



Welcome

DNA and the Crime Lab: The Role of DNA in Sexual Assault

September 9, ,2016

12pm-1pm

Facilitator: Cindy Moore

Presenter: **Misty Marra, Forensic DNA Analyst and Laboratory Coordinator**

As with all technology, we may experience a momentary lapse in the Webinar session. In the event of a problem, please be patient and remain on the line. If the problem persists, please contact: Danielle.McLean@icfi.com for technical assistance.

The session will be recorded. The session will begin shortly.



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Office for Victims of Crime
OVC



Transforming The Care of Sexual Assault Survivors

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OFFICE FOR VICTIMS OF CRIME Training and Technical Assistance Center



Today's Topics

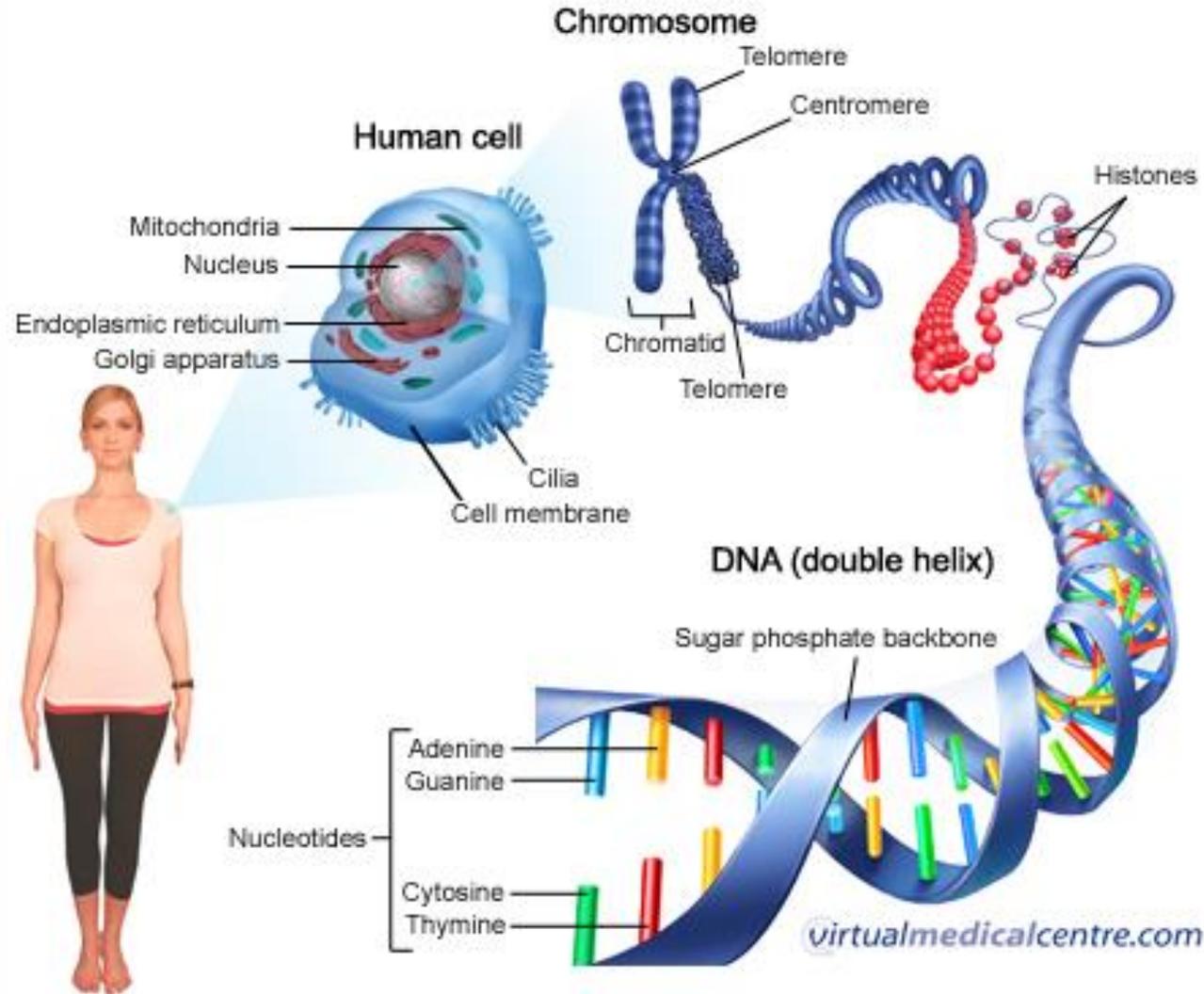
- Basics of DNA
- DNA evidence
- What happens at the crime lab...
- DNA profiles
- CODIS database
- Limitations of DNA testing
- New technologies



What is DNA?

- DNA stands for Deoxyribonucleic Acid
- Inherited from our parents
- Our body's "Instruction Manual"
 - Physical characteristics (eye color, hair color, height)
 - Bodily function
 - Disease predisposition

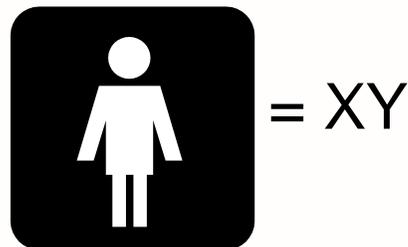






Nuclear or Autosomal DNA

- Nuclear DNA is packaged as chromosomes
 - $\frac{1}{2}$ inherited from MOM
 - $\frac{1}{2}$ inherited from DAD
- Nucleus also contains sex chromosomes





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More about DNA

- 99% of our DNA codes for cell function
 - Identical for all humans
 - Gives us two eyes, a heart, and other biological functions
- Approximately 1% of our DNA is unique from person to person
 - One exception: Identical twins!
 - Used for human identification



www.worldwildlife.org



www.orkin.com



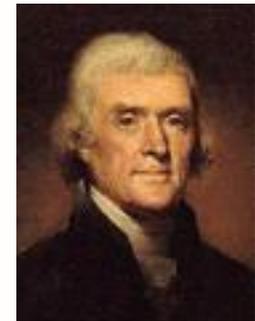
Nuclear/Autosomal DNA

- The most common type of DNA tested by crime labs
 - Unique to one individual barring identical twins
- All crime labs will analyze autosomal DNA
- At least 13 different areas (loci) of DNA are characterized in one profile
 - # is determined by FBI
 - As of January 2017, 20 different loci will be required for testing



Y Chromosome DNA

- Male DNA only – from Y chromosome
- Inherited in its full form from the father so same Y chromosome DNA as father and other paternally related individuals
- Useful when a sample contains DNA from multiple males or a mixture of female and male DNA
 - Large amount of female DNA + small amount of male DNA
- Not unique to one individual
- More useful for eliminations than identifications
 - Thomas Jefferson
- Public crime labs have this testing capability

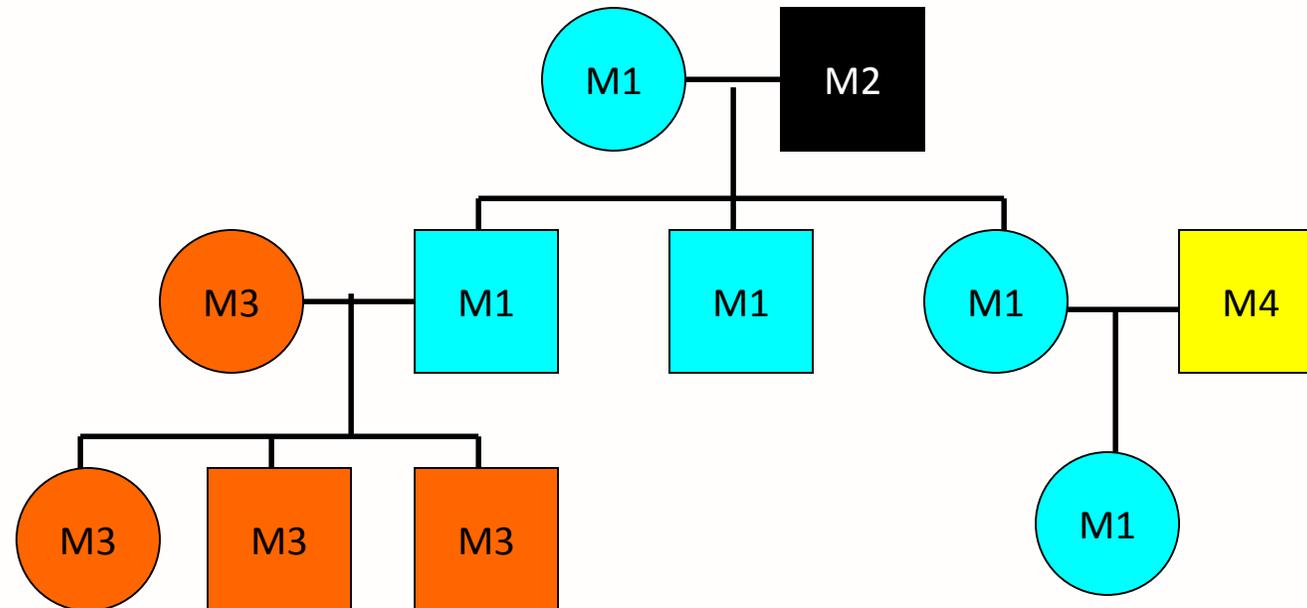


igene.com



Mitochondrial DNA (mtDNA)

- Mitochondria are energy factories of the cell
- Both males and females have mtDNA
- Everyone in the same **maternal lineage** has the same mtDNA



□ = male

○ = female



Mitochondrial DNA

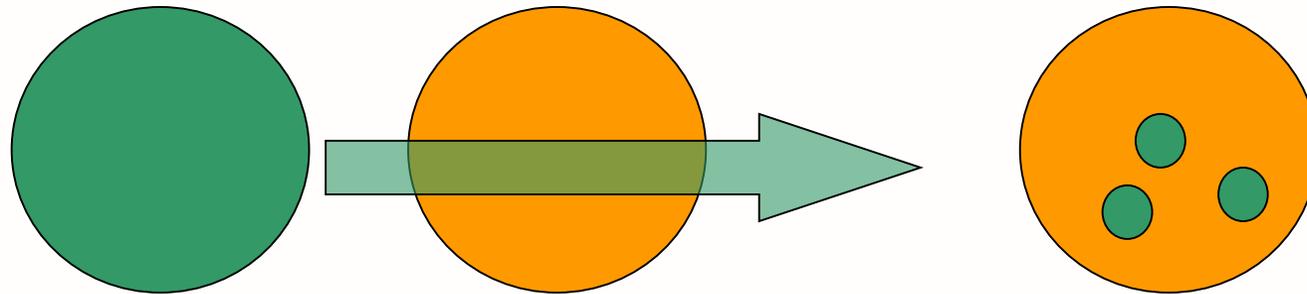
- Often used to identify human remains
 - mtDNA “survives” longer than nuclear/autosomal DNA
- Typical samples that undergo mtDNA testing:
 - Rootless hairs / hair shafts
 - Old or burnt skeletal remains
- Not unique to one individual
- More useful for eliminations than identifications
- Few public labs will analyze mtDNA



Foundation for Forensic Science

Locard's Principle

*Whenever two objects come into contact,
an exchange of matter occurs*



Every contact leaves a trace



DNA Evidence as an Investigative Tool

- Physical evidence at the scene can be examined for the presence of biological materials to:
 - Help identify individuals associated with the crime
 - Place an individual at the crime scene
 - Identify human remains
 - Link separate crimes to a common person
 - Eliminate suspects/exonerate the innocent
- Evidence is the Silent Witness!!



DNA Evidence in Sexual Assault Cases

- The purposes of DNA evidence in a sexual assault case:
 - Identify an assailant (stranger rapes)
 - Prove sexual contact
- The vast majority of sexual assaults are committed by someone known to the victim.



Question on value of DNA evidence in acquaintance rape cases

What will defense be?

Should the kit be tested by the crime lab?

- Proves sexual contact
- Corroborates victim's story
- Provide links to other crimes; investigative leads



Role of Forensic Examiner

- *Body of the Victim = Crime Scene*
 - in addition to secondary scene where crime occurred
- Protect the integrity of the evidence
- The underlying intent of protection
 - Avoid the loss of evidence
 - Avoid the loss of its use



Chain of Custody

- Chain of Custody is the “Golden Ticket”
 - Documentation of the chain of custody guarantees the identity and integrity of the evidence submitted.
 - Proper seals ensure chain of custody.





Possible Sources of DNA

- Blood
- Semen
- Saliva
- Sweat
- Feces
- Vomit
- Urine
- Bone
- Tooth pulp
- Hair roots
- Tissue (POC)
- Skin cells



Forensicmag.com



Insertcheckmate.com



Tritechforensics.com



dps.mn.gov



Possible DNA Evidentiary Items

- Swabs/samplings of biological fluids
- Undergarments & clothing
- Bed sheets/blankets
- Condoms*
- Fingernail swabbings
- Bite marks
- Cigarette filters/cigars
- Toothbrush
- Drinking containers
- Chewed gum, hard candy, food
- Face mask
- Hats
- Touch evidence
- Cell phones

*HPD Case



Off the Wall Cases



Wikipedia.org



My daughter



Evidence Collection

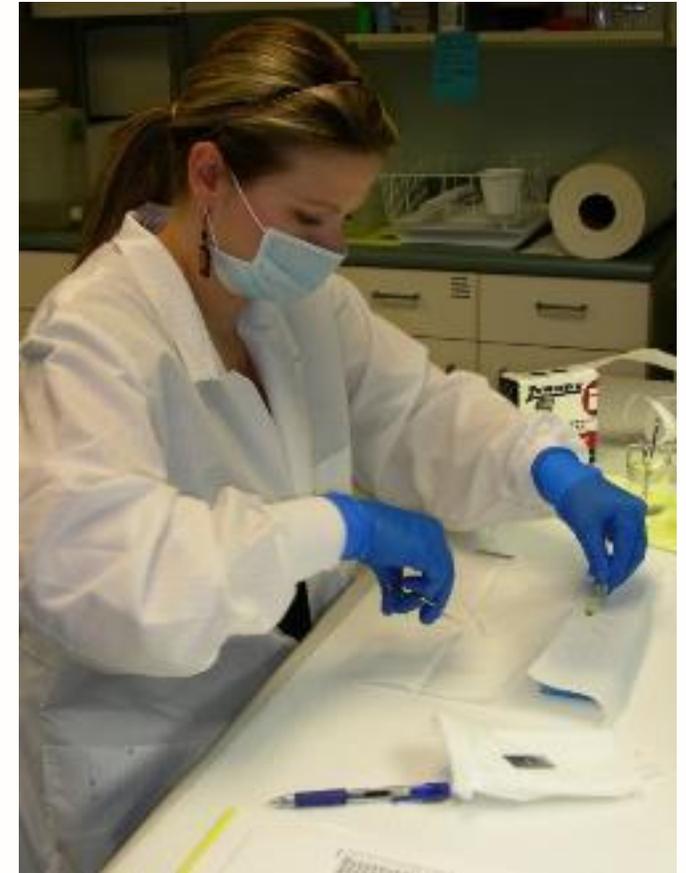
- Dry stains (majority of evidence)
 - Swab (Wet/Dry Swabs)
 - Cut
 - Adhesive Tape
 - Scrape – JonBenet Ramsey Case
 - MVac
- Liquid stains
 - Swab
 - Via Syringe (Blood)
 - Swab or absorbent FTA paper
 - Air dried
 - Prevents microbial activity





Contamination

- Very sensitive current technology can be prone to contamination
 - ~5-20 cells needed
- Anyone handling the evidence is a potential source of contamination
 - Coughing, sneezing, losing hair and skin cells
- Disposable options
 - gloves, masks, lab coats
- Technology cannot distinguish “relevant” DNA from “contaminating DNA”



MUFSC



Packaging & Storage

- Proper packaging and storage will prevent:
 - Sample loss
 - Harmful change
- If stored properly, DNA is stable for a very long time
- Items need to be air-dried and stored in **paper packaging at room temperature or below.**
 - Storing wet evidence in plastic or at higher temperatures can promote bacterial growth
 - Condoms?



www.scenesafe.co.uk



What Happens When Crime Lab Receives a Sexual Assault Kit?

- Logged into evidence inventory—Chain of Custody
- Analyst reads SAK documentation especially description of the assault to determine probative items to test
- Evidence items are screened for biological materials or male DNA
- Positive items will be taken on for DNA testing
- Evidence and reference DNA profiles are generated, a laboratory report will be submitted



Scenarios for Probative Samples- Dictates Testing

Single assailant, no loss of consciousness and no consensual sexual activity

- If vaginal assault, test vaginal swabs first
- If obtain male DNA profile then you can stop



Scenarios for Probative Samples- Dictates Testing

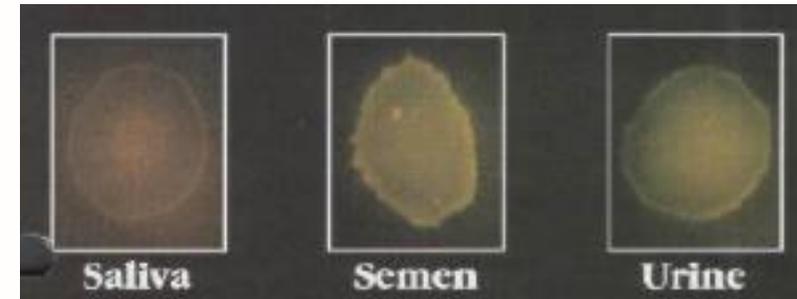
Multiple assailants, loss of consciousness or consensual sexual activity

- Will need to test more than one item in an attempt to detect all perpetrators or to be able detect the perpetrator and the consensual partner
- May have to test multiple items
 - My bra case example – tested 11 items before detected the second male
- National trend with grant money to only test up to 3 of the most probative items



Evidence Screening Presumptive Testing

- Searching clothing and other items for stains
 - UV light illuminates semen and other biological stains



csigizmos.com



Evidence Screening Presumptive Testing - Semen

- The Acid Phosphatase test is used for the identification of acid phosphatase in seminal fluid.
 - AP is also a color change reaction.
 - Positive=Purple
 - Vaginal fluids can test positive
 - Post mortem vaginal samples





Evidence Screening Confirmatory Testing- Semen

- Confirmatory tests confirm positive presumptive results
- Both tests are similar but test for different compounds.
 - Blood confirmation tests test for **human** hemoglobin
 - Prostate specific antigen (PSA) based tests for p30 or PSA protein commonly found in semen.

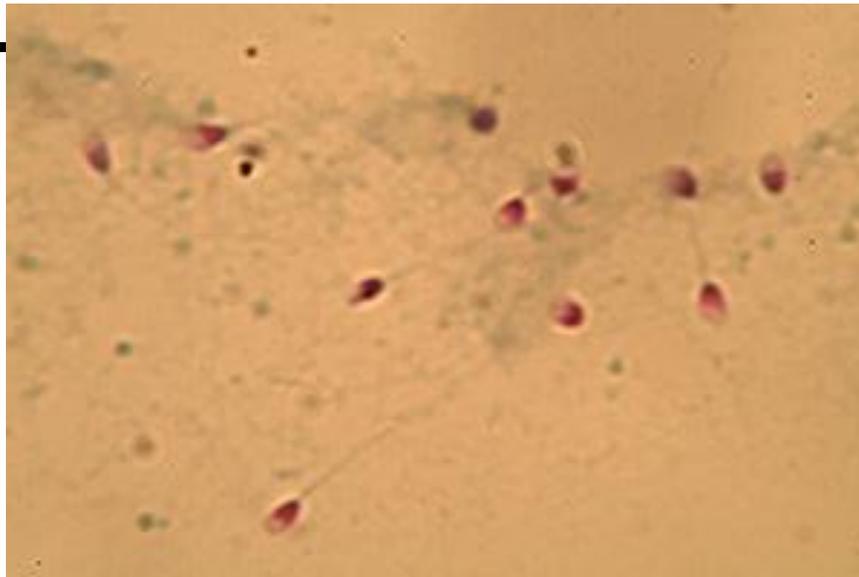


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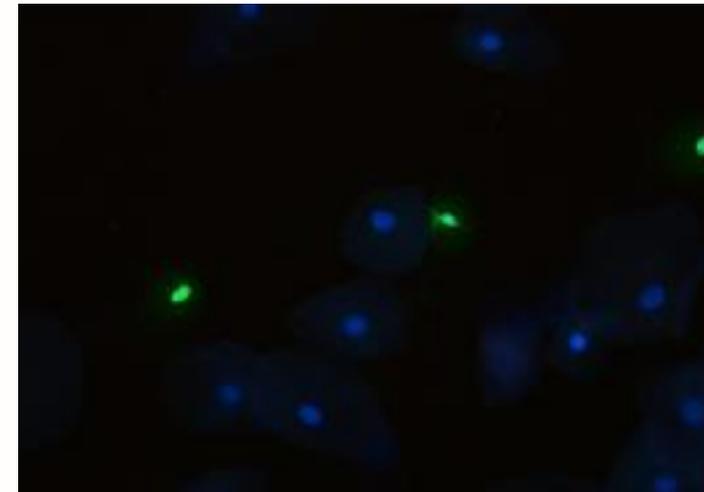


Evidence Screening Confirmatory Testing - Semen

- Another confirmation test is the identification of spermatozoa via Christmas Tree Staining or Sperm Hy-liter™.



nfstc.org



ifi-test.com



Evidence Screening Presumptive and Confirmatory Testing- Saliva

- Testing targets proteins specific to saliva such as Amylase
- Presumptive tests include
 - Phadebas – blue color
 - SALIgAE – yellow color



abacusdiagnostics.com

- Confirmatory test is RSID™ Saliva



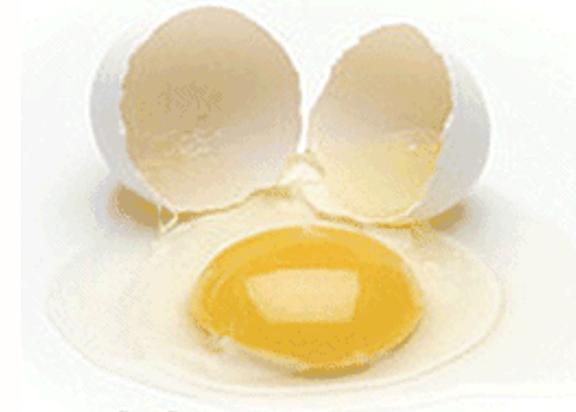
Y-Screen Methods

- Traditional screening is labor intensive and time consuming
- Y-screen allows for the rapid detection of male DNA
 - Targets DNA on the Y chromosome
 - Indicates that male DNA is present but not what type of cell it comes from
- Saves time, money and effort to allow labs to test cases with probative evidence
- Can do traditional screening after the testing if prosecution needs the court to hear that the male DNA came from sperm cells
 - Approximately half of all sexual assault kits are positive for male DNA and a small percentage of those go to trial (plea deals or no prosecution)



Extraction and Quantitation

- DNA testing of positively screened samples start with extraction
 - Crack open the egg (cell)
 - Clean up sample and isolate DNA
- Differential separation for samples containing semen
- Calculate the amount of human DNA present



100awesomethings.com



DNA Amplification

- Isolated DNA is not “analyzable”
- Polymerase Chain Reaction (PCR)
 - PCR increases the amount of DNA for typing (attaches fluorescent tag).
 - PCR amplifies only the fragments of DNA used for creating a profile.
 - Short Tandem Repeats (STRs) – short sequences of DNA that are repeated numerous times along the genome

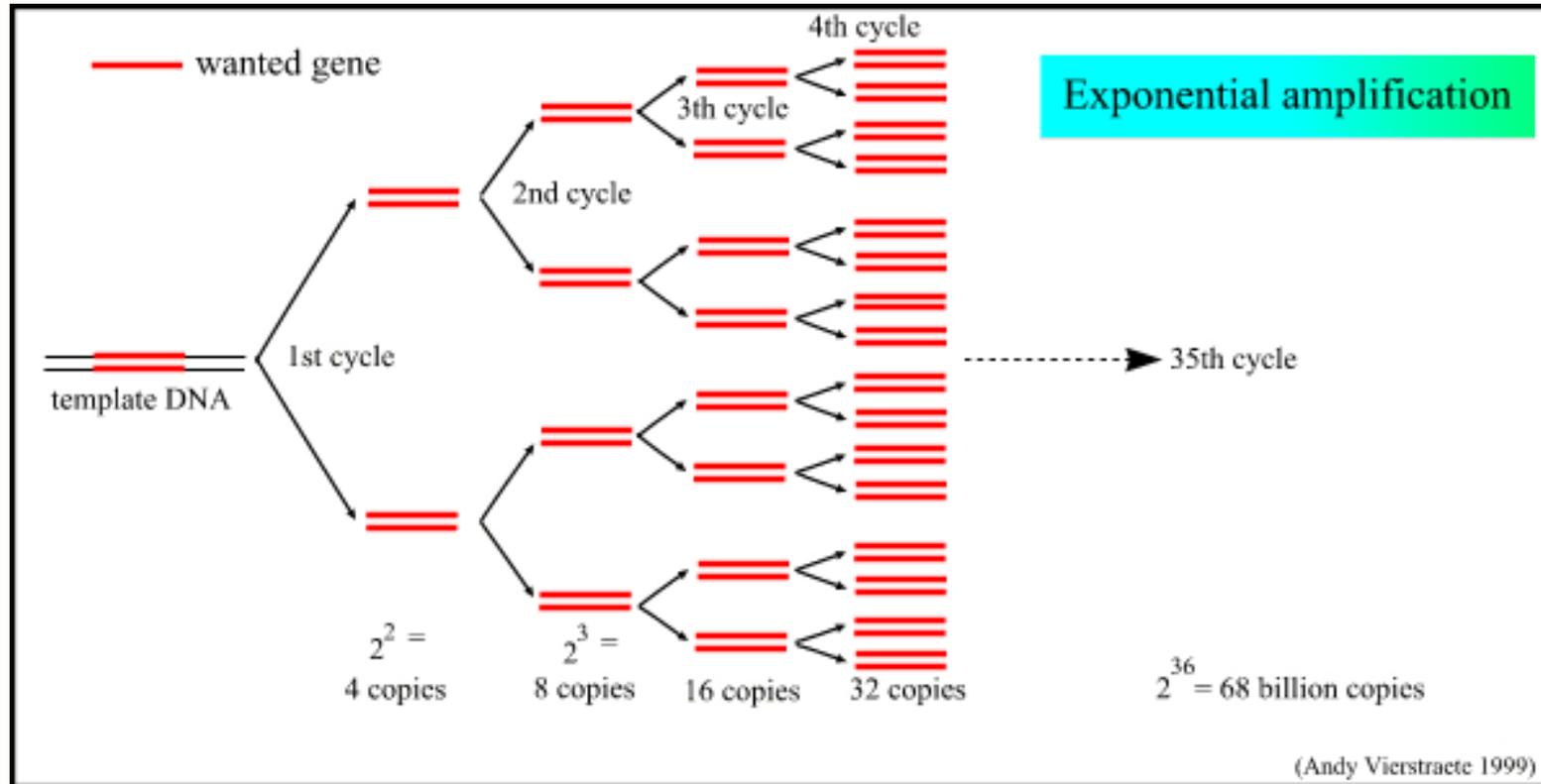


thermofisher.com



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PCR Amplification





Capillary Electrophoresis

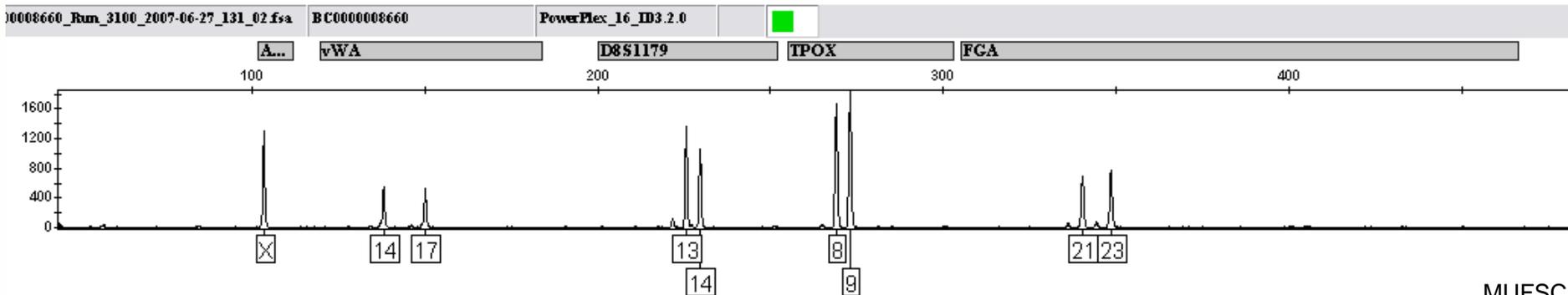
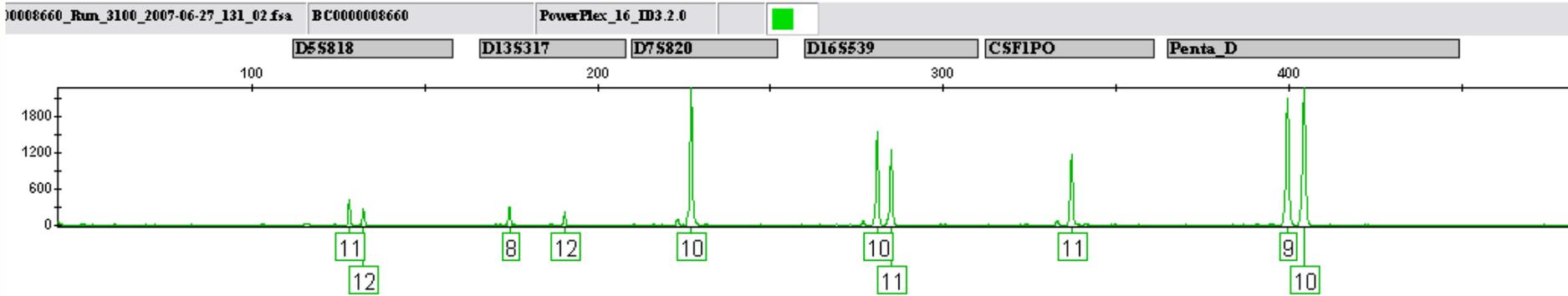
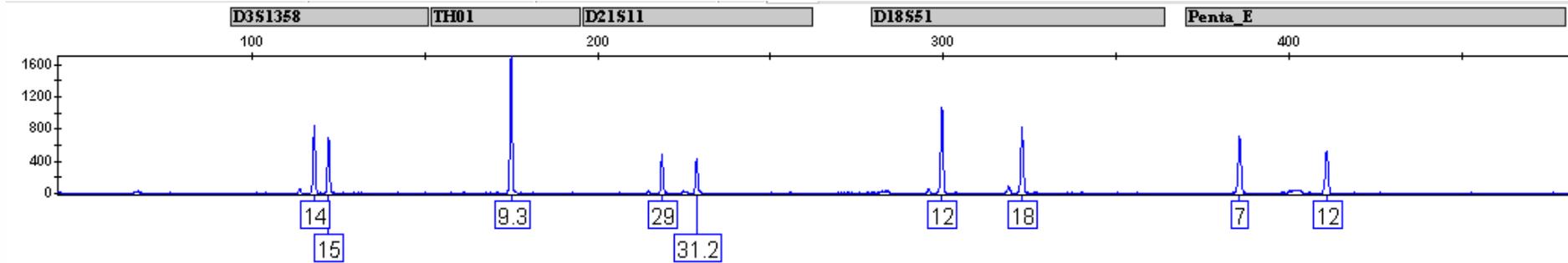
- Separation of amplified DNA fragments
- CCD camera records laser excitation of fluorescent tag
- Raw data in graphical form converted to a graphical and numerical DNA profile



Genetic Analyzer MUFSC



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16 Areas Characterized



Profiles in General

- What is a “Profile?”
 - A collection of characteristics
 - Characteristics should be variable from one sample to the next
 - Purpose is to distinguish one thing from another
 - For a highly informative profile, a large number of characteristics should be described



How would you visually profile this car?

- A. Blue Car
- B. Blue Volkswagen Beetle
- C. Blue 1974 Volkswagen Beetle
- D. Blue 2-door 1974 Volkswagen Beetle



affordableclassicsinc.com



Example Uninformative Profile: Visual Profile of a Car

DESCRIPTOR	CHARACTERISTIC
Color	Blue

- Uninformative profile
- Includes a large portion of cars on the road



affordableclassicsinc.com

OR



forums.pelicanparts.com



Example Informative Profile: Visual Profile of a Car

Descriptor	Characteristic
Color	Blue
Year	1974
Make	Volkswagen
Model	Beetle
Suspension	Low Rider
License Plate	PeaceLove
Bumper Sticker	Pizza Shop

- Highly informative profile
- Several characteristics described
- Narrows down the “suspect” cars

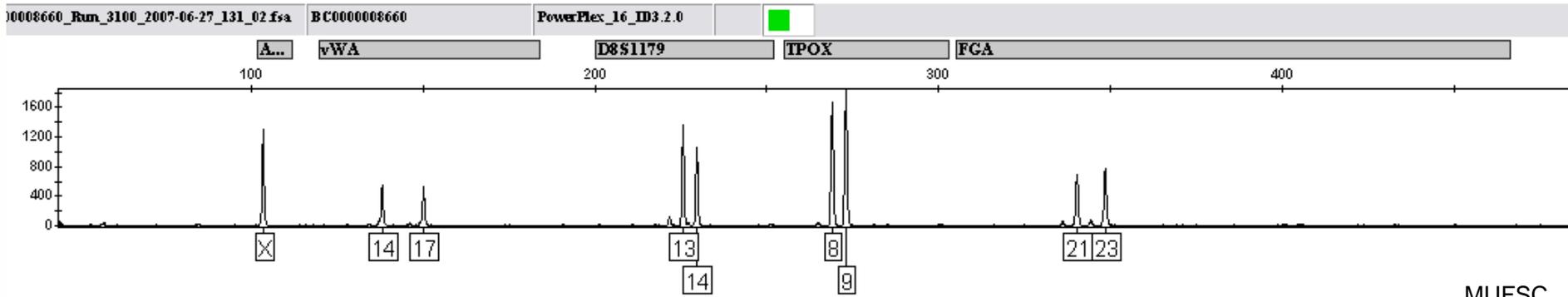
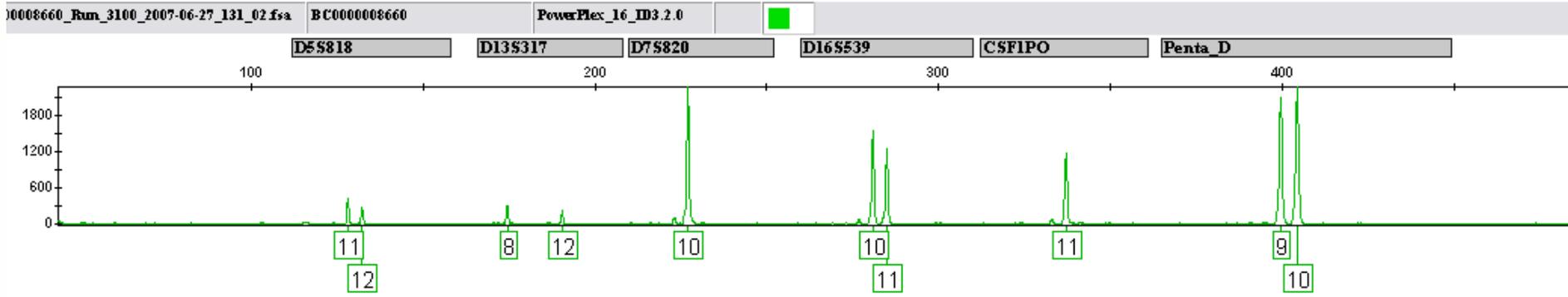
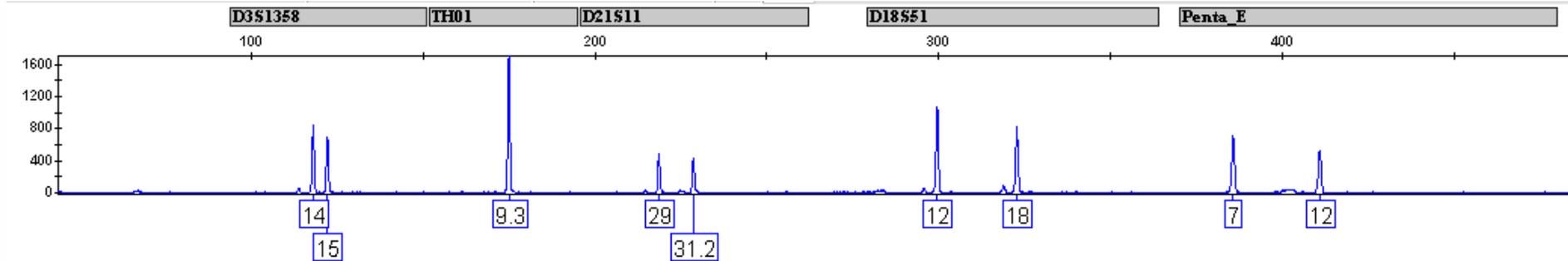


DNA Profile

- A collection of descriptive areas (locations or **loci**) on the DNA strand that demonstrate **variation** among humans
 - A description of DNA from the <1% portion that is variable among humans
- Each area has several possible “types” (**alleles**) which allow for variation among individuals
- **Multiple** areas are described (highly informative)



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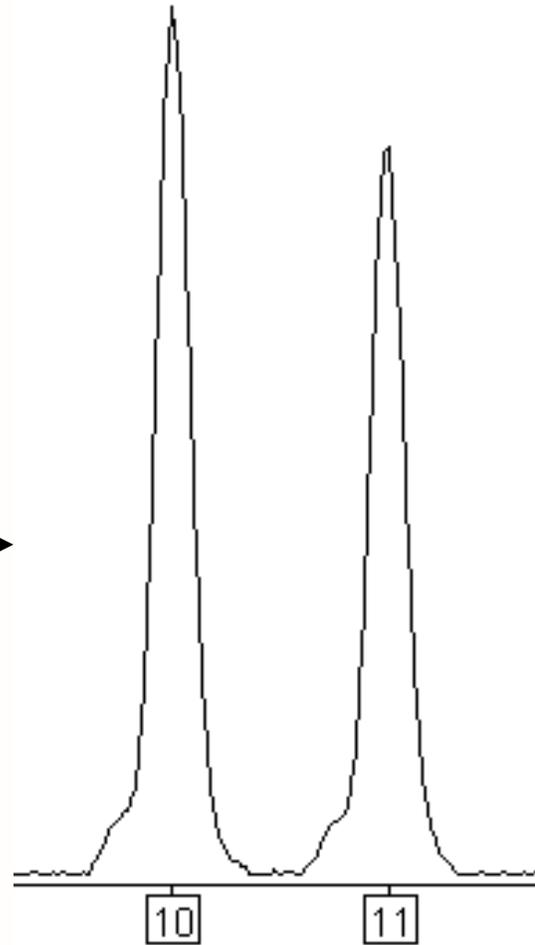
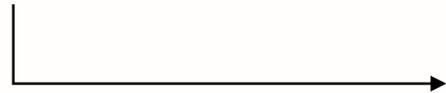
16 Areas Characterized



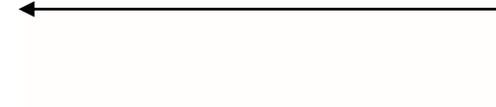
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	ATAG								
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10 Repeats
Inherited from
MOM



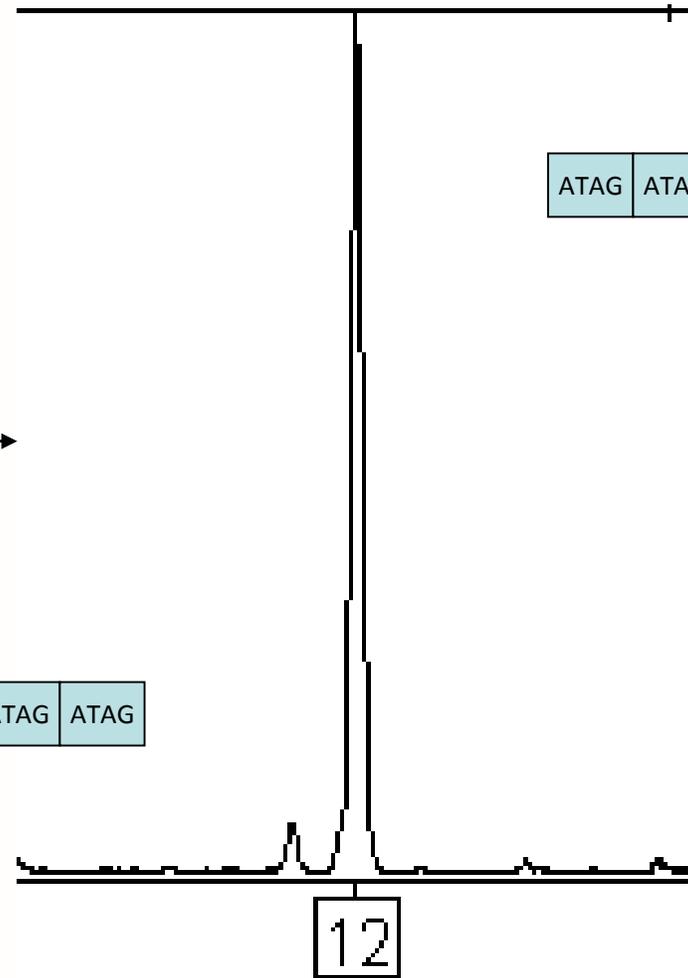
11 Repeats
Inherited from
DAD



ATAG										
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12 Repeats
Inherited from
MOM



12 Repeats
Inherited
from DAD

12



Collecting Reference Samples

- DNA evidence is meaningful when considered in the context of reference standards.
- **Blood and saliva are the most common sources of reference standards.**
- Samples from the suspect/victim can be collected either through a forensic examination by medical personnel or with mouth (buccal) swabs that can be obtained in the field by law enforcement.



Comparisons (Conclusions)

- After the testing is completed and the data is interpreted, a comparison will be made between the DNA profiles generated from the evidence samples and reference samples.
 - Victim, suspect, consensual partner
- The most common conclusions when comparing a reference sample to the results obtained from an evidence sample include:
 - Inclusion (Match)
 - Exclusion
 - No Conclusions



Exclusion Example

- The DNA profile of the known reference donor **does not match** the DNA profile of the questioned sample

Locus	Q1	K1
D3S1358	15,16	12,14
vWA	19,19	15,18
FGA	20,28	22,24
D8S1179	16,18	14,15
D21S11	29,30.2	28,32
D18S51	19,21	15,17
D5S818	14,15	12,13

“The individual associated with reference item K1 is excluded from the DNA profile obtained from the sampled portion of item Q1.”



No Conclusions Example

- If no results or incomplete results are obtained from a majority of the loci in a sample

“Due to the partial nature of the results obtained from the sampled portion of item Q1, no conclusions could be made.”

Locus	Q1	K1
D3S1358	12,--	12,14
vWA	No Results	15,18
FGA	No Results	22,24
D8S1179	No Results	14,15
D21S11	No Results	28,32
D18S51	No Results	15,17
D5S818	13,--	12,13



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Inclusion Example

- The DNA profile of the known reference donor **matches** the DNA profile of the questioned sample

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D21S11	29,30.2	29,30.2
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D5S818	14,15	14,15

“The DNA profile obtained from the sampled portion of item Q1 matches the DNA profile obtained from reference item K1.”



Generation of Statistics

- Once a “match” between DNA profiles occur, the **strength** of their association becomes critical
- Calculated with mathematical formulas utilizing the frequency each DNA fragment occurs in the population
- Example: 1 in 249 quadrillion from the US Caucasian population



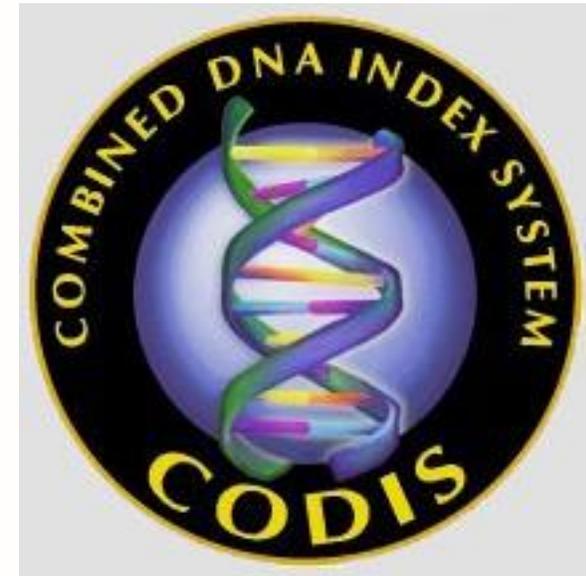
Numbers

- MA and AZ populations = ~6.7 million
- CA population = ~38.8 million
- US population = ~319 million
- World population = ~7.4 billion
- Ever born = ~108.2 billion
- Forensic DNA stats are typically in trillions, quadrillions, quintillions, sextillions
- ~5 sextillion grains of sand on worlds beaches



CODIS

- Combined DNA Index System
 - Central database of DNA profiles - FBI
 - Local DNA Index System (LDIS)
 - State DNA Index System (SDIS)
 - National DNA Index System (NDIS)



<http://victimsnewsonline.com>

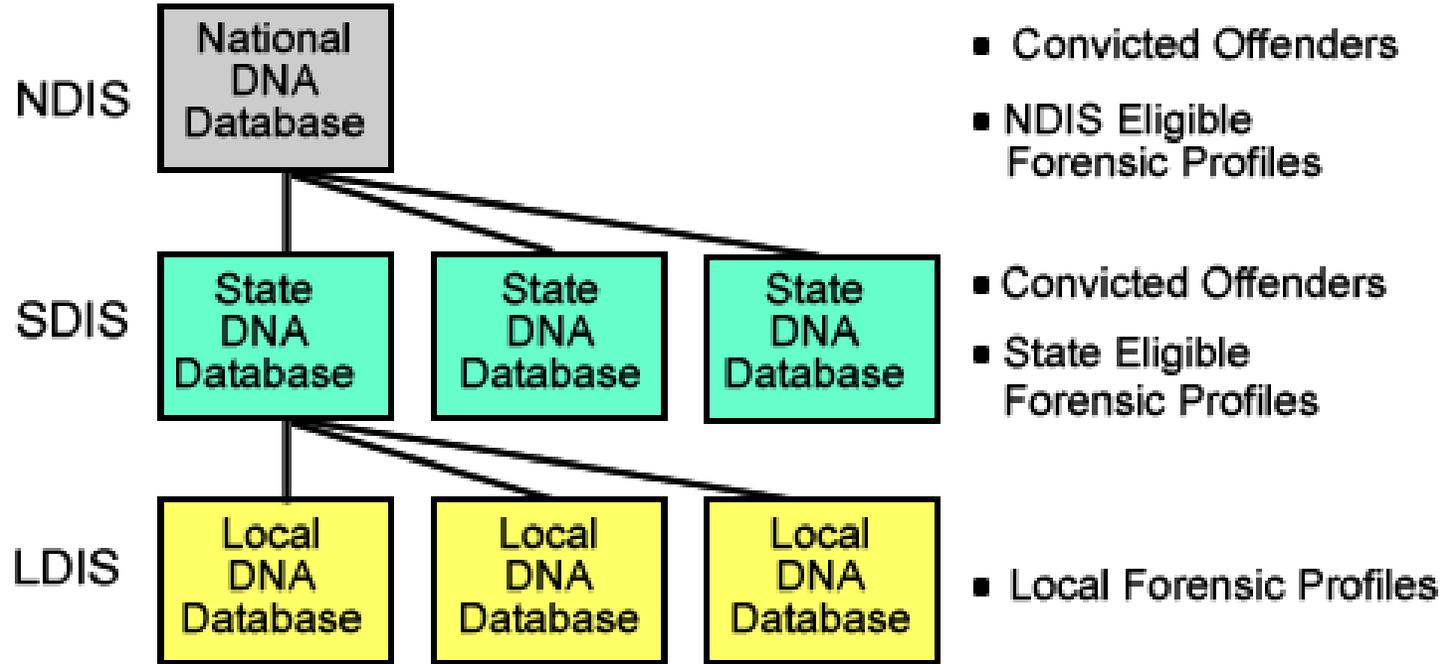
NDIS: Over 12 million offender, over 2 million arrestee and over 720,000 forensic profiles.

As of July 2016, ~325,000 investigations were aided with CODIS (~339,000 hits)



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How CODIS Connects



http://projects.nfstc.org/property_crimes/module04/pro_m04_t03_01.htm



Types of CODIS “Hits”

- Unknown profile from evidence matches a convicted offender, arrestee or suspect
- Unknown profile from evidence matches another unknown profile
- Investigative leads
- Impact on victim



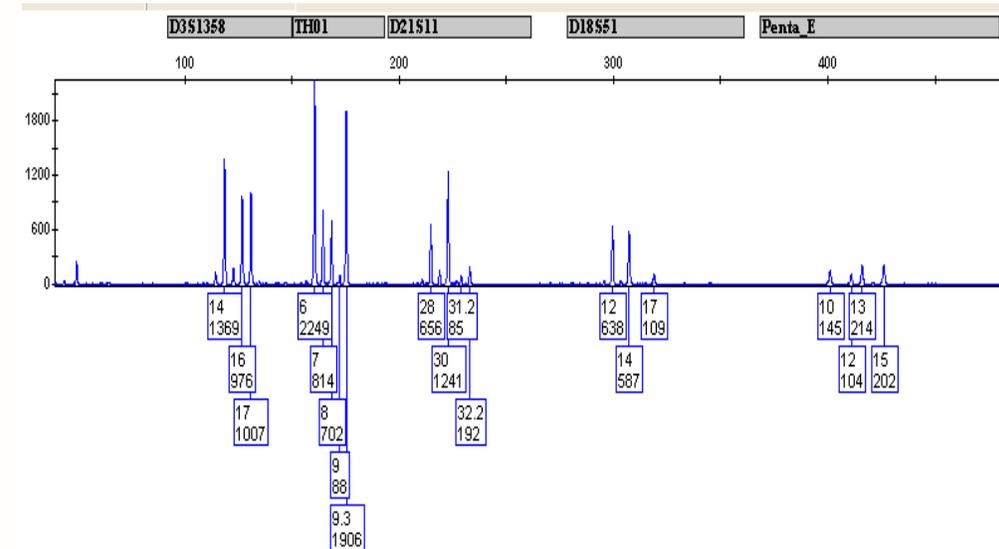
Negative Impact of CODIS on the Victim

- Shock/mental anguish – emotionally vulnerable
- Family or partner not aware of sexual assault
- Victim was engaged in illegal activity at time of the assault (prostitution, drug use, etc.)
- Fear of law enforcement
- Even then case may not be resolved
 - Statute of limitations
 - Case is not prosecuted for various reasons



Limitations of DNA Technology Used in Crime Labs

- Cannot determine age of stain or physical characteristics of donor (except gender)*
- Does finding someone's DNA = rape?
- Mixtures of DNA can be hard to interpret
- DNA technology is sensitive but sometimes no results are generated





What if No DNA Results

- Possible reasons include:
 - Perpetrator did not leave any DNA behind
 - Too much time passed between crime and evidence collection
 - Evidence was improperly stored or handled
- Obtaining no DNA results does not mean that no crime has occurred
 - Other evidence and witness statements – back to basics investigative techniques



Untested Sexual Assault Cases in the US

- Number not known but projected in the hundreds of thousands
- Reasons why
 - Law Enforcement
 - Crime Labs
 - Victims
- States passing laws for submission and testing of the untested kits
 - Ohio Case



Crime Laboratories

- Federal funding to increase capacity has not resulted in an elimination of the backlog
- Increased demand for testing/case submissions
 - Increased awareness
 - Property crimes
 - Scientific advances
 - Cold cases
 - Post-conviction testing
 - All arrestee testing
- Triage system
 - Which cases are going to court next week?



Media – “CSI Effect”: Want more and faster

- Effect on Trials
 - Everyone is now an expert
 - Jurors expect more forensic evidence
 - Higher rate of acquittal when forensic evidence is not present
 - More confidence in DNA evidence – more convictions

- Effect on Crimes
 - What are criminals learning on TV?



Rapid DNA Service (RADS)

Traditional route – SAK collected at hospital transferred to law enforcement who decides if SAK will be sent to crime lab for DNA testing

RADS is innovative evidence triage

- Forensic medical personnel collect up to 3 evidence swabs that they deem to be the most probative and most likely to yield the DNA profile of the perpetrator based on the incident history and medical exam
- RADS swabs are sent straight to crime lab (overnight) for quick turn around testing
- Sexual assault kit is still collected and given to law enforcement who holds it until they get the RADS results



Rapid DNA Service (RADS)

Lab uses automation with reduced processing time to increase lab capacity

- 15 days for testing of 20 cases, generation of report and CODIS upload

More requests for DNA analysis in sexual assault cases can be accommodated

Forensic analyst reviews medical exam form and the results

- If no DNA profile or a partial DNA profile is obtained, will contact law enforcement to obtain full kit for additional evidence (i.e. panties)
- Need to process full kit about 30% of the time



New Technologies

RAPID DNA Analysis

- Fully automated tabletop system for DNA testing of buccal swabs in the field or police booking stations
- Tests up to 5 samples in less than 90 minutes
- Allows for local database search while suspect is still in custody



www.gelifesciences.com



New Technologies

Forensic Phenotyping

- Uses DNA sequencing techniques
- Can accurately predict
 - Genetic ancestry
 - Eye color
 - Hair color
 - Skin color
 - Freckling
 - Face shape
- In individuals from any ethnic background, even individuals with mixed ancestry



Snapshot Prediction Results Composite Profile



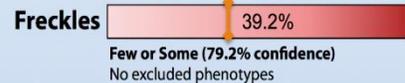
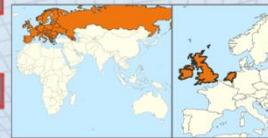
Actual Photo

Predicted (■) & Excluded (⊠) Phenotypes



Sex: Female

Ancestry: 100% European
(Northwest – British Isles)





Misty Marra, MSFS

Forensic DNA Analyst III/Laboratory Coordinator

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