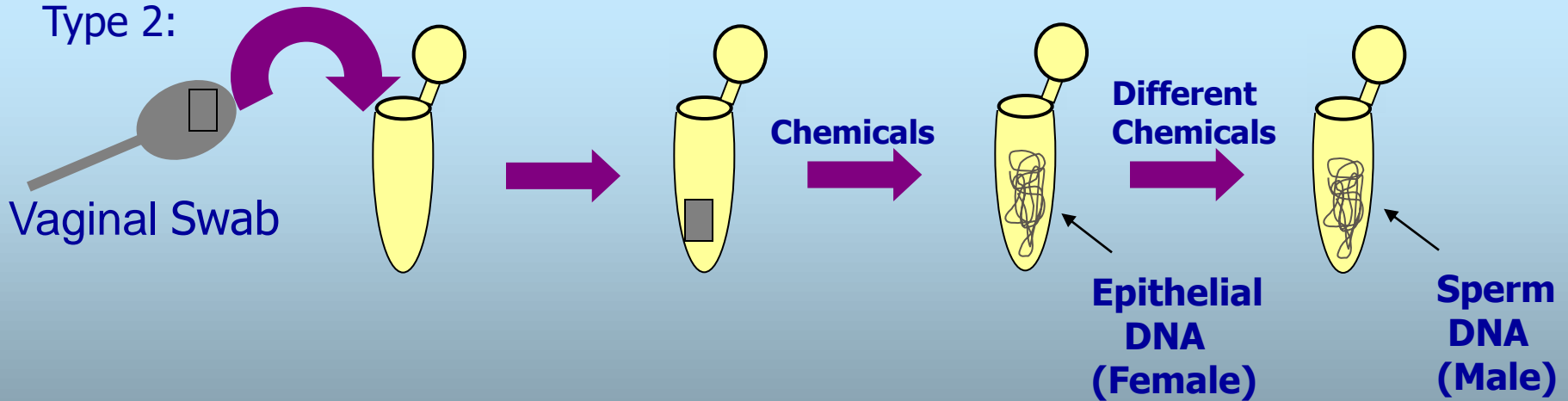


DNA Extraction and Quantitation

Extraction
Type 1:



Extraction
Type 2:





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DNA Amplification

- Polymerase Chain Reaction-PCR
- Process of 'Biological Xeroxing'
- Temperature controlled process targeting and fluorescently labeling parts of DNA molecule
- Amount of starting DNA is increased exponentially with each cycle





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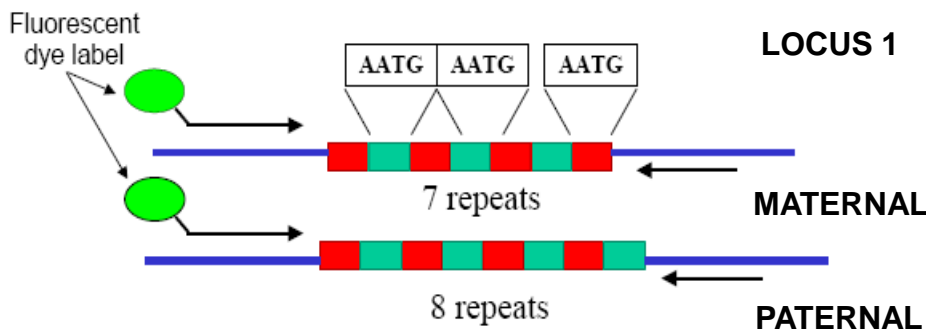
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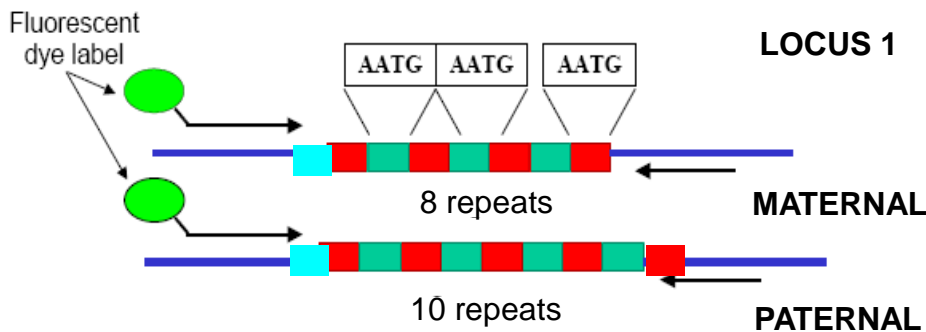


DNA Amplification

SAMPLE 1



SAMPLE 2



- Primer with fluorescent tag attaches to DNA and targets region of interest
- Individual is assigned a designation for each of 13 loci tested
 - SAMPLE 1 (7,8)
 - SAMPLE 2 (8,10)



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Capillary Electrophoresis



- Amplified DNA product analyzed by *capillary electrophoresis*
- DNA is separated by size and color
- Laser detection of DNA product
- Samples are analyzed using computer software



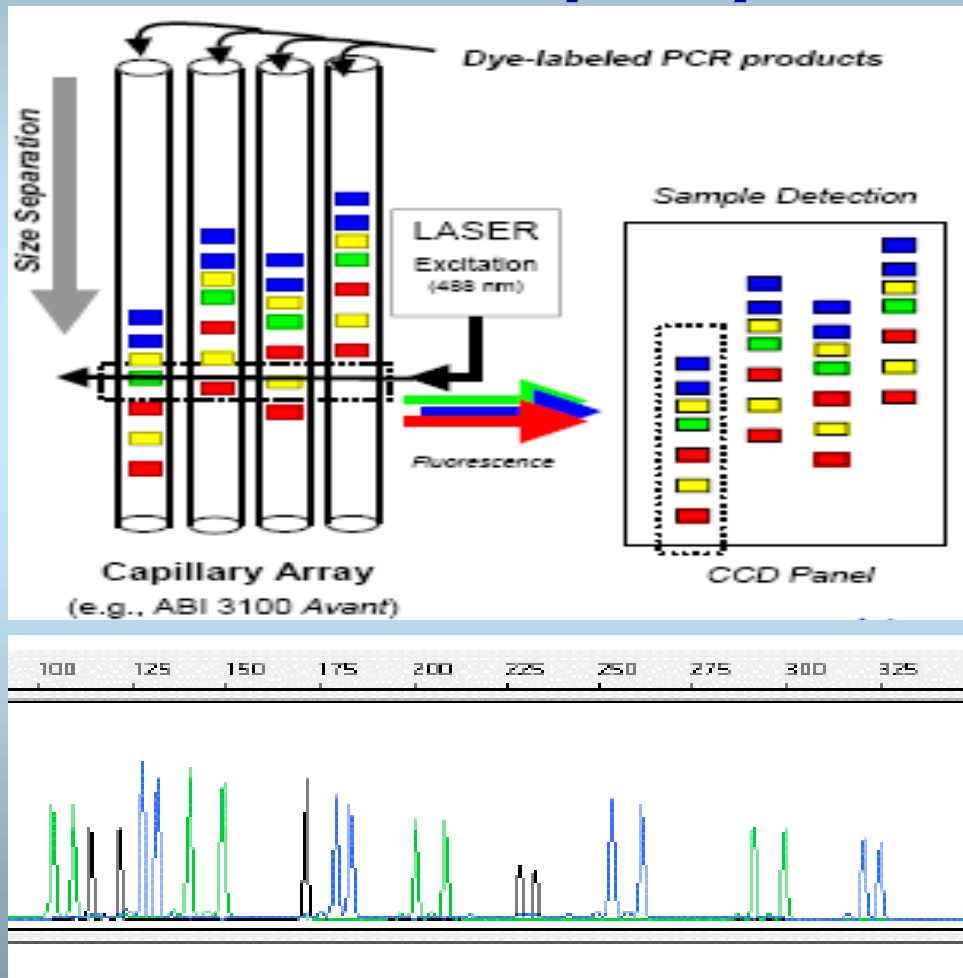
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Capillary Electrophoresis



- Fluorescently labeled DNA fragments separated by size migrate by the laser detection region on the capillary electrophoresis instrument
- Fluorescent dyes with excitation and emission traits result in detection of DNA fragments



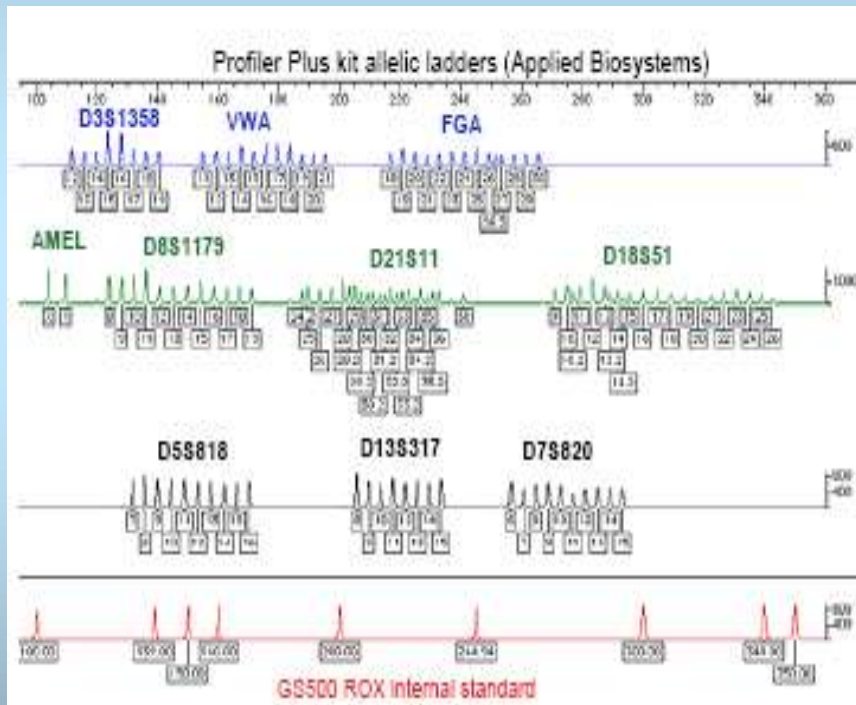
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STR Analysis



- Genotyping is performed by comparing to *STR allelic ladder*
- STR allelic ladder represents all possible STR designations for a given DNA site
- Alleles represent different lengths of STRs on a chromosome
- Sizing assured by internal sizing standard



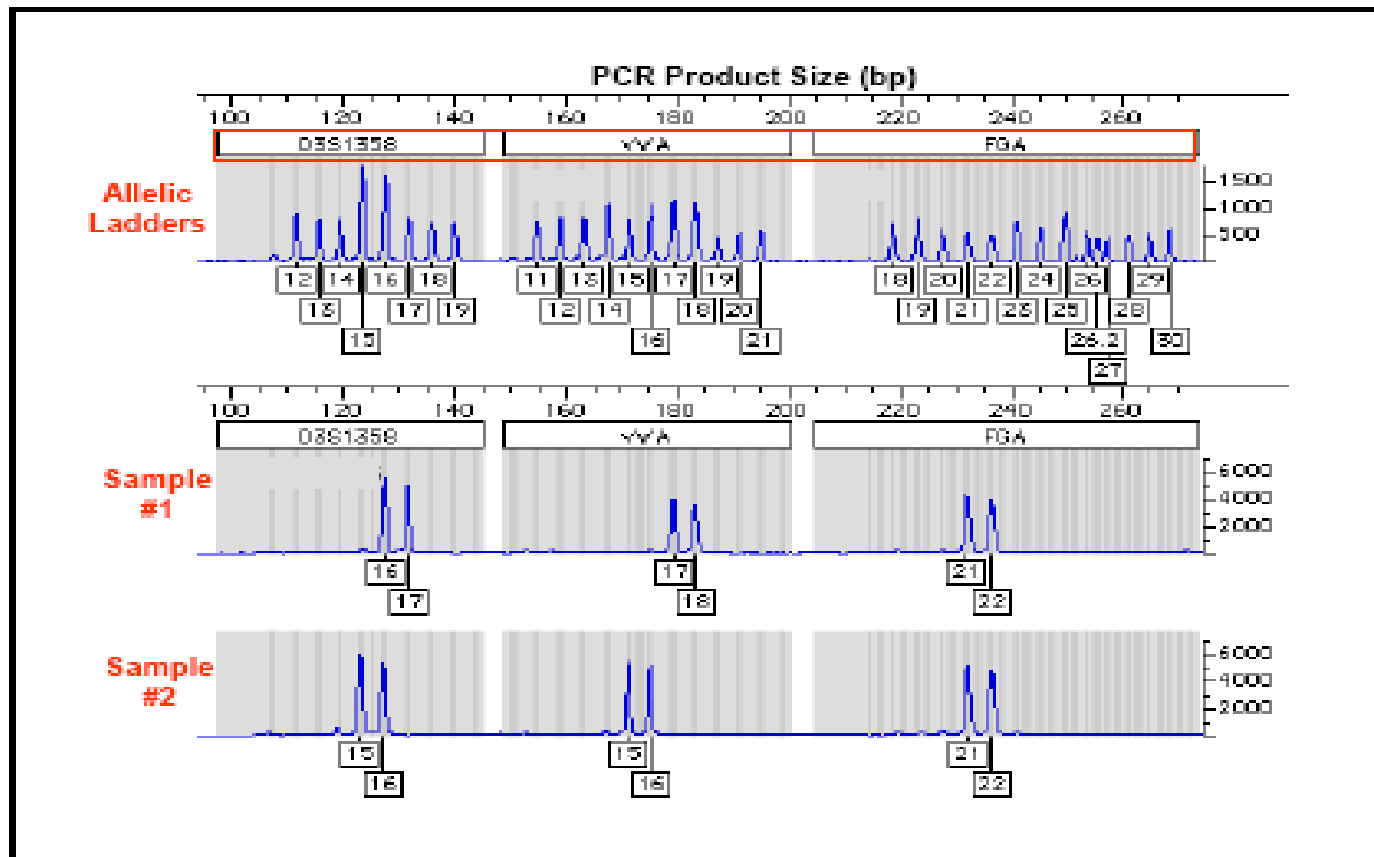
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STR Analysis



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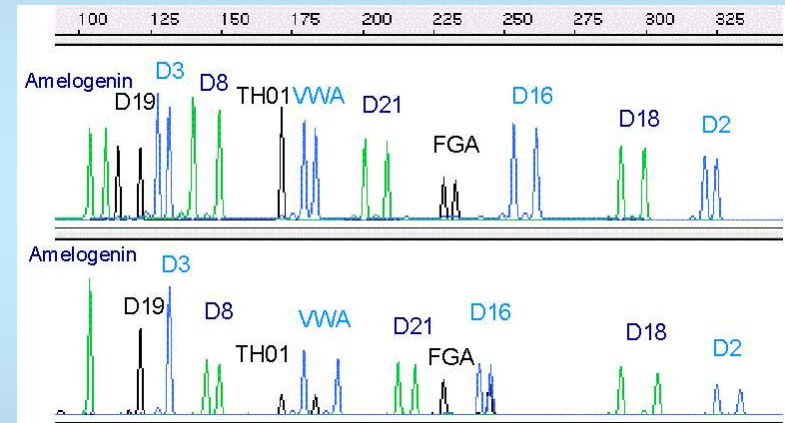
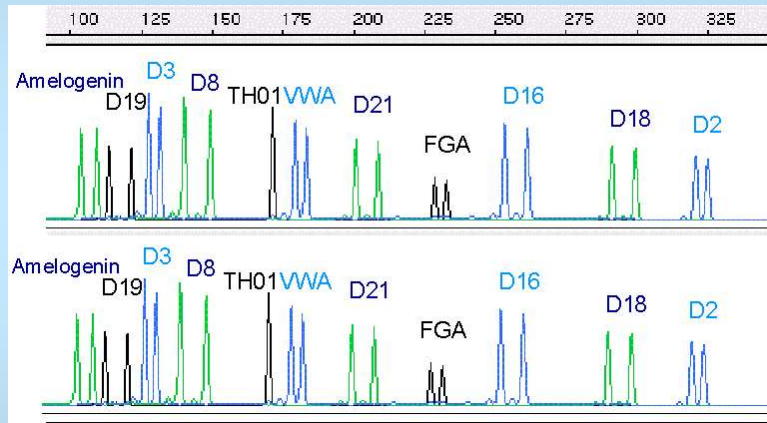
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STR Analysis

Three outcomes of comparison between crime scene and reference sample



MATCH

NO MATCH

INCONCLUSIVE



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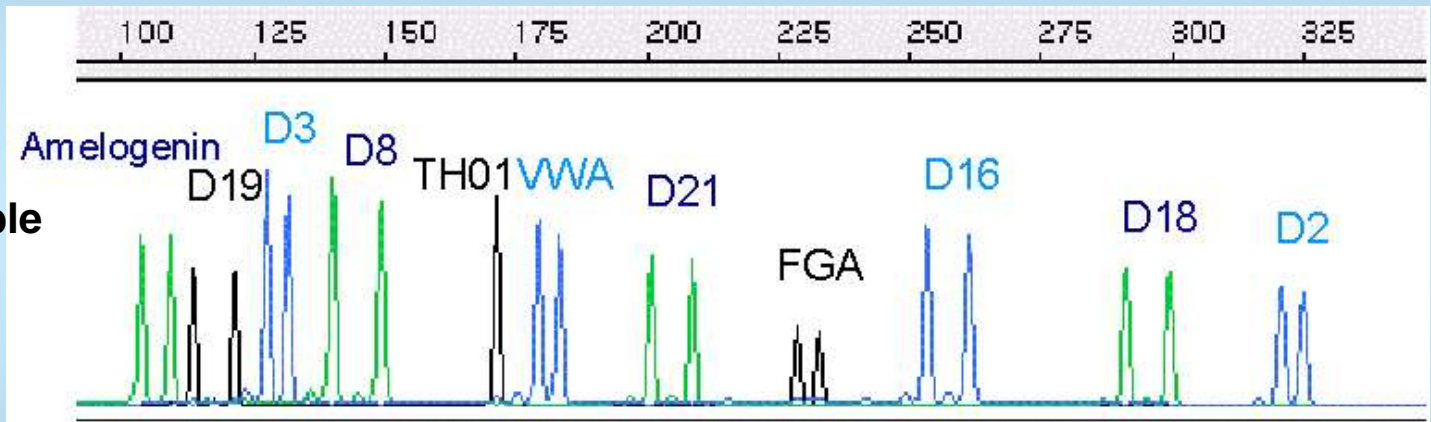
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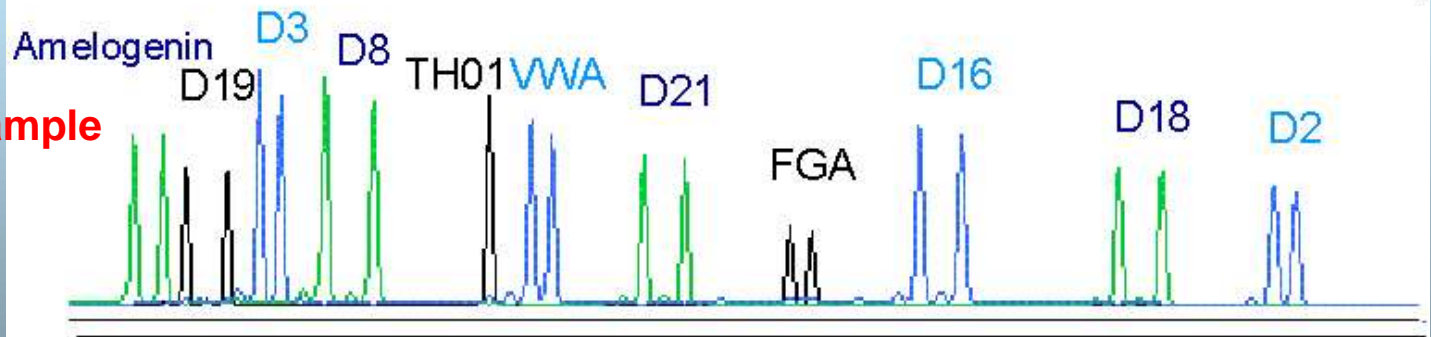


Comparison of DNA profiles-MATCH

Reference Sample
1:



Crime Scene Sample
2:



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Comparison of DNA profiles-MATCH

LOCUS	Reference Sample 1:	Crime Scene Sample 2:
D3S1358	14, 15	14, 15
vWA	15, 16	15, 16
FGA	22, 23	22, 23
Amelogenin	X,Y	X,Y
D8S1179	10, 13	10, 13
D21S11	29,30	29,30
D18S51	12,14	12,14
D5S818	11, 13	11, 13
D13S317	10,11	10,11
D7S820	10,10	10,10
D16S539	9,11	9,11
THO1	6,8	6,8
TPOX	8,8	8,8
CSF1PO	12,13	12,13

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Comparison of DNA profiles-MATCH

LOCUS	Reference Sample 1:	Crime Scene Sample 2:
D21S11	11,15	11,15

A male DNA profile obtained from the crime scene sample was found to match the DNA profile of the suspect.

D7S820	10,10	10,10
D16S539	9,11	9,11
TH01	6,8	6,8
TPOX	8,8	8,8
CSF1PO	12,13	12,13



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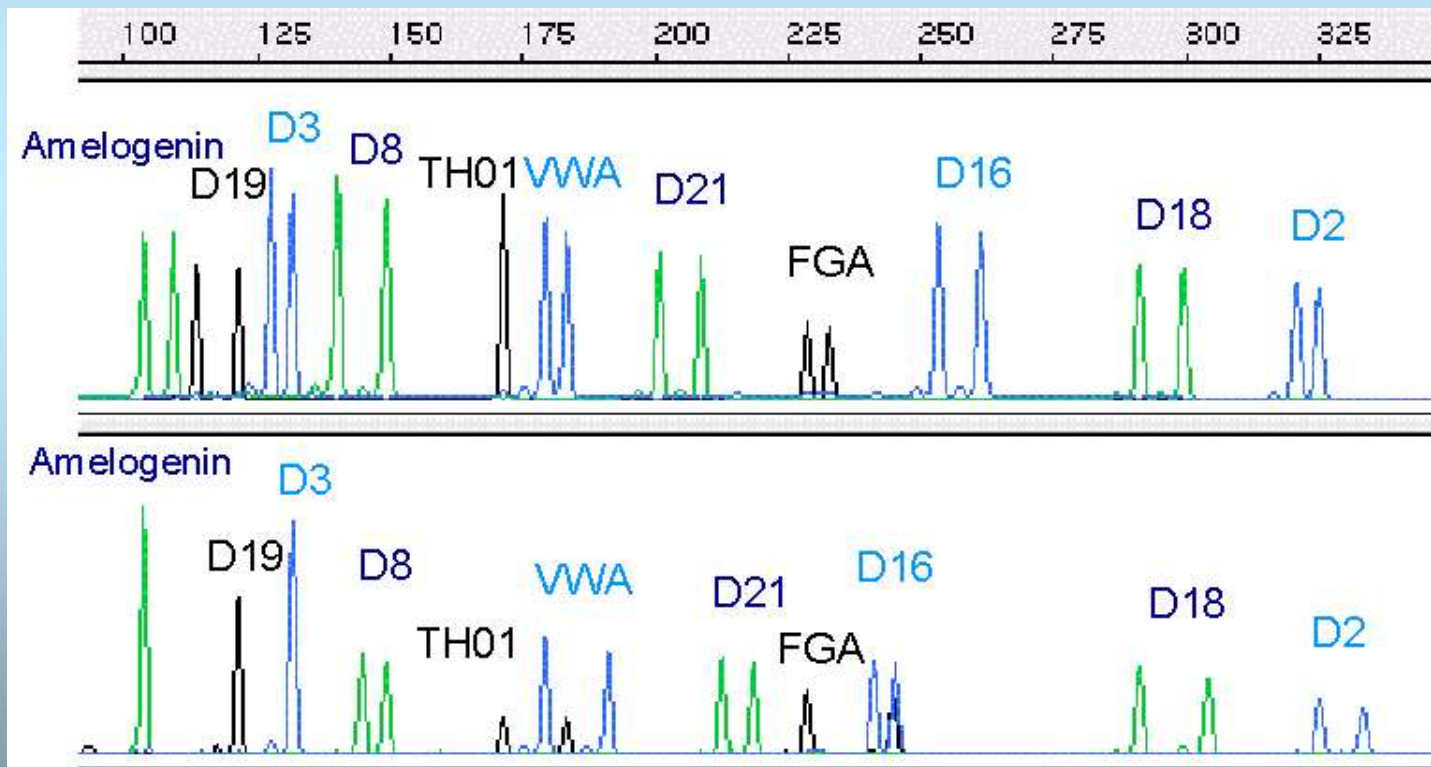
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Comparison of DNA profiles- NO MATCH

Reference Sample
3:



Crime Scene Sample
4:

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Comparison of DNA profiles- NO MATCH

LOCUS	Reference Sample 3:	Crime Scene Sample 4:
D3S1358	14, 15	14, 15
vWA	15, 16	16, 18
FGA	22, 23	22, 23
Amelogenin	X,Y	X,X
D8S1179	10, 13	10, 12
D21S11	29,30	29,30
D18S51	12,14	12,14
D5S818	11, 13	11, 13
D13S317	10,11	10,13
D7S820	10,10	9, 10
D16S539	9,11	9,11
THO1	6,8	6,8
TPOX	8,8	8,8
CSF1PO	12,13	12,13

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Comparison of DNA profiles- NO MATCH

LOCUS	Reference Sample 3:	Crime Scene Sample 4:
The suspect is excluded as a donor of the DNA profile obtained from the crime scene sample.		
D7S820	10,10	9, 10
D16S539	9,11	9,11
THO1	6,8	6,8
TPOX	8,8	8,8
CSF1PO	12,13	12,13

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DNA Statistics

HOW TO CALCULATE RANDOM MATCH PROBABILITY?

- **Collect data and determine allele frequency estimates in a population**
 - Count how many times each allele is seen in a given population
 - If in a sample of 300 people we see allele 8 thirty time at locus TPOX assign allele 8 frequency of 0.1
- **Based on these allele frequencies, determine allele frequencies at each locus of a DNA sample**
 - Apply relevant formulas for each locus
 - Use **PRODUCT RULE** to determine the frequency of a DNA profile; multiply all loci together



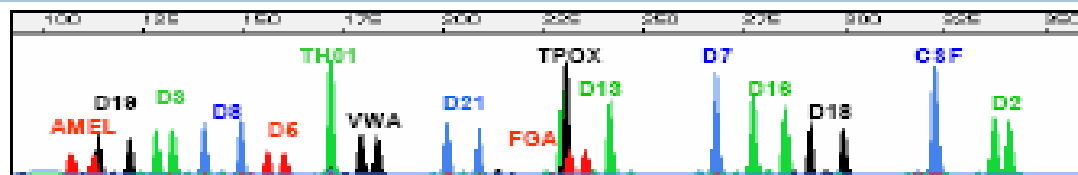
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DNA Statistics



Locus	allele	value	allele	value	frequency, 1 in
D3S1358	16.0	0.2315	17.0	0.2118	10.20
VWA	17.0	0.2628	18.0	0.2219	8.57
FGA	21.0	0.1735	22.0	0.1888	15.26
D8S1179	12.0	0.1454	14.0	0.2015	17.07
D21S11	28.0	0.1658	30.0	0.2321	12.99
D18S51	14.0	0.1735	16.0	0.1071	26.91
D5S818	12.0	0.3539	13.0	0.1462	9.66
D13S317	11.0	0.3189	14.0	0.0357	43.92
D7S820	9.0	0.1478			43.28
D16S539	11.0	0.2723	13.0	0.1634	11.24
TH01	6.0	0.2266			18.83
TPOX	8.0	0.5443			3.35
CSF1PO	10.0	0.2537			15.09

The Random Match Probability for this profile in the FBI Caucasian population is 1 in 1.56 quadrillion (10^{15})

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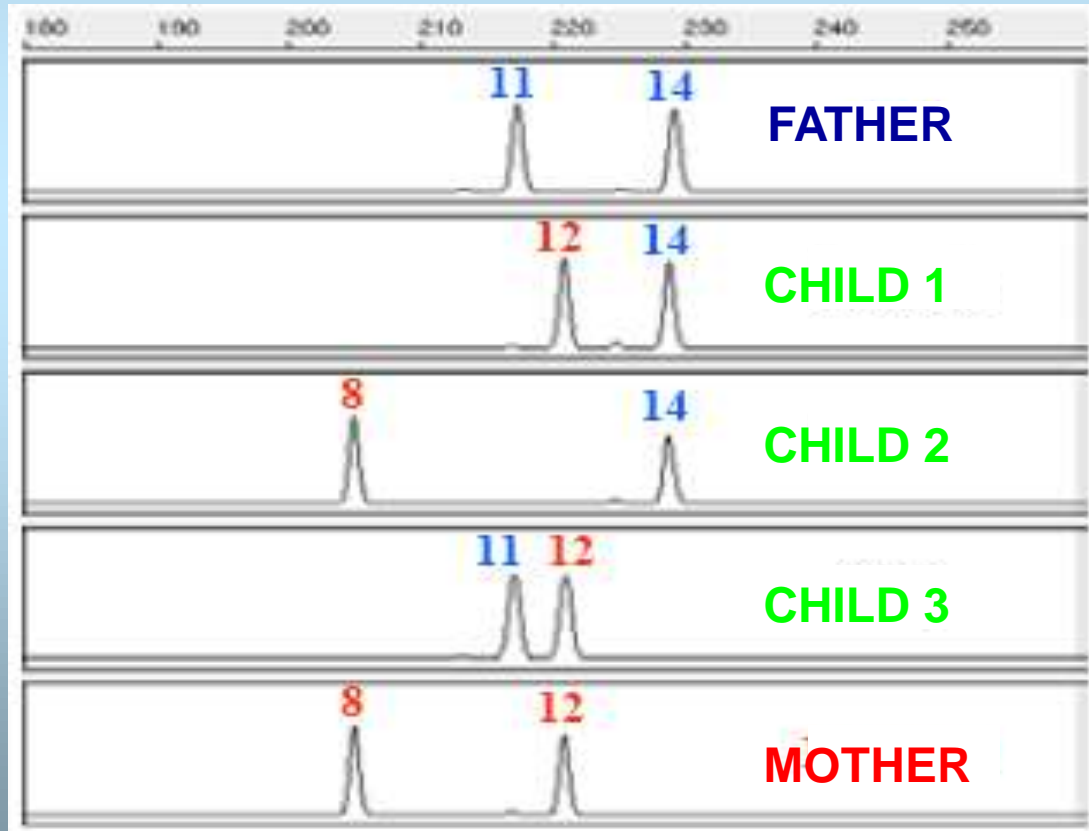
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Other Applications of DNA Analysis

PATERNITY





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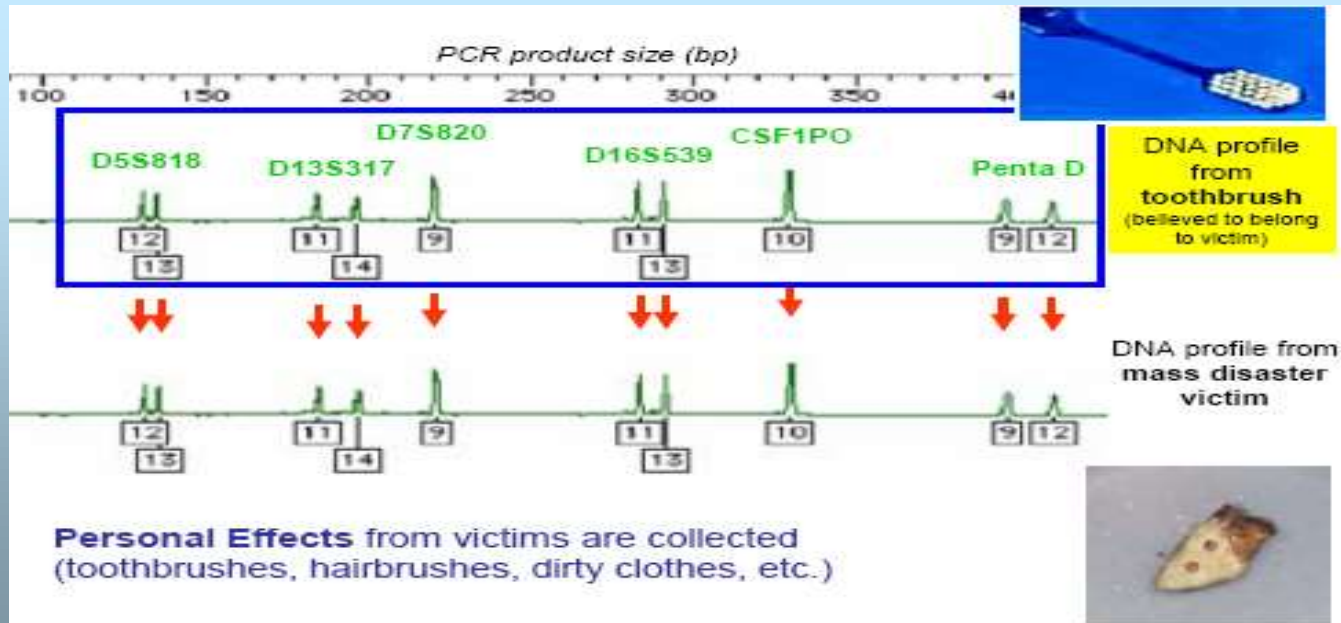
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Other Applications of DNA Analysis

IDENTIFICATION OF MASS DISASTER VICTIMS

- World Trade Center, Tsunami, Hurricane Katrina
- Comparison of biological samples from the scene of disaster (bone, teeth, hair) to personal effects from a missing person (razor, toothbrush)





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Other Applications of DNA Analysis

INNOCENCE PROJECT

- Created in 1992
- Organization dedicated to exonerating wrongfully convicted people through DNA testing and reforming the criminal justice system to prevent future injustice

Address: <http://www.innocenceproject.org>

Innocence Project <http://www.innocenceproject.org>

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Michael A. Williams
Exonerated

Kenneth Wyniemi
Year of Incarceration: 1994
Jurisdiction: Michigan
Sentence: 80.00 years
Year of Exoneration: 2005

March 11, 2005 163 exonerated as of October 12, 2005
187 EXONERATED

DNA EXONERATIONS BY YEAR IN THE U.S.

Year	Number of Exonerations
'89	1
'90	1
'91	2
'92	4
'93	4
'94	6
'95	6
'96	12
'97	7
'98	5
'99	8
'00	16
'01	22
'02	19
'03	16
'04	13
'05	4

The Innocence Project at the University of North Carolina is a non-profit legal clinic through which wrongful DNA testing and cases where scientific DNA testing was used to exonerate innocent people.



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DNA Database

- CODIS: Combined DNA Index System
- Contains DNA profiles from crime stains and known individuals (Convicted Offenders)
- Designed to link (serial and unsolved) crimes and convicted offenders (repeat)
- Launched October 1998
- Linking all 50 states
- Currently contains about 150,000 DNA profiles from crime stains and 2 million DNA profiles from known convicted offenders
- In Arizona as of January 1, 2008-all arrestees



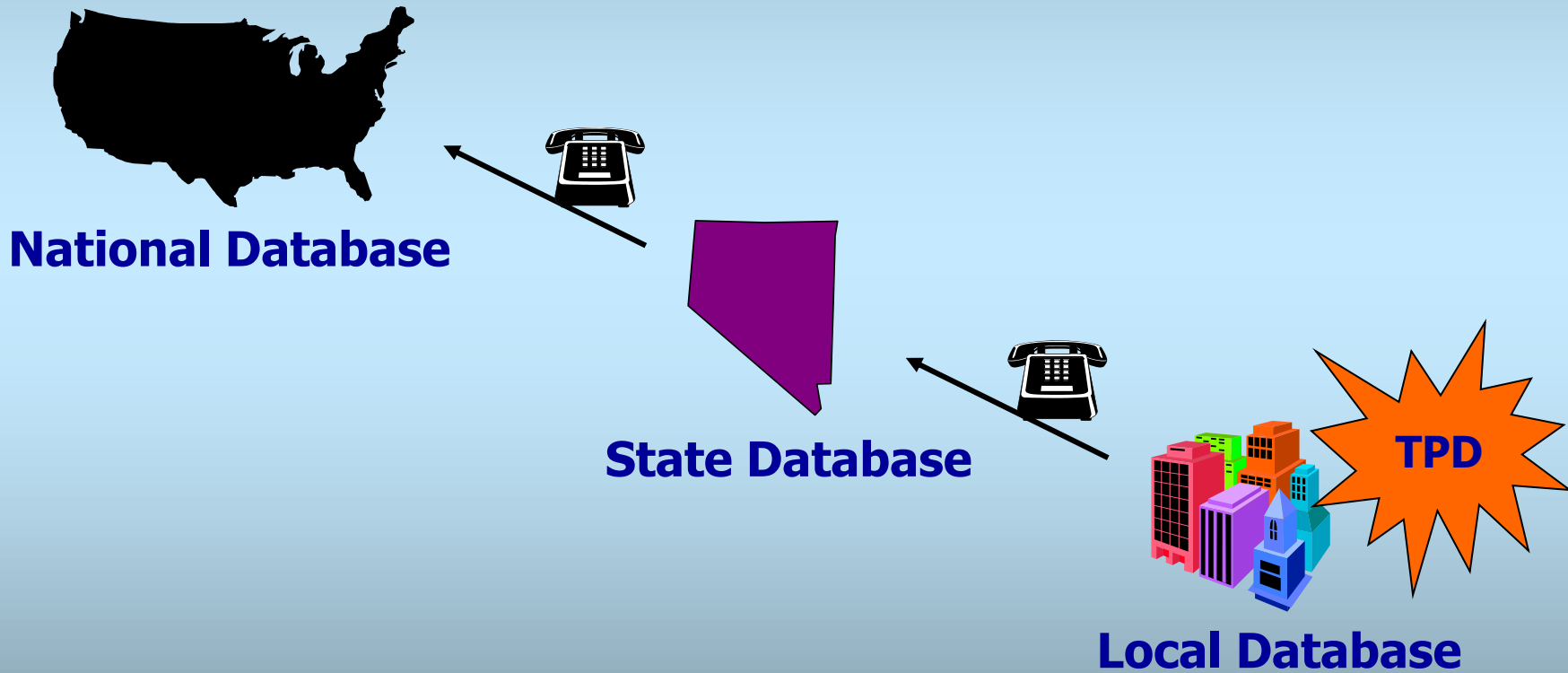
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DNA Database





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DNA Database



**Database of DNA
profiles from known
offenders
(INDIVIDUALS)**



**Database of DNA
profiles from unknown
suspect casework
(CRIME)**



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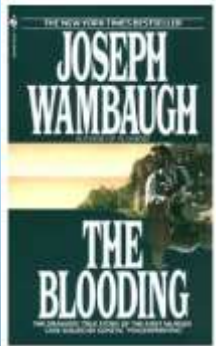
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Forensic DNA Cases



- Double rape and murder of two girls in England in 1983 and 1986
- Search for a suspect based on collection of voluntary reference DNA sample from 5,000 local men
- One of these men, Ian Kelly, gave a sample for his friend Colin Pitchfork and was later overheard bragging about it
- Colin Pitchfork, local baker, was subsequently tested and arrested
- The first person to be convicted based on forensic DNA evidence, sentenced to life in prison
- Detailed in 'The Bleeding'





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Forensic DNA Cases

- Murder of ten people in Kansas between 1974 and 1991-case goes cold
- Murderer initiates communication with the Police in 2004
 - series of letters and exchange of information on floppy disks follows
 - the Police determine his name 'Dennis' and his connection to a local 'Lutheran' church
 - able to find his full name by internet searching 'Lutheran Church Wichita Dennis'
- Daughter asked to provide a DNA sample
- Dennis Rader-known as BTK (bind, torture, kill) arrested in 2006 and convicted to serve ten consecutive life terms





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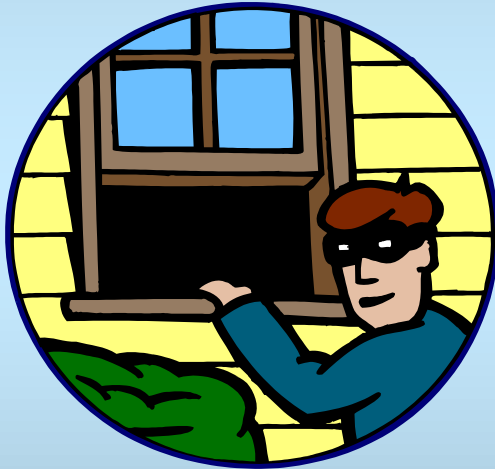
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Forensic DNA Cases

Sexual Assaults

- Series of sexual assaults linked via CODIS DNA database
 - 1999 NV and OK
 - 2000 San Diego, CA
 - 2001-2002 Tucson, AZ
 - 2002 CO
- James Selby was nominated as a suspect
- A warrant issued for his arrest and relevant information distributed
- Arrested at the VA facility in CO
- Tried and convicted in Tucson
- Never sentenced, committed suicide 2004





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Forensic DNA Cases

Property Crimes

- Most commonly processing burglaries and auto theft
- In CODIS hit rate about 50%

A suspect will be nominated in one out of every two unsolved property crimes





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