Forensic DNA Casework

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About Sorenson

- Established in South Salt Lake since 2006
- Laboratory accreditation through ANAB.
- Sexual Assault Kit Backlog
- Innocence Project, Cold Justice
- Validation & L.S.S. Services
- Case Consultation

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About Me

- Double Bachelors of Science in Biology & Biotechnology.
- Worked at Sorenson Forensics since 2012
- Reviewed & reported over 2,000 Forensic DNA cases.
- Testified multiple times throughout the U.S. as an expert witness.

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Forensic DNA Laboratory

SORENSON FORENSICS

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Forensic DNA Laboratory

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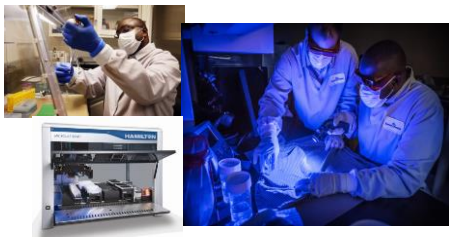

https://crf.huji.ac.il/hamilton-liquid-handling-robot

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DNA:
The Blueprint of Life

http://www.genesisweek.com/is-racism-in-our-dna-guest-article/

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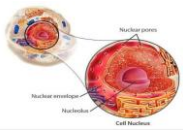
DNA : The Blueprint

- DNA is in all living organisms.
- Each cell contains the same DNA blueprint.
- Two main types of DNA: Mitochondrial & Nuclear.



http://www.genesisweek.com/is-racism-in-our-dna-guest-article/

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DNA : The Blueprint

Nuclear DNA

- DNA is like a large encyclopedia with lots of books that make up the whole.
- Each book is called a chromosome.
- Humans have 23 pairs of chromosomes
- Just like a book, each chromosome contains articles or genes.

http://www.dingbatz.com/wp-content/uploads/2013/04/Encyclopedia-Set.jpg

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DNA : The Blueprint

Genes

- There are two basic types of genes, coding & non-coding.
  - Coding:
    - Instructions on how to make EVERYTHING made "in-house"
  - Non-Coding:
    - Used to be called "junk DNA"
    - These are the genes of interest in forensic DNA

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Casework Process

- Evidence Collection
- Serology
- Extraction
- Quantification
- Amplification
- Detection
- Analysis & Interpretation

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Evidence Collection

Types of Biological Evidence

- Body fluids
  - Blood
  - Semen
  - Saliva
- Other Body Items
  - Skin
  - Hair
  - Muscle/Organs
  - Bone





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Serology

- Itemization
- Alternative Light Source (ALS) Screening
- Serological Testing
  - Blood
  - Saliva
  - Semen
  - Y-Screening (male DNA)

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Extraction

- Apply the use of detergents to break open cells, then isolate DNA
- Two types of extraction methods
  - Non-differential (References & Question samples with no sperm suspected)
  - Differential (sperm suspected)

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Extraction

Differential

- Through centrifugation, sample is separated into two general fractions.
  - Epithelial (all non-sperm cells)
  - Sperm
- Helps alleviate the possibility of the female donor overwhelming the male profile.

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Quantification

How much DNA do we have?

- Typically reported in nanograms (ng)

QuantValues		DNATotals	
Auto Conc:	0.0949ng/uL	Auto DNA:	3.6062ng
Auto/Y:	1.1	Y DNA:	3.4124ng
Y Conc:	0.0898ng/uL		

What do these numbers mean?

1,000,000,000 ng = 1 g

The DNA from one cell = ~0.006ng.

3.6062/0.006=601 cells

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Amplification

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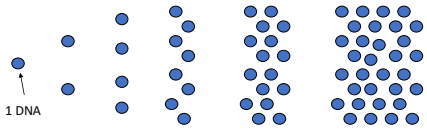
Polymerase Chain Reaction (PCR)

- Takes a small amount of DNA and makes MILLIONS copies of specific locations.



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Amplification

PCR: Primers

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How do we find those specific locations?

- Primers work to find the specific area.

- Copies also contain a fluorescent probe that will later be used for detection.

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Detection

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- After amplification, samples are placed on a genetic analyzer.
- Analyzers use a process called capillary electrophoresis.

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Detection

Capillary Electrophoresis

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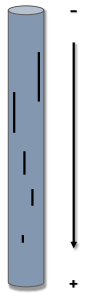

- By applying a current, it utilizes an effect known as, electroosmotic flow.
- DNA strands migrate at various speeds based on size
- Smaller strands are faster than larger strands

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Detection

Capillary Electrophoresis

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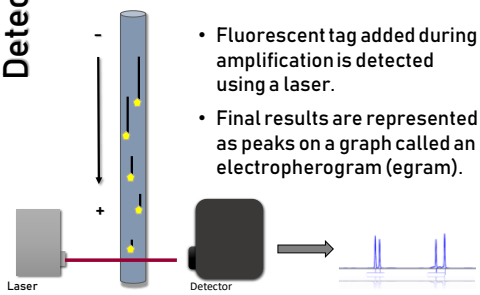

- Fluorescent tag added during amplification is detected using a laser.
- Final results are represented as peaks on a graph called an electropherogram (egram).

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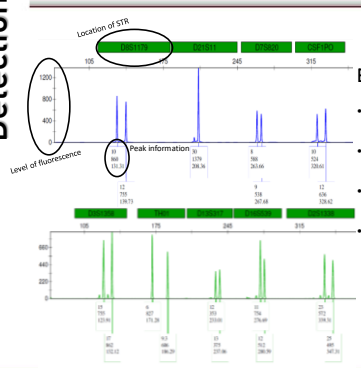
Detection



Electropherogram

- Usually has 4 to 6 different dyes
- Peak heights measured by RFU
- Location on the DNA
- Peak information:

# of repeats
Peak height
# of base pairs

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Analysis & Interpretation

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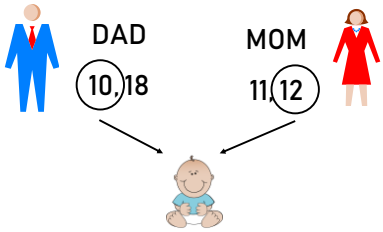
Inheritance:



Baby's DNA Profile = 10,12

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Analysis & Interpretation

DNA: Base Pairs

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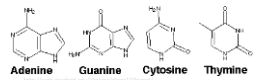
- DNA is made up of base pairs



- These base pairs are commonly referred to as A, G, C, & T.
- Sequences of base pairs is what makes up the genetic code.

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Analysis & Interpretation

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STRs

- Short tandem repeats
- Typically 3, 4, or 5 units long

GATC GATC GATC GATC

1 2 3 4

4 REPEATS

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Analysis & Interpretation

STRs

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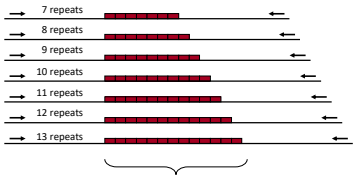
TCCCAAGCTCTTCCTCTTCCCTAGATCAATACAGACAGAAGACAGGTG
GATCGATCGATCGATCGATCGATCGATCGATCGATCGATCGATC
TCATTGAAAGACAAAACAGAGATGGATGATAGCTTACAGATGCACAC



Target region
(short tandem repeat)

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Analysis & Interpretation

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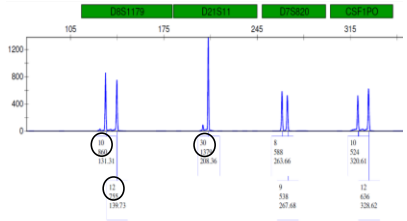

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Analysis & Interpretation

DNA profile: Allele Summary Table

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Locus	Item 4.0 Reference - John Doe
D8S1179	10,12
D21S11	30
D7S820	8,9
CSF1PO	10,12
D3S1358	15,17
TH01	6,9.3
D13S317	12,13
D16S539	11,12
D2S1338	23,25
D19S433	14,15
vWA	17,19
TPOX	10,11
D18S51	12,17
AMEL	X,Y
D5S818	11,12
FGA	21,25

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Single Source

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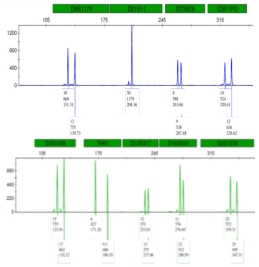

Locus	Item 4.0 Reference – John Doe - K_
D8S1179	10,12
D21S11	30
D7S820	8,9
CSF1PO	10,12
D3S1358	15,17
TH01	6,9.3
D13S317	12,13
D16S539	11,12
D2S1338	23,25

No more than two numbers at each location.

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Two Person Mixture

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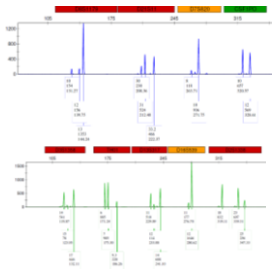

Locus	Item 2.0 Mixture profile
D8S1179	10,12,13
D21S11	30,31,33.2
D7S820	8,10
CSF1PO	10,12
D3S1358	14,15,17
TH01	6,7,9.3
D13S317	11,12,14
D16S539	11,12
D2S1338	18,23,25

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Y-STR

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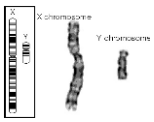
- Male specific
- Short tandem repeats (STRs) specifically on the Y chromosome.
- Able to get a profile even with high amounts of female DNA.
- Sensitive kit
  - Typically better able to obtain a profile with low amounts of DNA compared to STRs.



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Y-STR

Things to keep in mind

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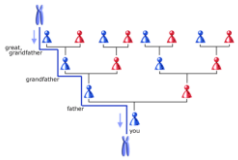
- Lower mutation rates, meaning statistics are typically less "rare"
- No CODIS uploads.
- Possibility of same profile in paternal line.



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Paternity

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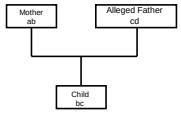
- Typically involves using profiles from mother & child to determine if male profile can be excluded as alleged father.



Genetic System	Mom	Child	Alleged Father
CSF1PO	8, 12	11, 12	11, 12
D2S1338	20, 21	20	20, 26
D3S1358	15, 17	16, 17	16
D5S818	12, 13	13	11, 13
D7S820	10, 12	10, 12	8, 10
D8S1179	14, 15	14	12, 14
D13S317	11, 12	11, 12	12
AMEL	X	XY	XY

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Paternity

Things to keep in mind

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- Possible reasons for genetically dissimilar parent-child relationship
  - Mutation
  - Null Allele
- Motherless profile cases are typically more difficult to determine.
- Possibility that related individuals can't be excluded.

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Statistics

Typically three major types of statistics performed

- Random Match Probability (RMP)
  - Used for single source samples
- Combined Probability of Inclusion (CPI)
  - Used for mixtures that can't be deconvoluted.
- Likelihood Ratios
  - Can be used on a wide range of profile types.
  - Currently being used in our laboratory for Y-STRs & Paternity.

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Statistics

Random Match Probability

Item 1.0 (Fabric – Sperm Fraction):
A DNA profile that genetically types as male was obtained from this item. This DNA profile matches the DNA profile obtained from Reference – John Doe. The frequency of occurrence of this profile among unrelated individuals in the U.S. population is estimated to be:

One in 226 quadrillion for Caucasians
One in 151 quintillion for African Americans
One in 4.28 quintillion for Hispanics

What does that mean?

- The probably of randomly selecting a non-related person from a population who also matches our profile.

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Statistics

Random Match Probability

Frequencies:

D8	
10 – 0.1025 12 – 0.1676	2(0.1025)(0.1676) = 0.03436
D21	
30 – 0.2825	$(0.2825)^2 = 0.07981$
D7	
8 – 0.144 9 – 0.1676	2(0.144)(0.1676) = 0.04827
CSF	
10 – 0.2202 12 – 0.3601	2(0.2202)(0.3601) = 0.1586

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Statistics

Random Match Probability

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Profile frequency

(0.03436)(0.07981)(0.04827)(0.1586) = 0.00002099

Profile Ratio

1 / 0.00002099 = 47,600

Therefore, the frequency of occurrence of this profile among unrelated individuals in the U.S. population is approximately 1 in 47,600.

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Statistics

CPI-Mixture Stats

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- Similar wording & logic to RMP

Item 1.1 (Apparent Outside of Condom-Epithelial fraction):
A mixture of DNA profiles from a minimum of three contributors, at least one of which genetically types as male, was obtained from this item. This mixture is suitable for comparison. The donor of Reference-John Doe is included as a possible contributor to this mixture. Assuming three contributors, the following unrelated individuals in the U.S. population are included as possible contributors to this mixture:

One in 1.27 Thousand for Caucasians
One in 845 for African Americans
One in 1.00 Thousand for Hispanics

- Takes into account all possible combinations during calculations (making the stats typically less rare than RMP)
- Often unable to use all the information in the profile due to low level DNA or dropout.

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Statistics

CPI-Mixture Stats

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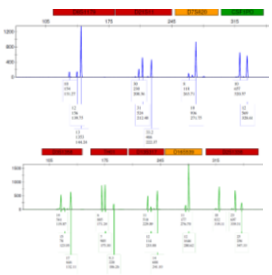

Locus	Item 2.0 Mixture profile
D8S1179	10,12,13
D21S11	30,31,33.2
D7S820	8,10
CSF1PO	10,12
D3S1358	14,15,17
TH01	6,7,9.3
D13S317	11,12,14
D16S539	11,12
D2S1338	18,23,25

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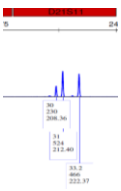
Statistics

CPI-Mixture Stats

SORENSON FORENSICS



D21S11	30,31,33.2

- Look at all possible genotypes
  - 30,31
  - 31,33.2
  - 30,30; etc.
- Find the frequencies of all possible genotypes.
- Add them together.

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Statistics

CPI-Mixture Stats

SORENSON FORENSICS

- Because it takes into account all possible combinations during calculations, stats are typically less rare.

Item 1.1 (Apparent Outside of Condom-Epithelial fraction):
A mixture of DNA profiles from a minimum of three contributors, at least one of which genetically types as male, was obtained from this item. This mixture is suitable for comparison. The donor of Reference-John Doe is included as a possible contributor to this mixture. Assuming three contributors, the following unrelated individuals in the U.S. population are included as possible contributors to this mixture:

One in 1.27 Thousand for Caucasians
One in 845 for African Americans
One in 1.00 Thousand for Hispanics

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Statistics

Likelihood Ratio

SORENSON FORENSICS

"It is 2,911 times more likely for African Americans, 3,224 times more likely for Caucasians, and 1,664 times more likely for Hispanics that this Y-STR profile is derived from John Doe than if it is derived from a randomly selected male from the same population"

What does that mean?

- Based on the evidence, how likely it is for one hypothesis to be correct vs. another.

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Statistics

Likelihood Ratio-Cont.

SORENSON FORENSICS

$$\frac{P(E|H_1)}{P(E|H_2)}$$

E= Evidence
H_1=Prosecutor's Hypothesis
H_2=Defense Hypothesis

Likelihood Ratio	Verbal Qualifier
1	Uninformative
2 – 99	Limited Support
100 – 9,999	Moderate Support
10,000 – 999,999	Strong Support
≥1,000,000	Very Strong Support

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Statistics

Likelihood Ratio

SORENSON FORENSICS

"It is 2,911 times more likely for African Americans, 3,224 times more likely for Caucasians, and 1,664 times more likely for Hispanics that this Y-STR profile is derived from John Doe than if it is derived from a randomly selected male from the same population"

Likelihood Ratio	Verbal Qualifier
1	Uninformative
2 – 99	Limited Support
100 – 9,999	Moderate Support
10,000 – 999,999	Strong Support
≥1,000,000	Very Strong Support

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Statistics

Source Attribution

SORENSON FORENSICS

What makes one statistics more rare than other?

- Possible number of individuals in sample.
- Ability to deconvolute a profile.
- Quality of the profile.
- Lab thresholds and guidelines met.

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Statistics

Source Attribution

SORENSON FORENSICS

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Statistics

Source Attribution

SORENSON FORENSICS

Frequencies:

D8
11 – 0.0761
13 – 0.3296

2(0.0761)(0.3296) = 0.05016

x

D3
15 – 0.2728
17 – 0.2105

2(0.2728)(0.2105) = 0.11484

x

TH01
8 – 0.0955
10 – 0.1191

2(0.0955)(0.1191) = 0.022748

0.000131

$$\frac{1}{0.000131} = \textbf{One in 7,630}$$

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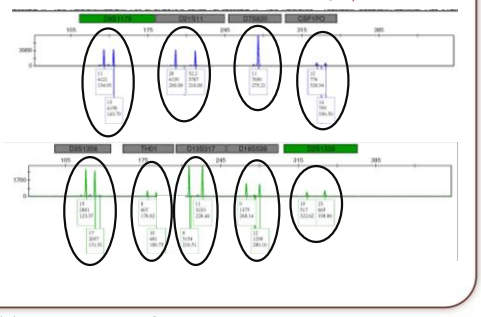
Statistics

Source Attribution

SORENSON FORENSICS



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Statistics

Source Attribution

SORENSON FORENSICS

Frequencies:

D8	**CSF**	**D13**
11 – 0.0761	12 – 0.3601	8 – 0.1204
13 – 0.3296	14 – 0.0096	11 – 0.3254
D21	**D3**	**D16**
28 – 0.1592	15 – 0.2728	9 – 0.1066
32.2 – 0.090	17 – 0.2105	12 – 0.3144
D7	**TH01**	**D2**
11 – 0.2049	8 – 0.0955	19 – 0.1204
	10 – 0.1191	23 – 0.1052

$$\frac{1}{1.51E-13} = \textbf{One in 6.63 Trillion}$$

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Examples

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Case Study #1

Case Information: Believed that syringe was used by subject 1 to inject subject 2. Syringe was concealed in drink cup filled with cola upon officer's approach. Attempting to identify which subject was injected and if the other subject handled the syringe.

Evidence Received:

- Insulin Syringe
- Reference from Subject 1.
- Reference from Subject 2.

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Examples

Itemization

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Item: 1.0 **Agency No: 201606108-1 - Syringe**
Item Description: One white syringe with an orange end measuring ~12cm x 2cm. An orange cap was protecting the needle. Syringe was m: ...1ml. U-100 INSULIN.
Itemized By: KEATON
Outer Package: OP0050153 SubItem No: SIT10184373
Level 1 Other (see marked) Seal: Tape Seal Unmarked Marked: Plastic Tube m: 201606108

Item: 1.1 **Agency No: 201606108-1 - End of Syringe**
Item Description: One wet and one dry swab was used to swab the orange cap at the end of the syringe, the orange cap was removed and the plunger of the syringe was swabbed, and the barrel up to the 70 units[sic] line.
Itemized By: KEATON
Outer Package: OP0050153 SubItem No: SIT10184374
Level 1 Other (see marked) Marked: Plastic Tube m: 201606108

Item: 1.2 **Agency No: 201606108-1 - Tip of Syringe**
Item Description: The orange cap covering the needle was removed and then one wet and one dry swab was used to swab the needle.
Itemized By: KEATON
Outer Package: OP0050153 SubItem No: SIT10184403
Level 1 Other (see marked) Marked: Plastic Tube m: 201606108

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Examples

Quantification

SORENSON FORENSICS

Item: 1.1 ND2208451
Agency No: 201606108-1 - End of Syringe
DNATotals Auto DNA: 0.498550ng
Y DNA: 0.413000ng
QuantValues Auto Conc: 0.01690ng/uL
Auto/Y: 1.2
Y Conc: 0.01400ng/uL
Degradation Indicator Deg: 5.12
Plate Locations Well:C02
Quant Action Dilution

Item: 1.2 ND2208450
Agency No: 201606108-1 - Tip of Syringe
DNATotals Auto DNA: 5.782000ng
Y DNA: 8.094800ng
QuantValues Auto Conc: 0.20650ng/uL
Auto/Y: 0.7
Y Conc: 0.28910ng/uL
Degradation Indicator OK: 1.07
Plate Locations Well:B02
Quant Action Dilution

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Examples

Analysis & Interpretation

Item 1.1- End of Syringe

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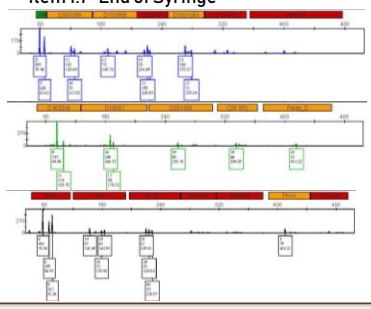

Locus	Item 1.1 End of Syringe
AMEL	X,Y
D3S1358	*,15,16
D1S1656	*,12
D2S441	*,10,11,11.3
D10S1248	*,13,15
D13S317	INC
PENTA_E	INC
D16S539	*,9,11
D18S51	*,16,17
D2S1338	*,19
CSF1PO	*,10
PENTA_D	10
TH01	*,6,8,9
vWA	*,14,18,19
D21S11	28,29,30
D7S820	INC
D5S818	INC
TPOX	*,8
DYS391	INC

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Examples

Analysis & Interpretation

Item 1.2- Tip of Syringe

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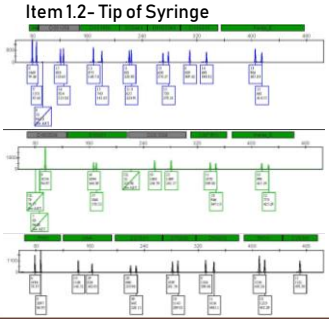

Locus	Item 1.2 Tip of Syringe -
AMEL	X,Y
D3S1358	15,16
D1S1656	12,15
D2S441	11,11.3
D10S1248	13,15
D13S317	8,14
PENTA_E	13,15
D16S539	9
D18S51	16,17
D2S1338	19,25
CSF1PO	11,13
PENTA_D	10,12
TH01	6,8
vWA	14,19
D21S11	28,30
D7S820	8,10
D5S818	8,11
TPOX	8,10
DYS391	11

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Examples

Report Conclusions

SORENSON FORENSICS

Item 1.1 (End of Syringe)

A mixture of DNA profiles from a minimum of two contributors, at least one of which genetically types as male, was obtained from this item.
This mixture is inconclusive.

Item 1.2 (Tip of Syringe)

A DNA profile that genetically types as male and is attributable to unknown individual #1 was obtained from this item. This profile is suitable for comparison.

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Examples

Comparison & Statistics

SORENSON FORENSICS

- Comparisons were made between subjects and the profile obtained from item 1.2-Tip of Syringe.
- A match was founds between the profile from item 1.2 and Subject 2.

A DNA profile that genetically types as male was obtained from Reference – Subject 2.
The DNA profile obtained from Reference – Subject 2 matches the DNA profile obtained from Item 1.2 (Tip of Syringe). The frequency of occurrence of this profile among unrelated individuals in the U.S. population is estimated to be:

One in 125 Nonillion for Caucasians
One in 3.47 Decillion for African Americans
One in 187 Nonillion for Hispanics

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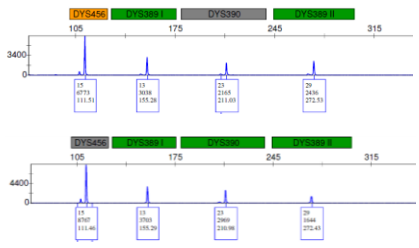
Examples

Y-STR

SORENSON FORENSICS



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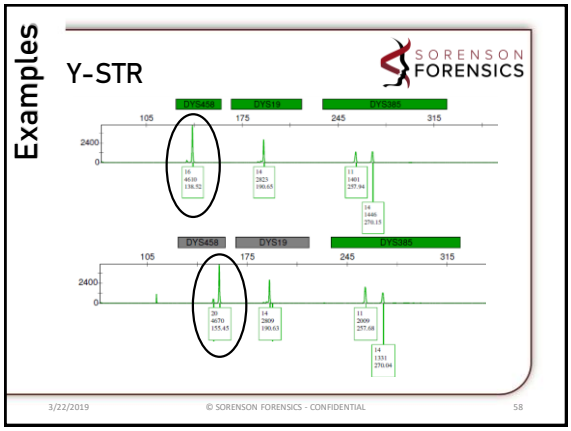
Examples
Y-STR
SORENSON FORENSICS
DYS458
DYS19
DYS385
105
175
245
315
2400
0
3/22/2019
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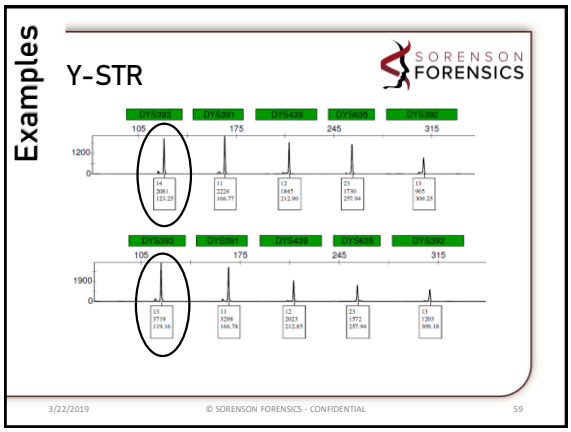
Examples
Y-STR
SORENSON FORENSICS
DYS393
DYS391
DYS439
DYS635
DYS392
105
175
245
315
1200
1900
0
3/22/2019
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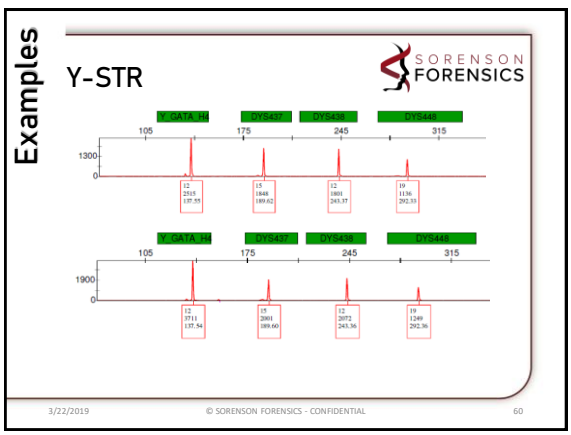
Examples
Y-STR
SORENSON FORENSICS
Y_GATA_H4
DYS437
DYS438
DYS448
105
175
245
315
1300
1900
0
3/22/2019
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Examples

Y-STR

SORENSON FORENSICS

Locus	Item 2.0 - Reference - K_ LPCR3805_10s	Item 4.0 Reference - K_ LPCR3820_10s
DYS456	15	15
DYS389 I	13	13
DYS390	23	23
DYS389 II	29	29
DYS458	20	16
DYS19	14	14
DYS385	11,14	11,14
DYS393	13	14
DYS391	11	11
DYS439	12	12
DYS635	23	23
DYS392	13	13
Y_GATA_H4	12	12
DYS437	15	15
DYS438	12	12
DYS448	19	19

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Examples

Motherless Paternity

SORENSON FORENSICS

Genetic	Child		Alleged Father		Paternity Index
Marker	Allele A	Allele B	Allele A	Allele B	
D8S1179	11	13	13	15	1.53
D21S11	30		30		3.01
D7S820	11		11	12	1.72
CSF1PO	10		10	12	1.94
D3S1358	15		15	18	1.17
TH01	7	9	7	9.3	1.48
D13S317	12	14	10	12	0
D16S539	10	12	10	11	0
D2S1338	19	20	17	20	3.48
D19S433	13.2	14	14	15.2	1.55
vWA	15	16	16	17	0
TPOX	8	12	11	12	0
D18S51	12	21	14	21	22.4
AMEL	X		X	Y	1
DS5818	10	11	11	13	1.02
FGA	24	25	22	24	1.97

- Scenario: Two brothers were tested as possible fathers.
- Originally, the mother's profile was not available.
- Lack of the mother's profile lead to a false inclusion.

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Examples

Motherless Paternity

SORENSON FORENSICS

Genetic	Mother		Child		Alleged Father		Paternity Index
Marker	Allele A	Allele B	Allele A	Allele B	Allele A	Allele B	
D8S1179	11	12	11	13	13	15	1.53
D21S11	29	30	30		30		3.01
D7S820	8	11	11		11	12	1.72
CSF1PO	10		10		10	12	1.94
D3S1358	15	18	15		15	18	1.17
TH01	9		7	9	7	9.3	1.48
D13S317	12		12	14	10	12	0
D16S539	10	14	10	12	10	11	0
D2S1338	19	25	19	20	17	20	3.48
D19S433	13.2	15.2	13.2	14	14	15.2	1.55
vWA	14	17	15	14	14	17	0
TPOX	11	12	8	12	11	12	0
D18S51	12	13	12	21	14	21	22.4
AMEL	X		X		X	Y	1
DS5818	10	11	10	11	11	13	1.02
FGA	24	25	24	25	22	24	1.97
			Combined Paternity Index				0
			Probability of Paternity				0%

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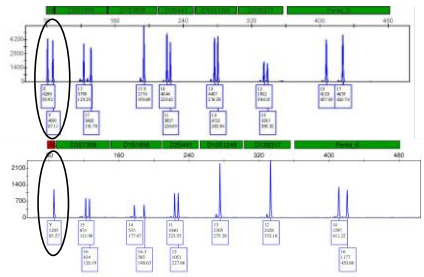
Examples

Null Allele

SORENSON FORENSICS



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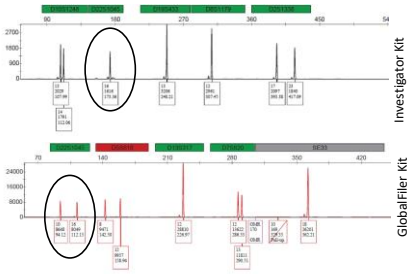
Examples

Null Allele

SORENSON FORENSICS



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Examples

Case Study #2

SORENSON FORENSICS

Case information:

Krystal Lynn Beslanowitch was found dead on the bank of the Provo River in December 1995.

The case went cold, but was reopened in 2006.

Evidence, believed to be weapons of murder, were submitted for DNA testing.

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Examples

Submitted Evidence

SORENSON FORENSICS

- Among the items sent to us, the following probative items were tested…

Rock #1

Rock #2

Cigarette Butt- Secondary Reference

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Examples

Evidence Collection

SORENSON FORENSICS

- Evidence was collected using our M-Vac system.
- Works by soaking evidence in a sterile liquid, then collecting it using a vacuum system.

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Examples

Quantification

SORENSON FORENSICS

Item: 6 **Two Rocks**

DNATotals	Auto DNA: 21.23ng Y DNA: 8.08ng	**Degradation Indicator**	Deg: 5.12
QuantValues	Auto Conc: 0.740ng/uL Auto/Y: 2.6 Y Conc: 0.0622ng/uL	**Plate Locations**	Well:C02
		Quant Action	Dilution

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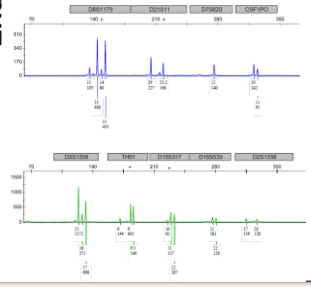
Examples

Analysis & Interpretation

SORENSON FORENSICS



Run Name	LPCR0647_10s
D8S1179	11, 13, 14, 15
D21S11	29, 32.2, *
D7S820	11
CSF1PO	10, 11
D3S1358	15, 16, 17
TH01	6, 9, 9.3, *
D13S317	10, 11, 12
D16S539	11, 12, *
D2S1338	17, 20, *

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Examples

Profile Comparison

SORENSON FORENSICS

Major profile was placed into CODIS and there was a hit to Joseph Simpson. His reference was then processed and compared to the major profile.

A complete DNA profile that genetically types as male was obtained from Reference-Joseph Simpson.

This DNA profile matches the major DNA profile obtained from item 6 (Two Rocks). The frequency of occurrence of this profile among unrelated individuals in the U.S. population is estimated to be:

One in 4.69 million for Caucasians
One in 58.2 million for African Americans
One in 30.2 million for Hispanics

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Examples

Conclusion

SORENSON FORENSICS

Joseph Simpson had been convicted of a 1987 murder in Utah but was paroled in April of 1995.

Simpson had not been a suspect until the DNA hit.

He was found guilty of aggravated murder and sentenced to life in prison.

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For the Future

SORENSON FORENSICS

- Probabilistic Genotyping (Probgen)
- Rapid DNA Testing
- Next Gen. Sequencing (NGS)

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Need Help on a Case?

SORENSON FORENSICS

- Case reviews
  - Customizable level to fit specific needs
- Experienced analyst recommendations
- Preparation help for cross-examination
- Expert witness testimony

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Need a Case Tested?

SORENSON FORENSICS

- All case types
- Multiple turnaround time options
  - 2-3 day, 5 day, 10 day, 15 day, 30 day, 60 day
- Multiple STR and YSTR chemistries available
- Next generation sequencing (NGS) starting in 2019

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Questions?
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