

DNA Biometrics:

Standards and Technology

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NDIA Biometrics Conference (Arlington, VA)
January 21, 2010

Acknowledgments

- **NIST DNA
Biometrics Team:**



Pete Vallone



Erica Butts



Kristen Lewis

- **FBI funding** through an interagency agreement with the NIST Information Access Division
- Early efforts with rapid PCR funded by Interagency Agreement 2008-DN-R-121 between the **National Institute of Justice** and NIST Office of Law Enforcement Standards

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Outline

- Importance of standards
 - in support of technology growth/application
- DNA as a biometric modality
 - advantages & challenges
- DNA basics
- NIST efforts with DNA
- Summary & future prospects with DNA

National Security Presidential Directive and Homeland Security Presidential Directive (NSPD-59 / HSPD-24)

Biometrics for Identification and Screening to Enhance National Security

- This directive establishes a framework to ensure that Federal executive departments and agencies (agencies) **use mutually compatible methods and procedures** in the collection, storage, use, analysis, and sharing of biometric and associated biographic and contextual information of individuals in a lawful and appropriate manner, while respecting their information privacy and other legal rights under United States law.

Signed by President Bush – June 5, 2008

<http://www.biometrics.gov/Documents/NSPD59%20HSPD24.pdf>

Importance of Standards

- **Interoperability** (data sharing) is facilitated
 - Example: common core DNA markers used in forensics
- **Quality** is enhanced
 - Example: FBI Quality Assurance Standards for forensic DNA testing laboratories
- **Technology** is enabled
 - Example: commercial vendors have target goals for product development

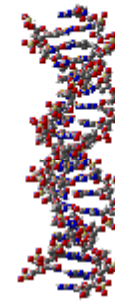
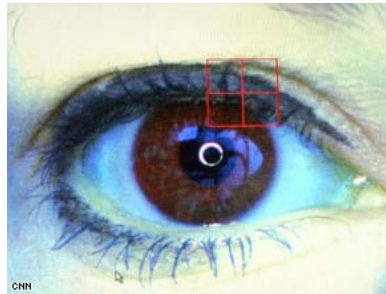
Characteristics of a Biometric

- **Universality**
 - each person should have the characteristic
- **Uniqueness**
 - how well the biometric separates individuals from another
- **Permanence**
 - how well a biometric resists aging and variance over time
- **Collectability**
 - ease of acquisition for measurement

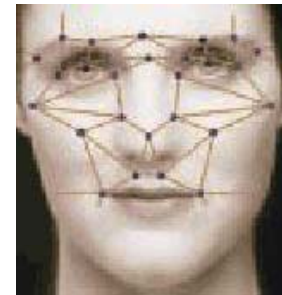
Current Biometrics

Some commonly measured features

- Physical
 - Fingerprints (Palm/hand geometry)
 - Face
 - Iris, retinal
 - Odor/scent
 - **DNA**



- Behavioral
 - Gait
 - Voice
 - Vein (IR thermogram)
 - Hand geometry
 - Handwriting



We are finding new ways to use DNA...

BIZARRO

We're taking back your first place ribbon. — We found traces of your parents' DNA all over your science fair project.



<http://www.freewebs.com/desirealbano/bizarro.jpg>

DNA can be Viewed as the Ultimate Biometric

Captured December 13, 2003



**Is this man really
Sadaam Hussein?**

**Matching Y-STR
Haplotype Used to
Confirm Identity**



(along with allele sharing
from autosomal STRs)

**Relatives Used
to Confirm
Identity**



DNA Typing as a Biometric

Advantages

- High level of accuracy (Gold Standard)
- Solid foundation of forensic DNA testing (population stats, genetics, molecular biology, court acceptance)
- **Kinship determination**
- Potential use for:
 - Phenotype (traits)
 - Ancestry

Challenges

- Expensive
- **Time consuming**
- Sample collection (invasive, stability)
- Technical expertise required for analysis
- Low level template, mixtures, PCR inhibition

The Desire is There...



National DEFENSE **NDIA**
NDIA's Business and Technology Magazine

[National Defense](#) > [Archive](#) > [2009](#) > **July**

Security Beat

Wanted: One Affordable Field-Ready DNA Testing Device
July 2009
By Stew Magnuson

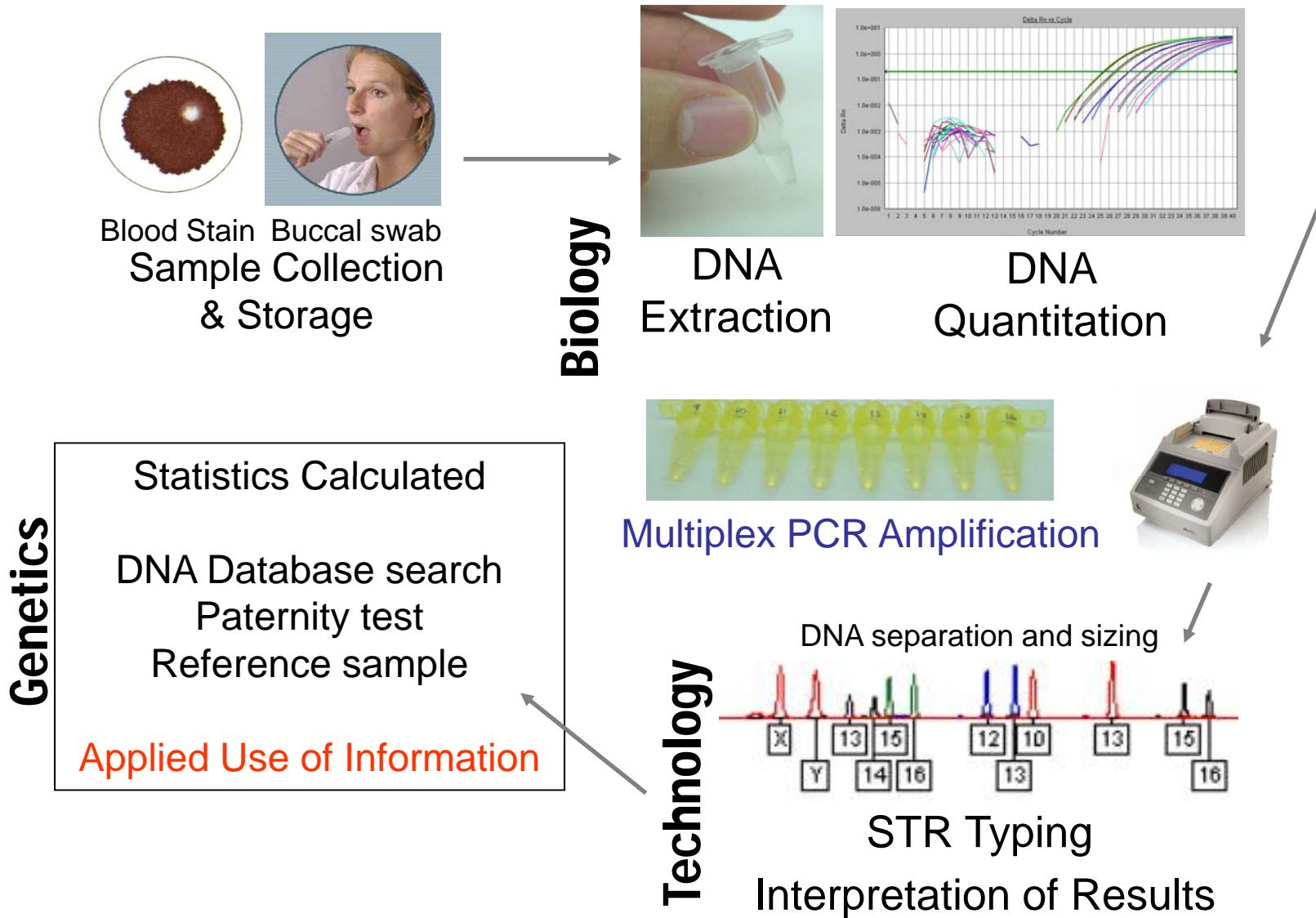
<http://www.nationaldefensemagazine.org/archive/2009/July/Pages/WantedOneAffordableField-ReadyDNATestingDevice.aspx>

- Use in refuge camps to confirm family relationships for asylum seekers (~80% fraud)
- Prevention of overseas adoption fraud where women may kidnap another's child in a baby-selling scheme

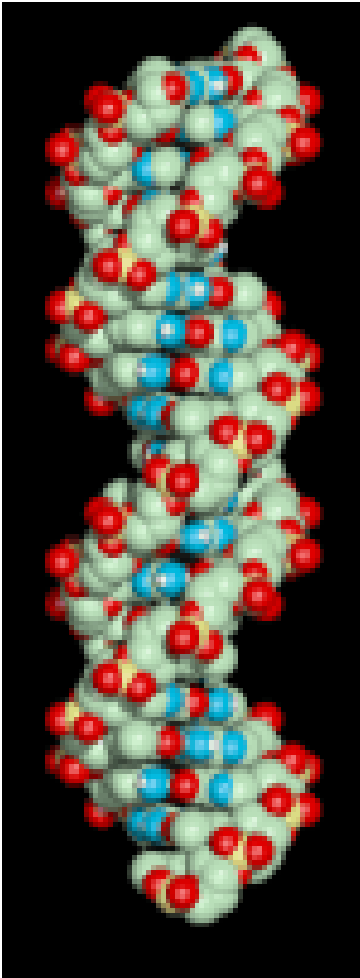
Want result for <\$100 per test in <45 minutes

Steps in Forensic DNA Analysis

Usually 1-2 day process (a minimum of ~8 hours)

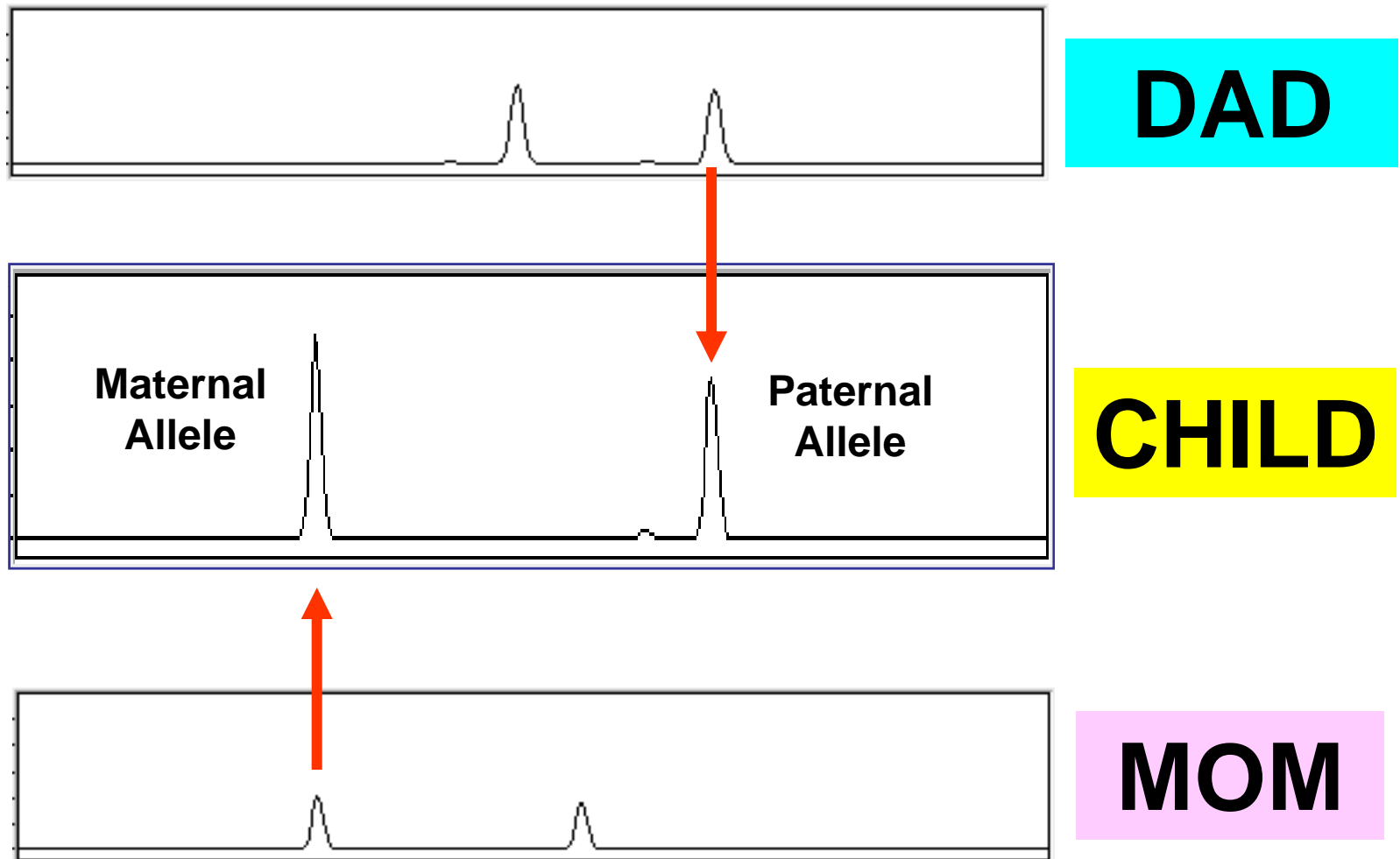


Characteristics of DNA



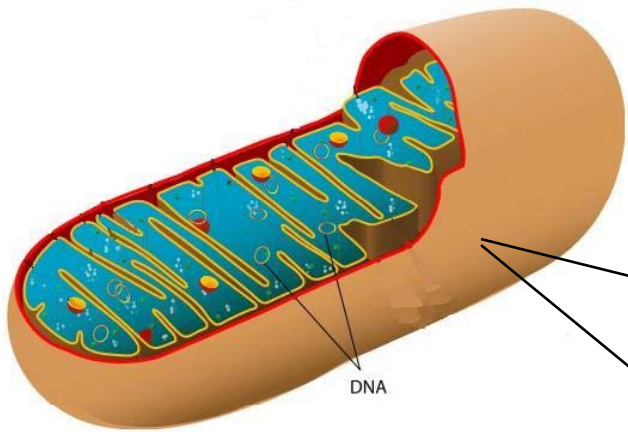
- Each person has a unique DNA profile (except identical twins).
- Each person's DNA is the same in every cell.
- An individual's DNA profile remains the same throughout life.
- Half of your DNA comes from your mother and half from your father.

Inheritance Pattern of DNA Profiles



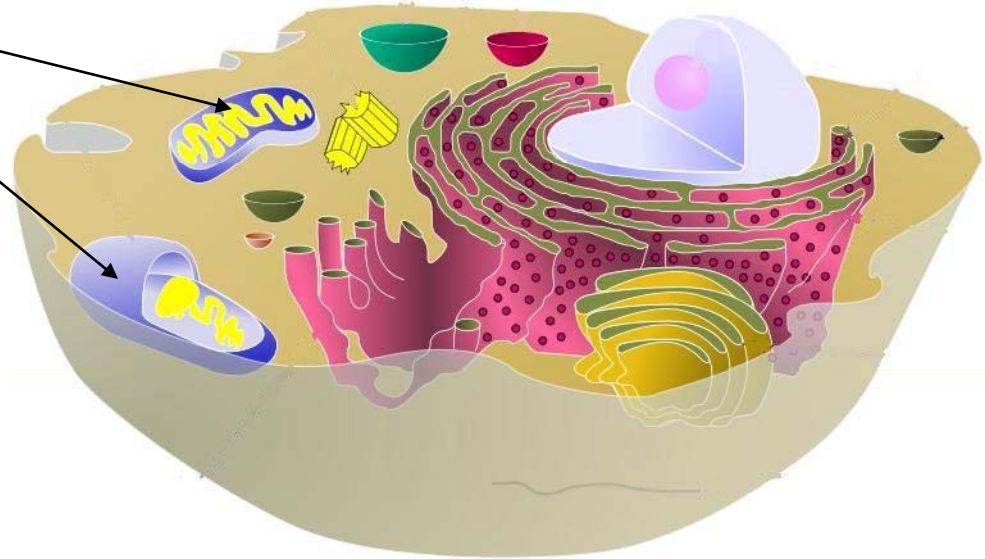
Result from a Single Locus (specific region of DNA)

The Human DNA Genome within a Cell



The Nucleus = control center for the cell (one per cell)

Mitochondria = the power houses for the cell (hundreds per cell)



Mitochondrial DNA
(16,569 bp)

Inherited from only your mother

Nuclear DNA
(3.2 billion bp)

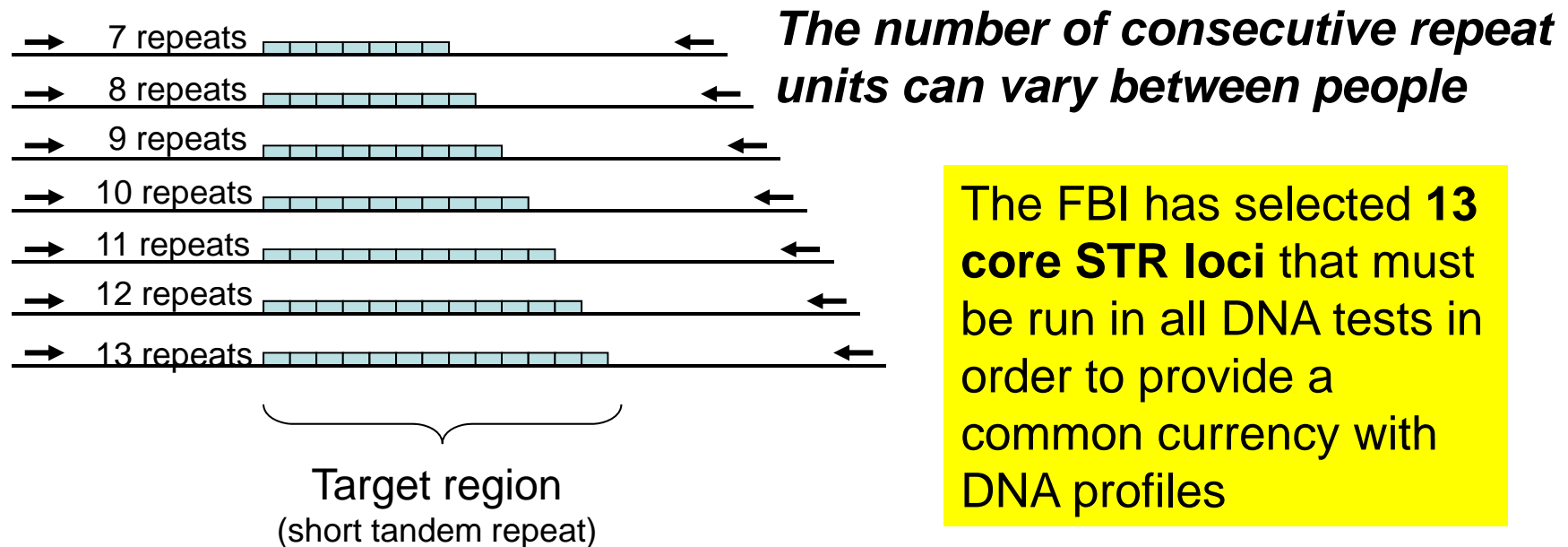
Inherited from both your mother and your father

Short Tandem Repeat (STR) Markers

An accordion-like DNA sequence that occurs between genes

TCCAAGCTCTTCCTCTTCCCTAGATCAATACAGACAGAAGACA
GGTGGATAGATAGATAGATAGATAGATAGATAGATAGATA
GATATCATTGAAAGACAAAACAGAGATGGATGATAGATACATGCT
TACAGATGCACAC

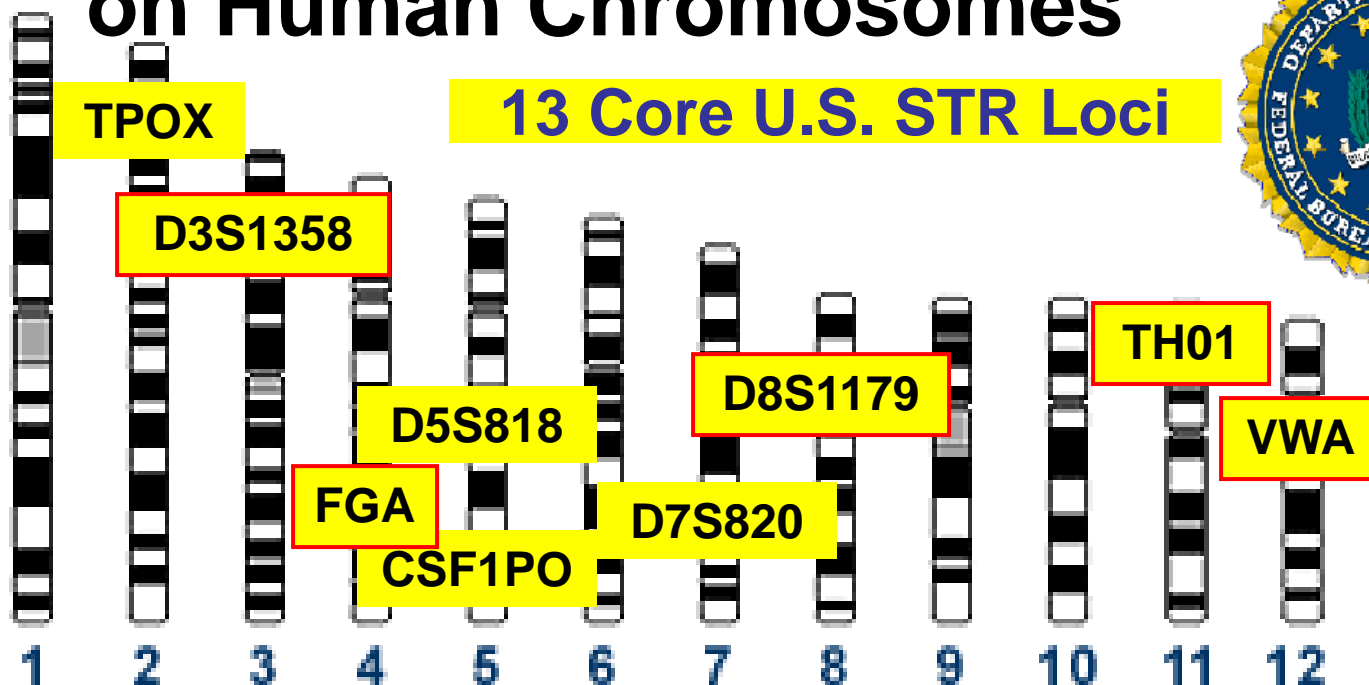
= 11 GATA repeats (“11” is all that is reported)



Position of Forensic STR Markers on Human Chromosomes

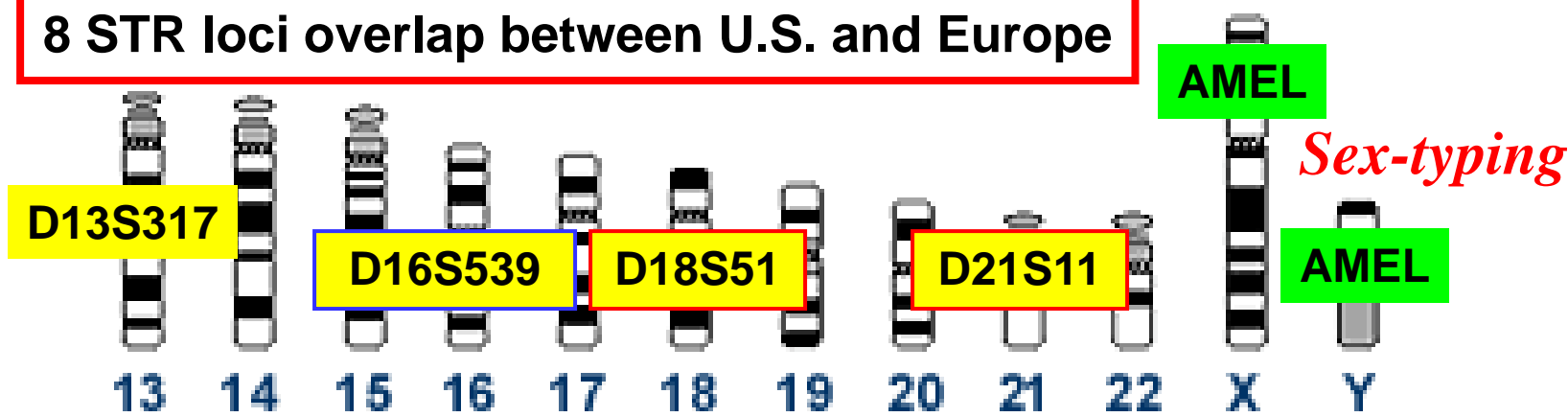


Core STR Loci for the United States



1997

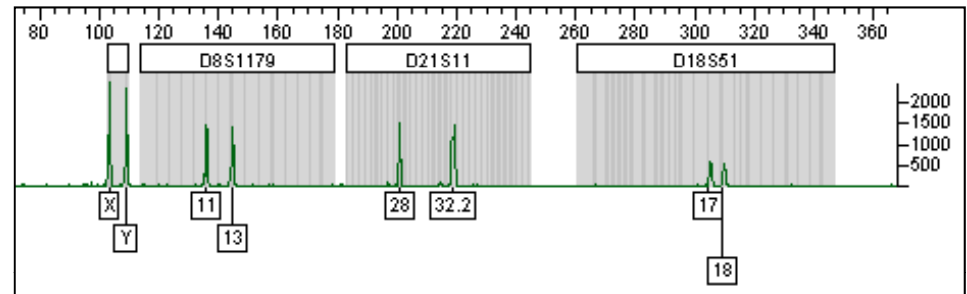
8 STR loci overlap between U.S. and Europe



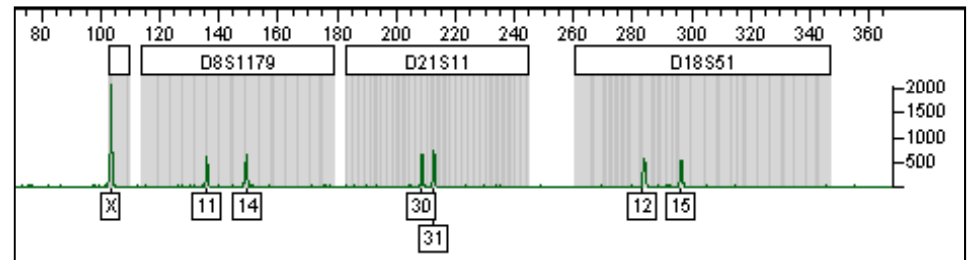
STR Results

- Individuals will differ from one another in terms of their STR profile
- STR genotype can then be put into an alpha numeric form for search on a DNA database

Individual #1



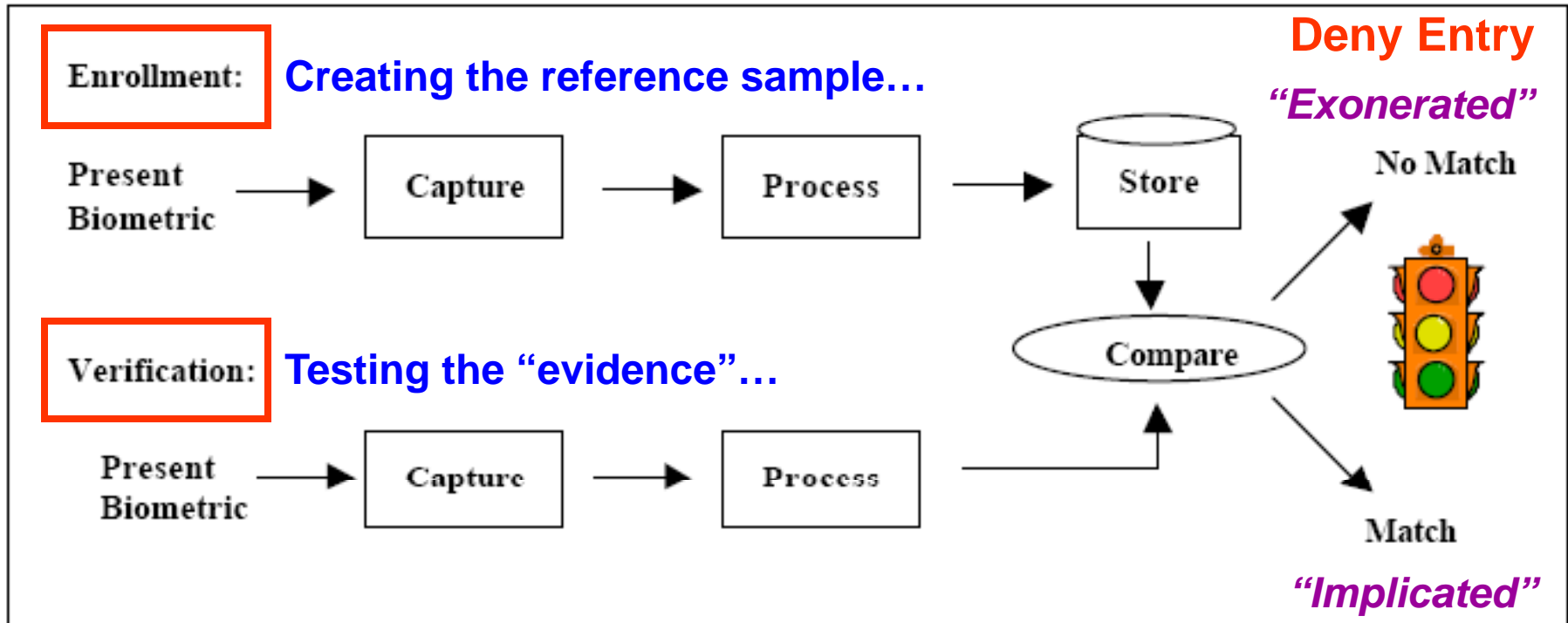
Individual #2



What would be entered into a DNA database for searching:

	<u>AMEL</u>	<u>D8S1179</u>	<u>D21S11</u>	<u>D18S51</u>
Individual #1	X,Y	11,13	28,32.2	17,18
Individual #2	X,X	11,14	30,31	12,15

DNA within the Biometric Model

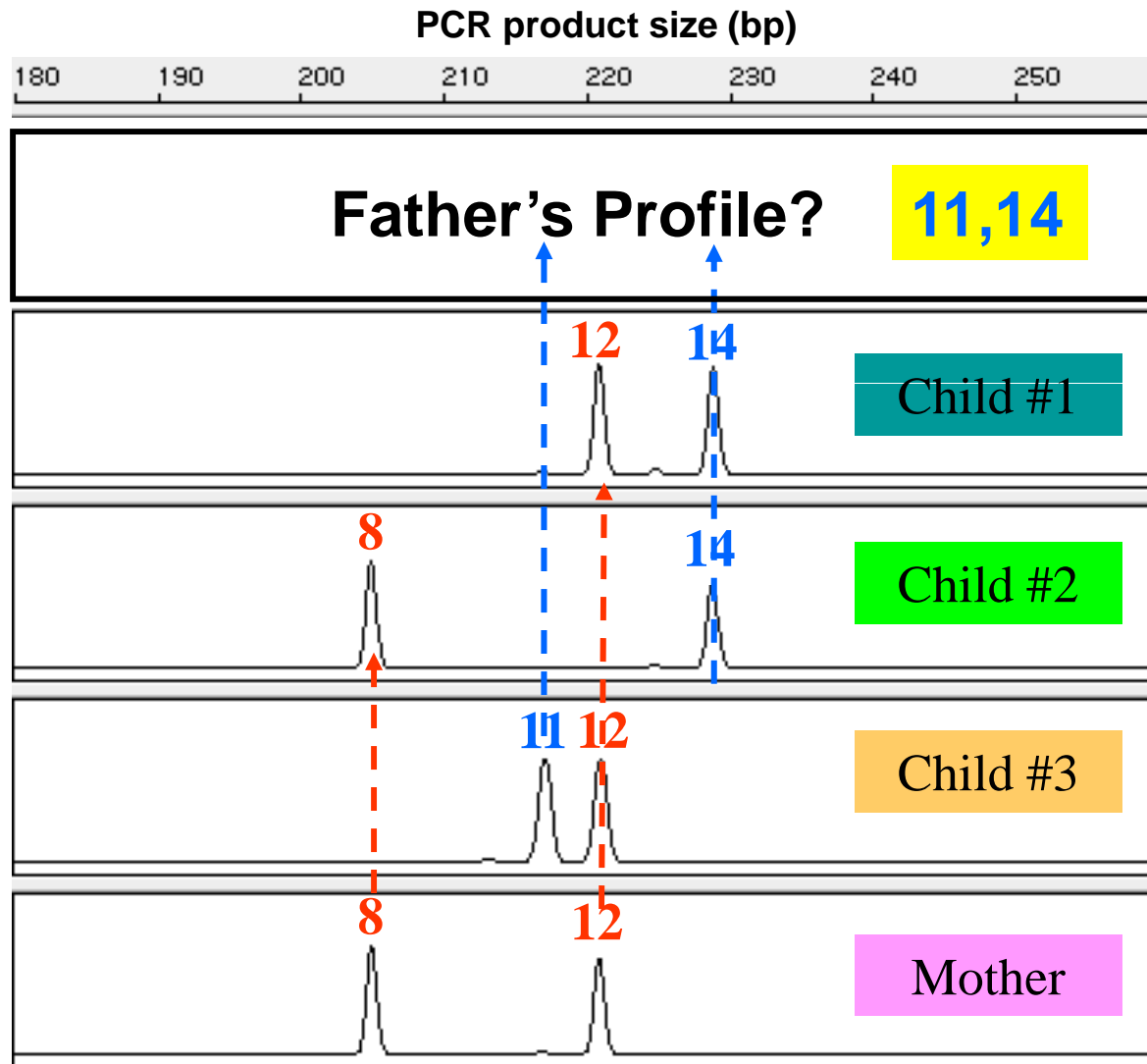


<http://www.itl.nist.gov/div893/biometrics/Biometricsfromthemovies.pdf>

Match of 13 points (each with 2 variable alleles) within DNA

String of 26 numbers (order of listing DNA results would have to be standardized)
16,17-17,18-21,22-12,14-28,30-14,16-12,13-11,14-9,9-11,13-6,6-8,8-10,10

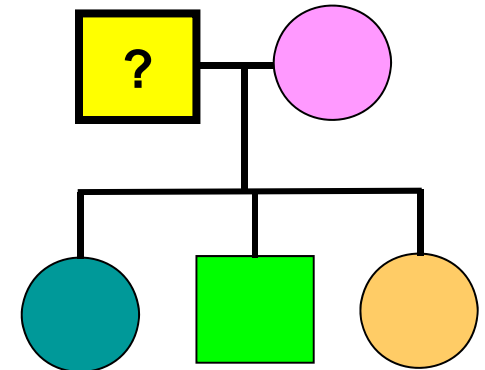
Enrollment through Relatives



STR Alleles from D13S317

Paternity Testing

Alleged Father(s) is asked to donate DNA sample



NIST Efforts with DNA Biometrics

- **Developing rapid PCR protocols**
- Evaluating kinship analysis software
- Support to other rapid DNA efforts
- Designing standards materials for device testing
- Preparing to test prototype rapid DNA devices

Current State of Rapid PCR Protocols

- Rapid amplification of at least 16 loci is possible
 - <20 minutes
- Faster DNA polymerases are required
- Faster thermal cyclers are required
- Optimized rapid STR typing kits could be produced specifically for portable integrated devices
- Success with ~1 ng of DNA template (single source)
- Sub 45 minute PCR will be essential for rapid typing in a integrated/ portable system

ANDE (Automated Nuclear DNA Equipment)

US Government Prototype Initiatives

Rapid DNA Profiling System Automated Nuclear DNA Equipment (ANDE)

(a joint DoD/FBI/DHS initiative)

- **Analysis and matching of multiple DNA samples in
1 hour (18 month development program)**

DHS Low-Cost and Rapid DNA-based Biometric Device

- **Demonstrate an automated desktop prototype device
that verifies identity or kinship within an hour
(2 year development program)**

Speed Improvements with DNA

Turnaround Time Over Last 20 Years

1988 - 94	P-32 RFLP	~ 7 weeks for 6 loci result
1995 - 96	Chemiluminescence	~ 9 days for 6 loci result
1994	PM – DQA-1 PCR	~ 3 days for 6 loci result, > Sensitivity, < Stats
1998	STR with CE	~ 3 days for 13 loci result, > Sensitivity, > Stats
1998	NDIS Established	
2006	Expert System Approved	
2009	R-DNA (R&D)	~ 4 hours for 13 loci (manual intervention)
2011	ANDE (Prototyped Plan)	~1hr 8-16 swabs @ \$100/Sample

Real time DNA analysis can lead to real time DNA ID

DNA Analysis Approach (integrated)

Steps Involved

Challenges

Collection

Target Times

Buccal swab, blood, other?

Extraction

~15 min

Rapid extraction (solid or liquid phase?)
Reagents stable and compatible with device

Quantitation

Can be skipped for a reference sample **BUT**
Does the extraction method allow for a target amount of DNA to be released?
~1 ng

Amplification

~20-30 min

Rapid PCR amplification of a commercial STR kit
Locus balance, stutter, adenylation, heterozygote balance, reproducibility

Separation/
Detection

~20 min

Resolution, reproducibility, sensitivity, post-run signal processing

Data
Interpretation

Expert system software? How much user intervention is needed?

Total Time

~1 hour

Can rapid typing be done reproducibly and accurately?
Cost efficient? (instrumentation, reagents, consumables)
General challenge of going from macro scale to micro scale!

Contact Information

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<http://www.cstl.nist.gov/biotech/strbase>

