DNA PROFILING: FORENSIC EVIDENCE IN CIVIL AND CRIMINAL TRIALS

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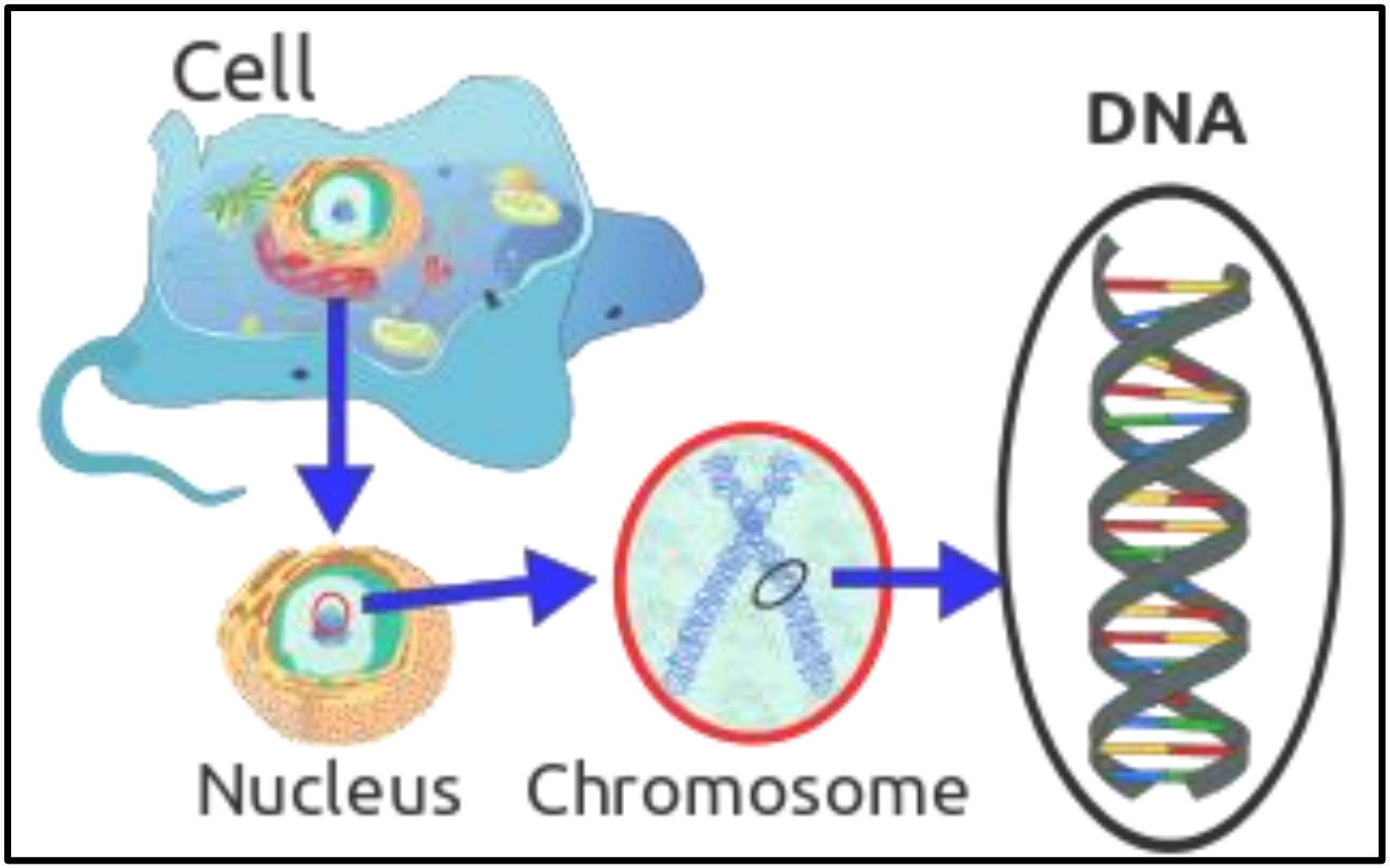
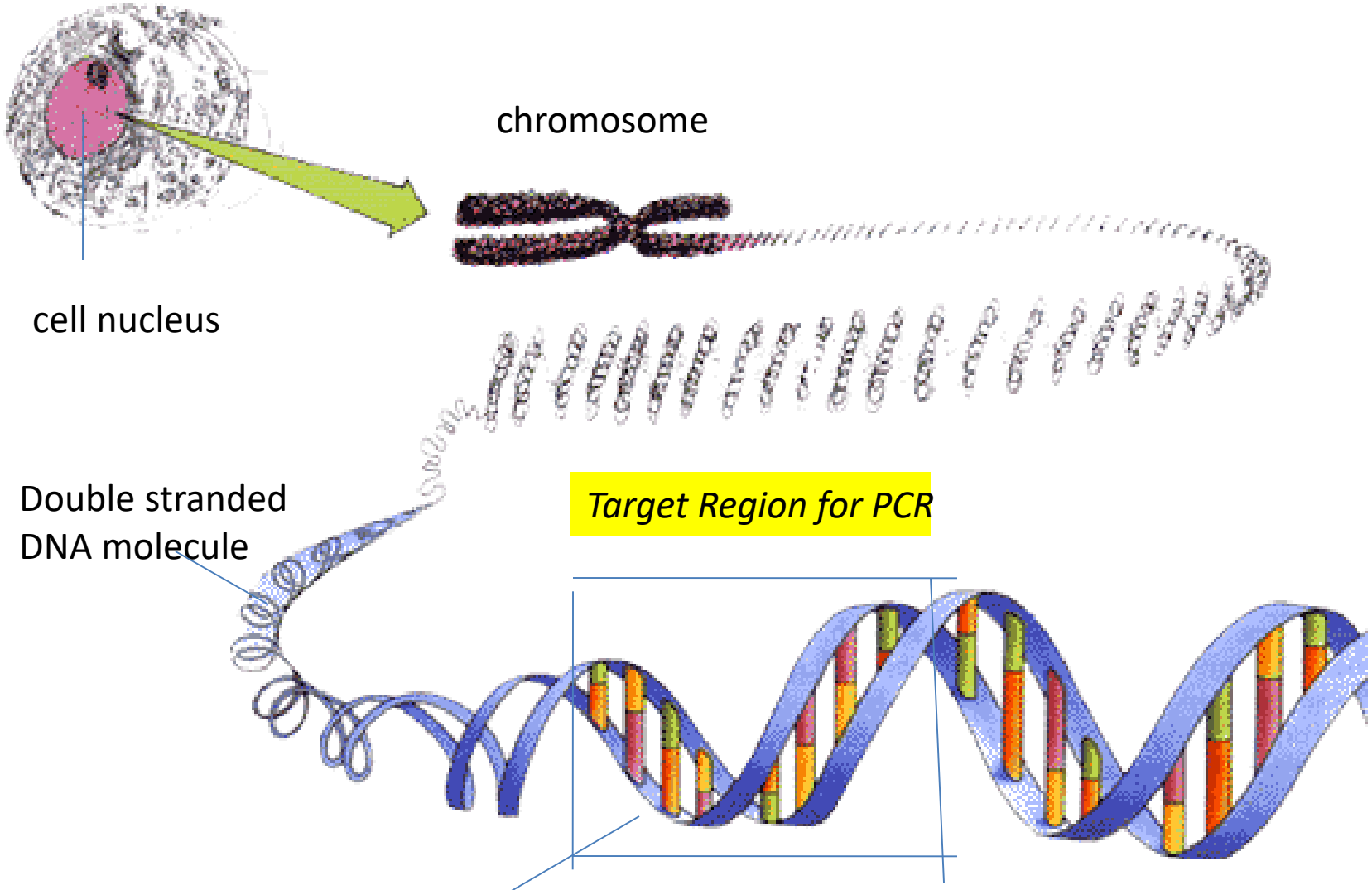
DNA

- DNA stands for deoxyribonucleic acid, the strands of identity that living beings receive from their ancestors.
- It's a basic genetic material in all human body cells.
- The structure of deoxyribonucleic acid (DNA) was described by James Watson and Francis Crick in 1953.
- Outside of identical twins, no two people have the same DNA pattern.

- DNA is chemical of hereditary and carries genetic instruction for growth, development, functions which is responsible for various character of each person -- hair color, eye color, body structure and functions.
- Every person inherits 50% of genetic material from their mother and 50% from their father.
- Every person has a unique strand of DNA


Cell
DNA
Nucleus
Chromosome

DNA in the Cell



APPLICATION OF DNA IN FORENSIC SCIENCE

- On September 10, 1984, Professor Alec Jeffreys and his team of genetic researchers at Leicester University produced what looked like nothing more than a murky barcode.
- Jeffreys realized that this "barcode" could be used as an identification tool for living organisms—much like barcodes identify the goods on our supermarket shelves.
- The production of these barcodes was given the term "genetic fingerprinting."

Locard’s principle

- **Locard's** exchange principle holds that the perpetrator of a crime will bring something into the crime scene and leave with something from it, and that both can be used as forensic evidence.
- Biological stain that are left over the crime scene. DNA of suspected accused is then matched with the left over biological sample over the site.

FIRST CASE WHERE DNA WAS USED

- This case involved the rape and murders of two 15-year-old girls,
- One had been raped and murdered in 1983 in the ancient Leicestershire village of Narborough.
- Her 5 feet 2 inches, 112- pound body was found on a frosty lawn by undressed below the waist and bleeding from the nose.
- In 1986, not far away in the same village, another girl was found naked from the waist down.

- DNA analysis of semen present on vaginal swabs from the two girls suggested that the same person had murdered them.
- In 1987 a man was arrested and charged with both murders but DNA profiling exonerated him but left the rape murders unsolved.
- The police, however, were convinced that the true perpetrator was a local man.
- Consequently, blood samples were requested from all males of a certain age group from three villages within the area of the two murders which led to the catching of a real perpetrator.

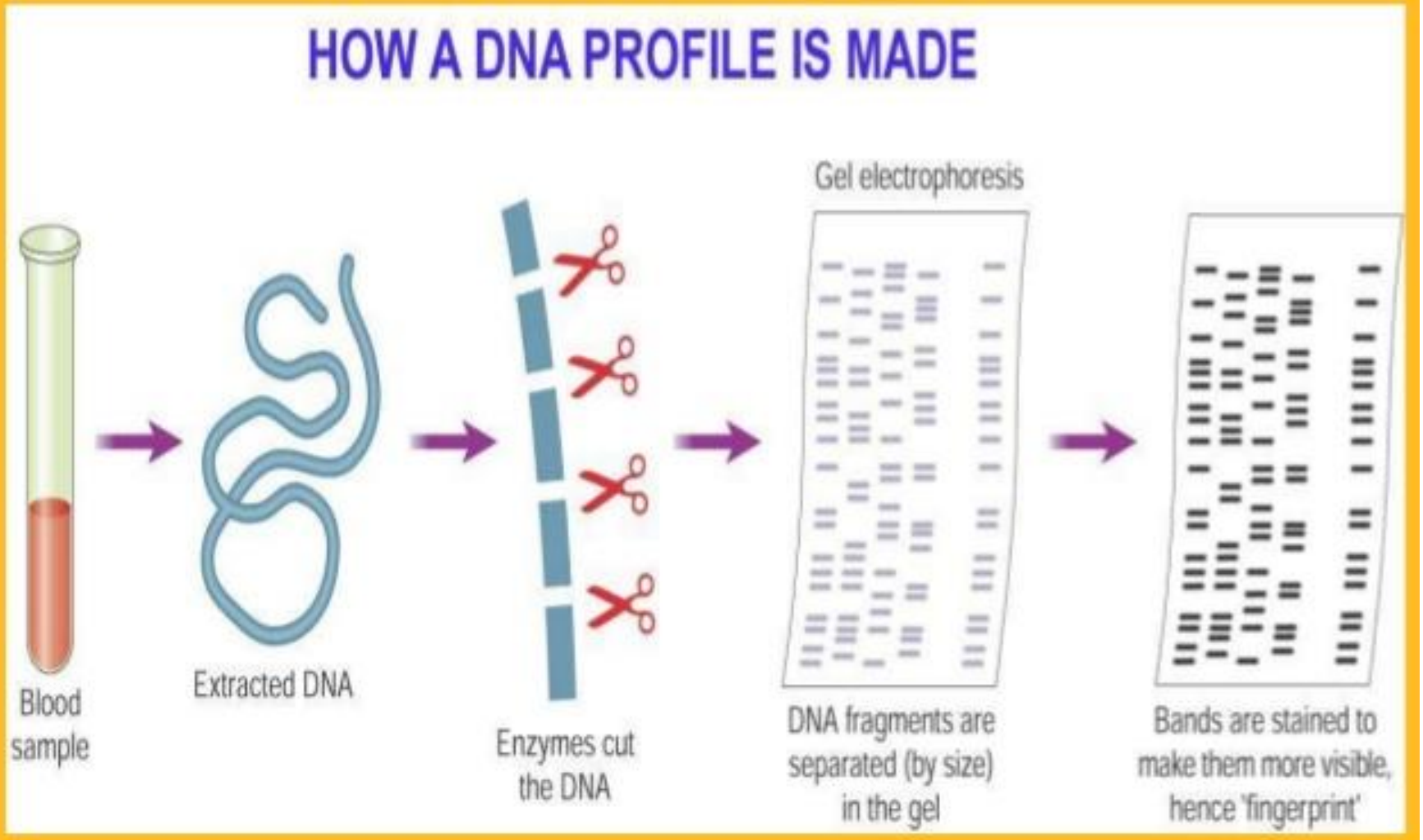
DNA PROFILING

- Sir Jeffreys' genetic fingerprinting was soon refined and improved upon, developing into the technique known today as DNA profiling .
- A DNA profile is produced after analysis of a *sample of genetic material* retrieved either from an individual *or* from a crime scene exhibit.
- It involves the creation of a database of DNA of those who are convicted, jailed or suspects for a crime. So that in the event of a crime in the future, their DNA can be matched against the details in the database.
- It is like the police keeping a record of fingerprint data of criminals.

- DNA profiling does not examine every single difference between individuals.

- The profiling process simply looks for the 10 loci which are *hypervariable* , *unique to an individual and known as hypervariable* regions.

Stages of DNA Profiling



Techniques for DNA Profiling

There are 5 commonly used techniques:

1. **RFLP** : Restriction fragment length polymorphism. The oldest technique which primarily involves radioactive fragmentation and examiner comparison.
2. **PCR** : Polymerase chain reaction. A copying technique for small or fragmented DNA which is amplified and a computer/operator estimated match probability is done.
3. **STR** : Short tandem repeats. A method which uses markers for short repeating segments of allele patterns (as short as 3-7 base pairs)

4. **Mitochondrial DNA analysis** : A variant of PCR used in samples subjected to extreme environmental conditions.

5. **Rapid DNA ID Microchip-based Genetic Detectors** : Type of field ready laptop analysis units that can be used at crime scenes, which displays profiles onsite or electronically uploads to a CODIS database.

From yr 2000 onwards, for forensic purposes, STR typing alone is the recommended method, involving study of at least 13 core loci.

ADVANTAGES OF DNA OVER CONVENTIONAL METHODS

- DNA is ubiquitous i.e. it is present in all the nucleated cells of the body.
- The DNA makeup of a person is same in all the cells of the body and cannot be altered.
- DNA of every person (except in monozygotic twins) is unique in its profile.
- DNA can be extracted from all body fluids and all the tissues of the body.
- In post-mortem cases DNA can be obtained from body tissues.
- In cases where the body has been buried, DNA can still be obtained from body tissues.

ADVANTAGES OF DNA

- In burnt and charred remains, DNA can be obtained from hard tissues like bones and teeth.
- DNA can be stored in small quantities easily as compared to other evidentiary material.
- DNA can be stored for very long periods of time without deterioration if stored appropriately.
- DNA does not combine and thus can detect the number of persons at the crime scene if they have contributed to it.

USES OF DNA

- Identification.
- Disputed paternity.
- Disputed maternity.
- Baby mix-ups.
- Abductions.
- Inheritance.
- Rape.
- Murder.
- Disaster Victim Identification

GENERATION OF DNA PROFILE IN POLICE INVESTIGATIONS

- Suspect samples—samples taken from individuals who have been arrested;
- Elimination samples—victim/volunteer samples;
- Crime scene samples—samples retrieved from crime scenes and crime scene exhibits.

BENEFIT OF DNA AS AN EVIDENCE

- Reliable
- Scientific
- Unbiased

A man can lie but science doesn't.

INTERPRETING RESULTS OF DNA ANALYSIS IN CRIMINAL INVESTIGATION

- 1) Inclusion: When the DNA profile of a known individual (A victim or suspect) matches the DNA profile from the crime scene evidence, the individual is “included” as a potential source of that evidence.
- 2) Exclusion: When the DNA profile from an individual (A victim or suspect) does not match the DNA profile generated from the crime scene evidence, the referenced individual is “excluded” as the donor of the evidence.
- 3) Inconclusive: Inconclusive results indicate that DNA testing did not produce information that would allow an individual to be either included or excluded as the source of the biological evidence.

COLLECTION OF SAMPLES COMMONLY USED for DNA IN FORENSIC PRACTICE

- **Liquid blood**: 2-5 ml of iv drawn blood in sterile, leak-proof, screw capped bottles containing heparin or EDTA along with an identification card.
- **Semen samples**: sterile cotton ear buds moistened with sterile water should be used to take swabs (from genital and other body parts) completely air dried, placed in sterile tubes, sealed and labelled.
- **Stains from crime scenes**: stains should be swabbed with cotton buds moistened with sterile water.

- **Blood/semen from individuals under field conditions**: can be collected in a sterile tube and same should be spread on a sterile bandage cloth folded several times so as to absorb all the fluid, air dried, placed in a clean envelope, sealed labelled and sent to DNA lab at room temperature.
- **Bones**: long and intact bones, e.g. femur /humerus are most suitable.
- **Visceral samples**: Muscle is the most ideal source. Approx 100 gms in wt should be dissected out and placed in sterile glass tube containing normal saline as preservative. (Dimethyl sulphoxide/DMSO is a better preservative)

- **In exhumation cases:** if dry tissue is present, should be placed in sterile bottle without preservative and sent to lab at room temperature.
- **Teeth**: molar teeth are generally used. If not available, any other teeth may be used. For teeth and bones no preservative is required.
- **Hair**: preferably with roots, to be packed in clean paper, sealed and sent at room temperature.
- **Finger nail scrapings**: sterile needle or tooth pick to be used to scrape the inside of finger nails. Material should be collected in clean paper envelopes and sent to lab without preservatives.

MISCELLANEOUS CRIME SCENE SAMPLES

- Clothing's, pillows, sheets- blood, semen, saliva, hair
- Bullet- blood
- Cigarette butt- saliva
- Condom- semen, vaginal secretions
- Envelope-saliva
- Fetal and maternal tissue- separate at the time of collection
- Urine
- Sweat
- Nasal secretions
- Faecal stains
- Vomitus
- Tissue (bone marrow, muscle, spleen, fingernail scrapings)
- Mouth swabs

Disputed paternity and maternity

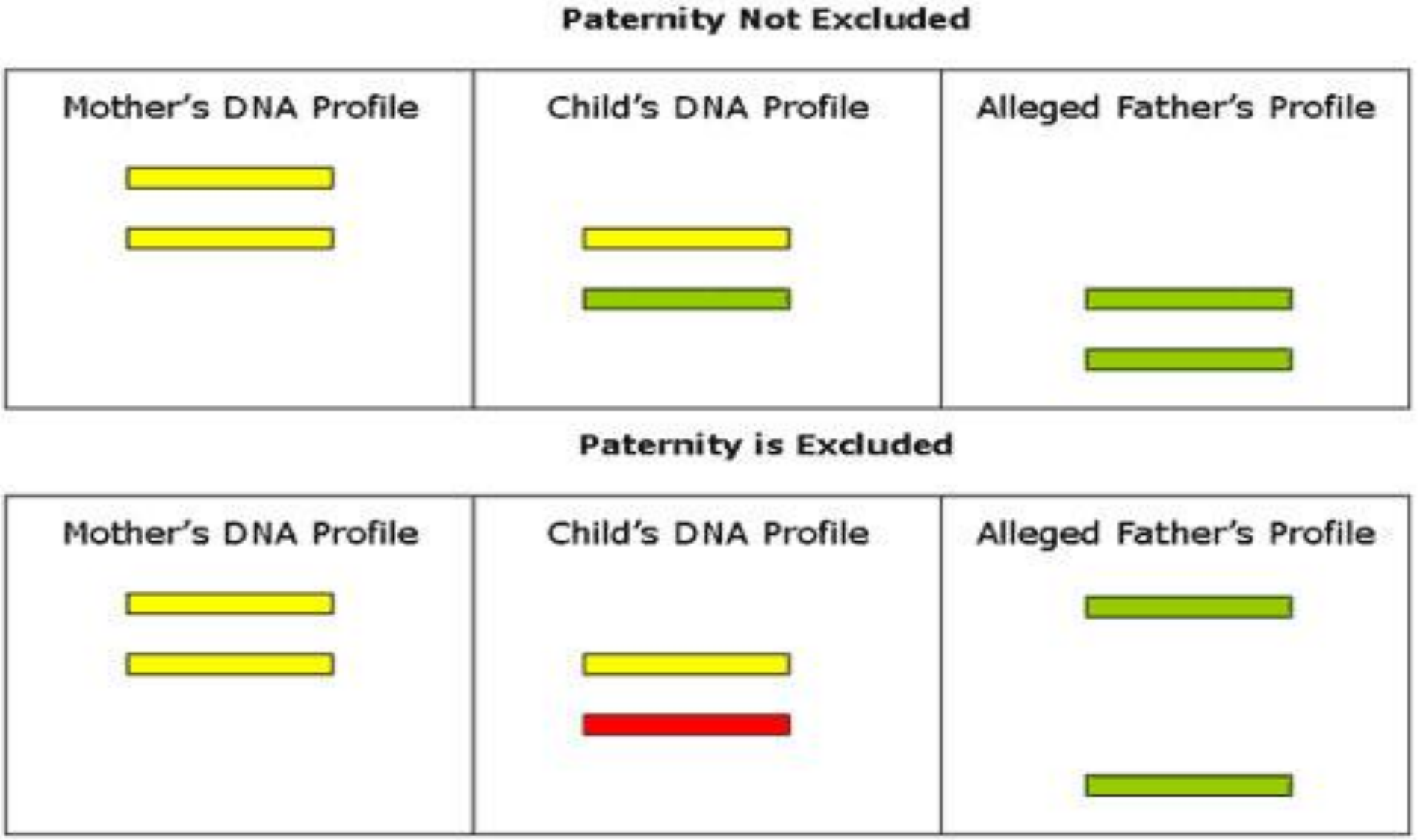
- The test is based upon the principals of inheritance. A child gets one half of his/her genetic makeup from the mother and the other half from the biological father.

- When the biological father of a child is in doubt, a DNA test is the most accurate form of paternity testing available.

- The testing is performed by collecting buccal cells found on the inside of a person's cheek using a buccal swab or cheek swab.

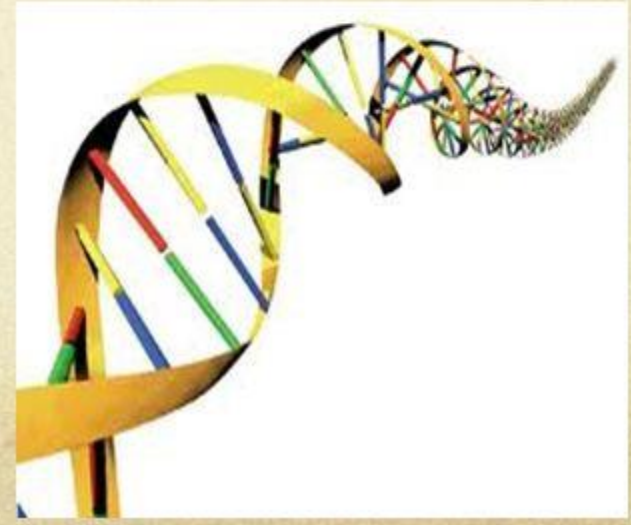
- For paternity testing, samples from the alleged father and child would be needed. For maternity testing, samples from the alleged mother and child would be needed.

DNA for proving Paternity



DNA Evidence

How can DNA be used to solve Crimes?

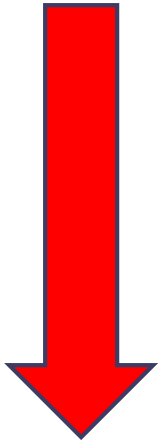


How DNA helps to solve crimes ?

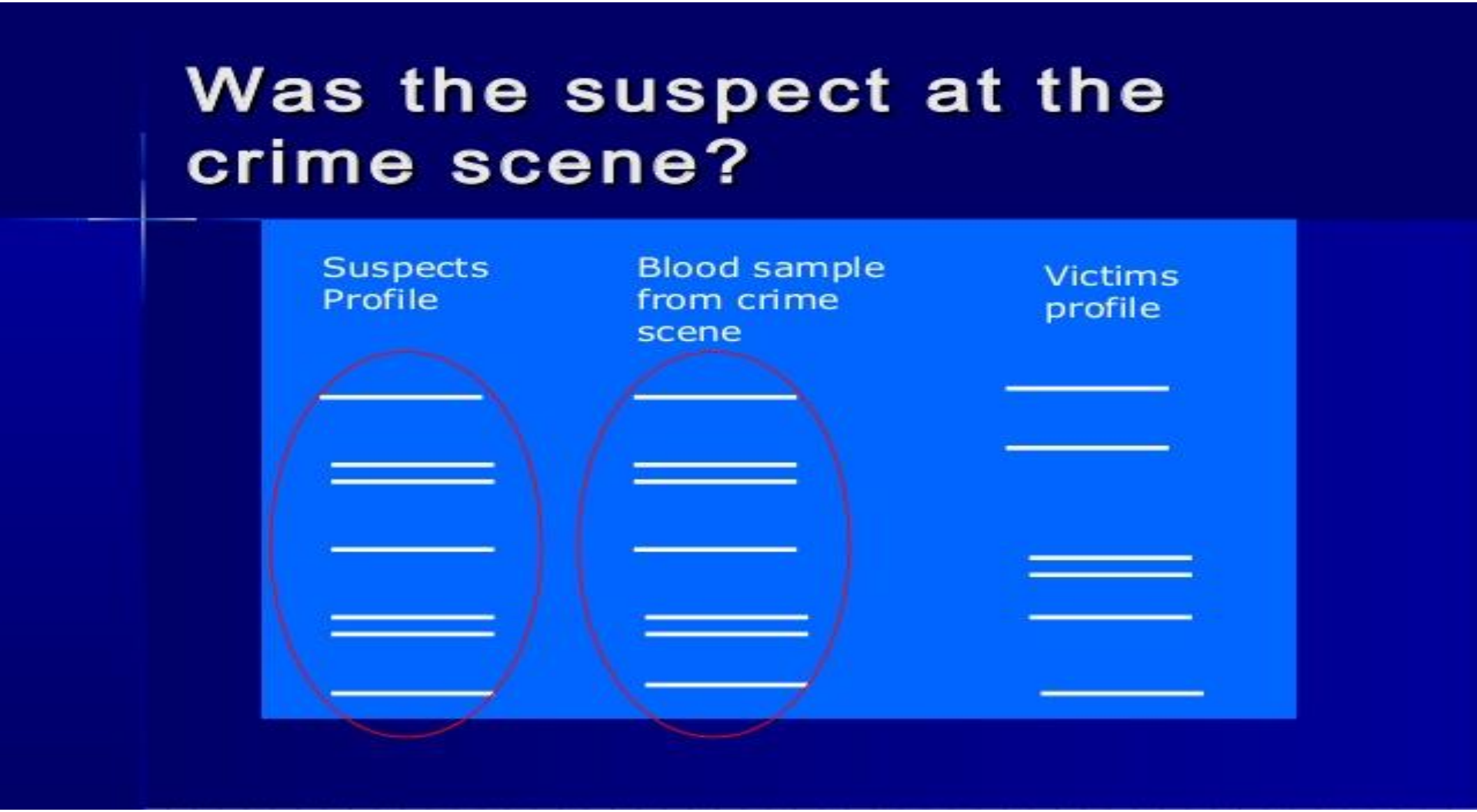
- Each person's DNA is different from other people (except in identical twins)
- DNA collected from a crime scene can either link a suspect to the evidence or eliminate a suspect (similar to fingerprints)
- DNA can identify victims through DNA from relatives even when no body can be found
- DNA can link crime scenes together by linking the same perpetrator to different scenes locally, statewide or across the nation.
- DNA can place an individual at a crime scene, in a home or in a room where the suspect claimed not to have been in
- DNA can refute a claim of self defense and put a weapon in the suspect's hand

Example:

- A violent murder occurred
- The forensics team retrieved a blood sample from the crime scene
- They prepared the DNA profile of the blood sample, the victim and the suspect as follows



Elimination of victims DNA from suspect's DNA from crime scene



Comparison of DNA samples from crime scene to that of different suspects

DNA sample from the crime scene

DNA in sexual assault cases like Rape

Samples taken in cases of rape cases-

1. Seminal stains
2. Blood stain
3. Loose and matted pubic hairs
4. Scalp hairs
5. Saliva and bite marks
6. Nail Clippings
7. Foreign material {mud and weed}
8. Blood for alcohol and drug.

In sexual assault, the contact between the perpetrator and the victim, or his/her environment, or both always leaves evidence which is transferred from the perpetrator to the victim, to the scene, and vice versa .

Attention should be devoted to avoiding contamination, degradation, and loss of biological evidence to maintain the chain of event.

When law enforcement investigates a case of sexual violence, DNA evidence can make or break the outcome.

It has emerged an important tool in achieving justice for survivors of sexual assault.


SEXUAL ASSAULT
EVIDENCE
COLLECTION KIT

What's the benefit of having a sexual assault forensic exam?

- **Increases chances of identifying the perpetrator** - Analyzing DNA samples allows forensic scientists to compare the profile of the perpetrator against a database/ sample from victim

- **Increases likelihood of holding perpetrators accountable** -The DNA evidence will likely carry weight in court. Many cases of sexual violence rely on first hand accounts and other evidence that leaves room for interpretation. DNA evidence helps build a stronger case against the perpetrator.

- **Prevents future sexual assaults from occurring** - Perpetrators of violence tend to be serial criminals, and sexual violence tends to be a serial crime.

When you agree to a sexual assault forensic exam and DNA testing, you increase the chances of taking the perpetrator off the streets and preventing any future instances of sexual violence.

Even if the perpetrator is not prosecuted, their DNA will be added to the database, making it easier to be connect the perpetrator to a crime in the future.

- The DNA from the rapist can be collected from the victim for up to 24 hours after the crime
- The DNA found can be compared with that of the suspect

Example

A DNA sample was retrieved from a rape kit completed at the hospital. The police have 3 possible suspects. A DNA fingerprint has been done to narrow done the suspect pool. Who is the police's MAIN Suspect?

Y-STR testing

- Spermatozoa are a rich source of DNA and are responsible for a vast majority of the DNA content of semen.

- In a sexual assault case, evidence such as vaginal swabs may contain both female and male DNA.

- Y-STR testing is sensitive and specific for male DNA and is essentially able to detect a ‘needle in the haystack’ of tiny amounts of male DNA mixed with large amounts of female DNA. Y- STRs are Short Tandem Repeats found on the male-specific Y Chromosome

- Since there is no Y-STR in the female evidence, the only contribution of Y-STR can only come from the assailant(s) in a sexual assault case.

- The male component will be easily detected, since only this part of DNA will be amplified.

- The Y-STR system is especially helpful when there are more than one assailant.
- The mixed pattern in the evidence can help to identify those males responsible for the assault digital penetration cases, detecting semen from a vasectomized male on vaginal swabs, and detecting low amounts of male DNA on female fingernail scrapings/clippings.

(** reference : Y Chromosome STR Typing: A Distinguishing Tool for Exclusion in a Casework of Sexual Assault (a case study) by Suminder Kaur, Monika Lamba and Ritika Gupta)

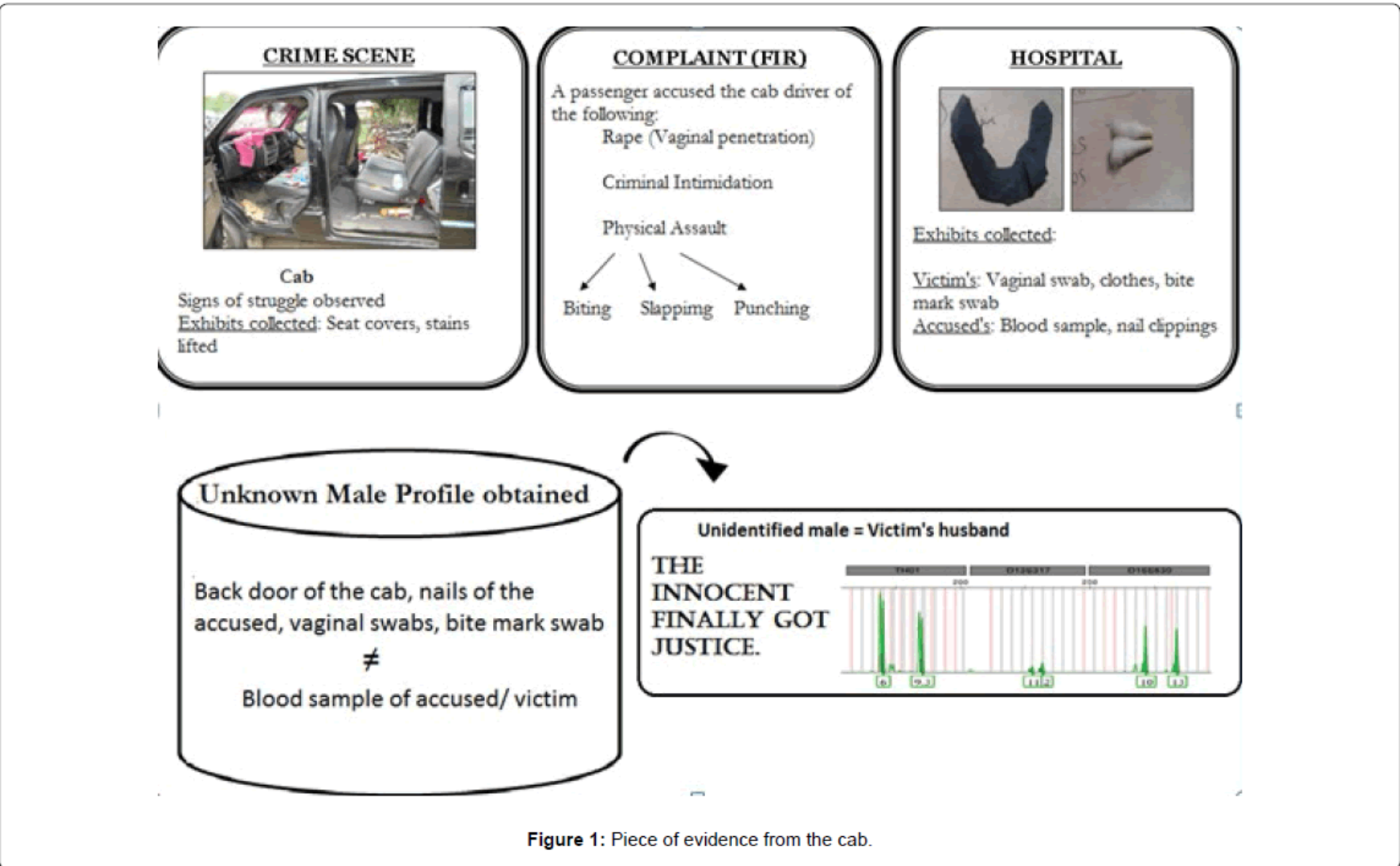


Figure 1: Piece of evidence from the cab.

Murder

- **DNA** is generally **used to solve crimes** in one of two ways. In cases where a suspect is identified, a sample of that person's **DNA** can be compared to evidence from the **crime** scene.

- The results of this comparison may help establish whether the suspect committed the **crime.**


1995 TANDOOR MURDER CASE


Priyadarshini Mattoo Murder Case

NIRBHAYA GANGRAPE CASE

DEATH SENTENCE FOR CONVICTS

Mukesh Singh

Akshay Thakur

Vinay Sharma

Pawan Gupta

SHEENA BORA MUDER CASE

Touch DNA

- **Touch DNA** is a forensic method for analysing DNA left at the scene of a crime.
- It is called "**touch DNA**" because it only requires very small samples, for example from skin cells left on an object after it has been touched or casually handled.
- The technique has dramatically increased the number of items of evidence that can be used for DNA detection.
- Touch DNA doesn't require you to see anything, or any blood or semen at all. It only requires seven or eight cells from the outermost layer of our skin.

Cracking the Bodhgaya case with Touch DNA

In the Bodhgaya blasts case, the bomber was masked and disguised as a monk.

Even though there was CCTV footage, it was difficult for the NIA to come to any conclusion.

After planting the bomb, the bomber left the monk's robe behind.

The Touch DNA sampling was put into effect and the skill cell samples were collected from the robe.

During this exercise it was found that an operative by the name Numan was also part of the bombing.

He had left for his home in Ranchi, Jharkhand and the agency managed to find his whereabouts.

However on reaching Ranchi, it was found that he had left the place, but he had kept his bag behind.

The Touch DNA method was used yet again and the samples collected from the bag and matched.

ARUSHI TALWAR AND HEMRAJ MUDER CASE

- The Talwars asked for a Touch DNA test to analyse the palm print found on the terrace (close to Hemraj's body), and the Scotch whisky bottle.

- The Talwars also asked for a Touch DNA test on the golf club that was allegedly used as the murder weapon.

- They even offered to pay for these tests.

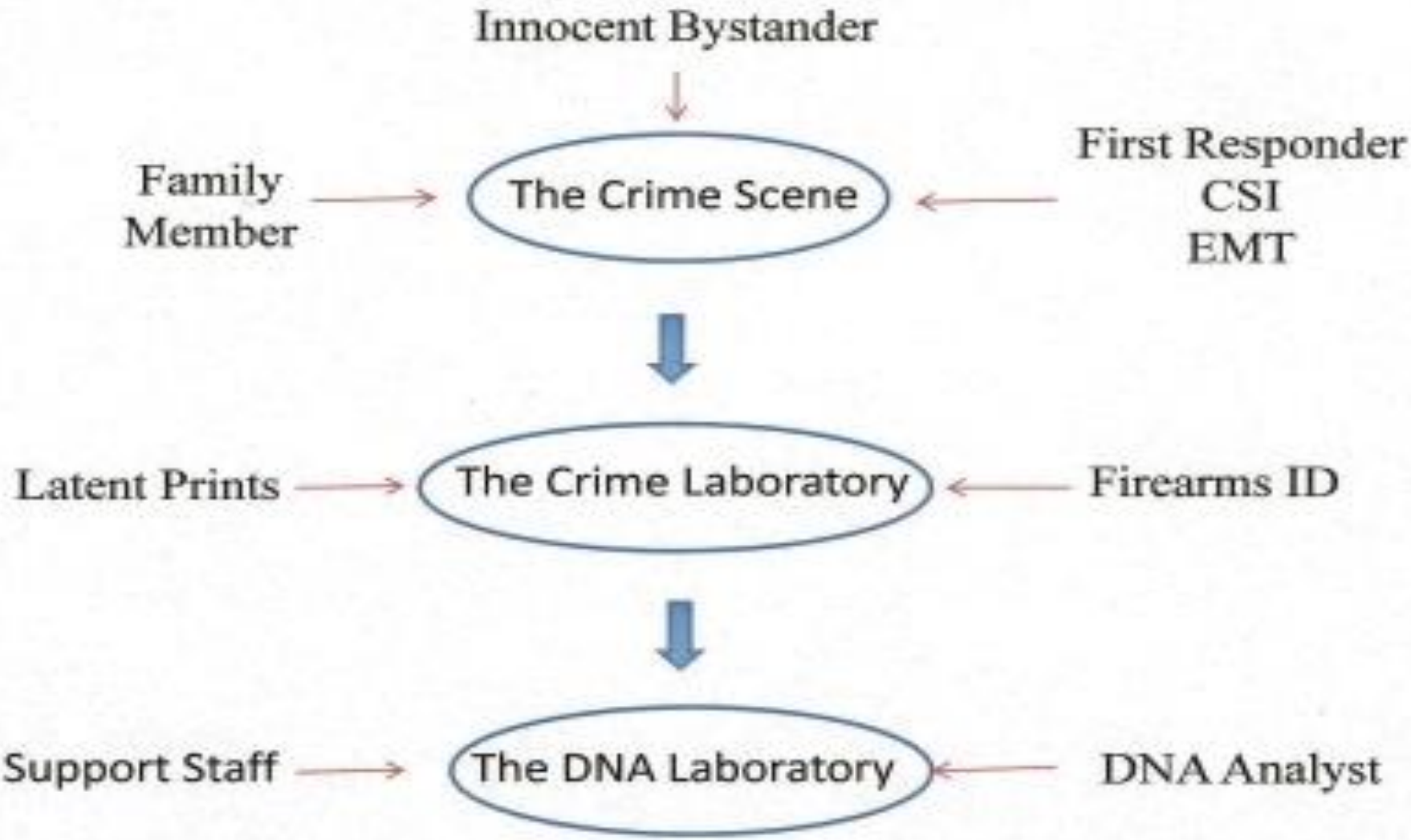
- The agency had approached four overseas laboratories for the test. There was only one UK-based lab that agreed to develop DNA from the exhibits with LCN technique.

- Due to the cost factor and experts opinion that the method is not foolproof, it was felt by the investigation agency to concentrate on the material at hand instead of embarking on a wild goose chase,.
- Nine years after being accused and charged of murdering their daughter, Aarushi, the parents, Rajesh and Nupur Talwar, were acquitted by the Allahabad High Court.
- “Neither the circumstances nor the evidence was enough to hold them (Talwars) guilty,” said the high court in its order.
- APPEAL PENDING IN SUPREME COURT

While touch DNA has become a much requested and successful test for DNA laboratories to perform, we must remember its limitations and be aware of the factors which may affect the results.

These include:

- Was the amount of DNA adequate for meaningful interpretation?
- Was contamination minimized and accounted for?
- Did uninvolved individuals have access to the scene or victim?
- Was it likely that a suspect could have deposited epithelial cells on the surface of the evidence?



Potential Sources of Epithelial Contamination

DNA AS AN EVIDENCE

- Presence of an individual's DNA on an item does not prove their guilt;
- conversely, a lack of DNA does not necessarily prove their innocence.

ISSUES AND LIMITATIONS CONS OF DNA PROFILING AS A FORENSIC TOOL

- Tests unreliable if quantity is less or the sample is degraded.
- Cost effectiveness.
- Lack of qualified experts.
- New techniques of DP can give incorrect results due to errors like cross contamination

- DNA profiles can only offer statistical probability instead of absolute results.
- DNA databases stored in computers can be hacked
- DNA evidence can be falsely planted at crime scenes easily.
- Social and ethical issues can arise if information is not kept securely in databases.
- Complex and tedious process

Laws in other Countries

- Most of the nations have enacted laws dealing with DNA profiling within the framework of their constitutional and other legal principles, particularly for dealing with the criminal cases.

- A mechanism has also been developed to identify the disaster victims through DNA profiling.

A. Argentina
B. United States of America
C. Canada
D. China
E. United Kingdom
F. Scotland
G. Trinidad and Tobago
H. UAE.

- The United states maintains the largest DNA database, with the Combined DNA Index system (CODIS) holding over 9 million records as of 2011.
- The United Kingdom maintains the National DNA database (NDNAD), which is of similar size, despite the UK's smaller population.
- In countries such as Holland, Germany, France or Austria only individuals who have committed certain serious crimes are included in the DNA profiling

THE HUMAN DNA PROFILING BILL, 2017

- “DNA Profiling Bill” has been renamed as – DNA Based Technology (Use and Regulation) Bill 2017 by the Law Commission of India. A newly renamed draft has been submitted to the GOI in July 2017

- The current Bill has subsequently modified the earlier Bill and suggested various measures to fortify the use of DNA samples for investigative and other purposes.

- The Bill proposed to form a National DNA Data Bank and a DNA Profiling Board which have consisted of molecular biology, human genetics, population biology, bioethics, social sciences, law and criminal justice experts.

- The National DNA Data Bank, was supposed to collect data from offenders, suspects, missing persons, unidentified dead bodies and volunteers. It was to profile and store DNA data in criminal cases like homicide, sexual assault, adultery and other crimes.

- The data was to be available also to the accused or the suspect for proving his noninvolvement in the crime or at least to establish that he was not present on the place of occurrence at the relevant time.

FEATURES OF DNA DATABANK

- Data banks will be set up both at national and regional level

- Data banks will primarily store DNA profiles received from the accredited labs and maintain certain indices for specifically 5 categories of data i.e.:

1. Crime scene index
2. Suspect's index
3. Offender's index
4. Missing person's index
5. Unknown deceased person's index

- Maintenance of strict confidentiality in relation to the records
- Sharing of records with/by international government agencies only for purposes specified by the Act
- Punishment for violators of the Act, by imprisonment which may extend up to 3 yrs and also a fine extendable up to 2 lakhs

Need of a law?

•DNA data becomes admissible as an evidence in judicial proceedings and handling of DNA testing, and use of this information by law enforcement agencies and others is to be regulated.

• DNA testing labs are unregulated and lack of uniform testing protocols and procedures.

•In the absence of a legal framework, a database can't be prepared and maintained.

•It depends on the government as to what kind of information to be included in the database - be it information on only convicted persons, suspects or all those jailed.

• If the database is to include all those in custody, then the DNA profile of innocent individuals will have to be deleted, as done in some countries.

• A DNA profiling law is supposed to codify everything and to set procedures for collection, safety, use and access of DNA samples and data.

Possibilities of misuse of DNA database

- Technically it may be possible that data can be used for non-forensic purposes and to interpret information such as family history, medical history and ancestry.

- Even If the draft Bill provides an elaborate procedure for accessing data at National and State data banks, than also there may be possibilities of leakage and misuse.

- The collection of data from criminals could lead to profiling of certain religion/castes and population groups.

•The UID database already has biometric information for most Indians. If any government in future decides to link the UID database with the DNA database, it would place in the hands of the government and its agencies all personal/genetic details about millions of citizens.

• The information can be use /misuse for any future research.

•For all DNA studies, scientists need consent of people whose samples are collected. Without proper consent procedures, it would be a gross violation of privacy and human rights.

FINDING THE PARENTS OF GEETA

- Geeta, a the deaf and mute girl brought back from Pakistan in 2015, to find her parents.
- A couple claiming to be her parents were ruled out by DNA tests rules out.
- Honorable External Affair minster Sushma Swaraj, through a video message, announced that whoever will help Geeta in finding her parents will be rewarded with Rs 1 lakh.
- Number of couples visited the institute in past two years to claim her to be their daughter, but she did not recognise any of them.
- DNA profile of Geeta has not matched with any of the claimants till date.


Nikon


INDONESIA'S BEST
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ETHICAL DILEMMA FOR COURTS IN CIVIL CASES

- Whether a person can be physically compelled to give a blood sample for DNA profiling in compliance with a Civil Court order in a paternity dispute?

Rohit Shekhar VS N D Tiwari Paternity case

- In 2008, Mr Rohit Shekhar filed for declaration, that he is the natural born son of a veteran and famous Congress Party leader Mr Narayan Dutt Tiwari, requested the court to restrain Mr ND Tiwari from denying in public or otherwise the fact that he is the father of the appellant.

Rohit Shekhar VS N D Tiwari Paternity case

- He submitted himself for a DNA test and/or any other test required to determine the parentage of the appellant.
- The said application was contested by the Mr ND Tiwari stating that that he can not be pressurized, compelled or forced in any manner to involuntarily provide blood and/or other tissue sample(s) for DNA testing.

Arguments in Favor

- a distinction has to be drawn between legitimacy and paternity of the child;
- Section 112 of the Indian Evidence Act, 1872 is intended to safeguard the interest of the child by securing his/her legitimacy and not to paternity;
- that a child has a right to know the truth of his/her origin;

- the right of a child to know his biological roots can be enforced through reliable scientific tests and if the interest of the child is best sub-served by establishing paternity of someone who is not the husband of his mother, the Court should not shut that consideration altogether;

- Indian law casts an obligation upon a biological father to maintain his child and does not disregard rights of an illegitimate child to maintenance.

Observations of Single Bench Judge of Delhi High Court

- Though a matrimonial Court and the Civil Court has power to order a person for medical examination but if despite the order of the Court, the respondent refuses to submit himself to medical examination, the Court is entitled only to take the refusal on record to draw an adverse inference therefrom.
- Physical confinement for forcible drawing of blood sample or sample of any other bodily substances is not envisaged in any statutory provision governing civil legislation.
- Mandatory testing upon an unwilling person would entail an element of violence and intrusion of a persons physical person and may leave irreparable scars and is unwarranted and impermissible under Article 21 of the Constitution of India.

Division Bench of High Court

- It is also not as if use of force and police for that purpose is unknown to Civil Jurisprudence. Such force, through the machinery of police is always used for execution of orders/decrees upon resistance by the judgment debtor/persons against whom such orders are made.
- Adverse inference from non-compliance cannot be a substitute to the enforceability of a direction for DNA testing.
- The valuable right of the appellant under the said direction, to prove his paternity through such DNA testing cannot be taken away by asking the appellant to be satisfied with the comparatively weak adverse inference.

Delhi High Court,

W vs H & Anr on 26 August, 2016.

MAT.APP.(F.C.) 17/2016 & CM No.5064/2016

1. A matrimonial court has the power to order a person to undergo medical test.

2. Passing of such an order by the court would not be in violation of the right to personal liberty under Article 21 of the Indian Constitution.

3. However, the court should exercise such a power if the applicant has a strong prima facie case and there is sufficient material before the court.."

- "Section 112 lays down that if a person was born during the continuance of a valid marriage between his mother and any man or within two hundred and eighty days after its dissolution and the mother remains unmarried, it shall be taken as conclusive proof that he is the legitimate son of that man, unless it can be shown that the parties to the marriage had no access to each other at any time when he could have been begotten.

Principles to be followed while considering application for DNA examination

1. A rebuttable presumption of legitimacy is attached to a child born of a married woman during a subsistence of marriage or within 280 days of its severance.
2. The DNA test is not to be directed as a matter of routine. Such direction can be given only in deserving cases.
3. The court must exercise its discretion only after balancing the interests of the parties and on due consideration whether for a just decision in the matter, DNA test is eminently needed.

4. There must be a strong prima facie case in that the husband must establish non-access in order to dispel the presumption arising under Section 112 of the Evidence Act.
5. Whether it is not possible for the court to reach the truth without use of such test.
6. "Access" and "non-access" mean the existence or nonexistence of opportunities for sexual intercourse; it does not mean actual "cohabitation."
7. Burden of proving illegitimacy is on the person who makes such allegation.
8. Even if the DNA test revealed that the child was not born to the husband, the conclusiveness in law would remain irrebuttable.

Conclusion of the Honorable court

DNA tests cannot be ordered to prove ‘bald allegations’ of infidelity

Mass Disaster : DNA Profiling

FORENSIC DNA ANALYSIS
IFMS of Soochow University

Applications of Forensic DNA Testing

Mass disasters can be classified in one of three ways:

1.Natural

2.Accidental

3.Criminal

- Large number of human remains
- Frgamented
- Incinerated or co-mingled

DNA Profiling in Mass Disaster Victim Management

- A disaster, as defined by the World Health Organization (WHO), is “a sudden ecological phenomenon of sufficient magnitude to require external assistance”.

- A Mass Disaster often result in severe fragmentation, decomposition and intermixing of the remains of victims.

- In such situations, traditional identification methods, based on the anthropological and physical characteristics of the victims, fail and DNA profiling became the gold standard for victim identification.

Current Challenges

Table 1. Representative mass disaster cases investigated by means of DNA technology and described in the scientific literature that were classified chronologically

Mass disaster	Case/location/date	No. of victims	Remains analyzed by DNA	Main challenges	References
Aircraft accident fatality	Airbus A320 aircrash/Mount Sainte-Odile (France), January 20, 1992	87	17	reduced number of PCR markers available	(2)
Collective suicide/genocide	Waco disaster/Waco (Texas), April 19, 1993	83	73	remains extensively charred; reduced number of PCR markers available	(3,4)
Terrorist bombing	Argentine-Israeli Association explosion/ Buenos Aires (Argentina), July 18, 1994	>100	70		(5)
Aircraft accident fatality	Spitsbergen aircraft accident/Spitsbergen (Norway), August 1996	141	257		(6)
Aircraft accident fatality	Taoyuan Airbus crash accident/Taoyuan (Taiwan), February 16, 1998	202	685	large-scale pair-wise genotype comparisons; large number of families among the victims	(7)
Aircraft accident fatality	aircrash accident/Philippines, February, 1998	104	187	low success rate with STR loci	(8)
Aircraft accident fatality	Swissair Flight 111 accident/Atlantic Ocean off Canada's coastline, September 2, 1998	229	1277	large-scale pair-wise genotype comparisons	(9)
Terrorist attack	World Trade Center disaster/New York (USA), September 11, 2001	2749	19,963	large-scale pair-wise genotype comparisons; high DNA degradation, sample disintegration	(10-12)
A tunnel-bound cable car disaster	Kaprun cable car fire disaster/Kaprun (Austria), November 11, 2000	155	155		(13)
Aircraft accident fatality*	Yakolev-42 aircrash accident/Trabzon (Turkey), May 26, 2003 (a)	74	86		this study
Terrorist bombing†	Madrid train bombing case/Madrid (Spain), March 11, 2004 (b)	191	220		this study
Natural disaster	South Asian Tsunami, December 26, 2004	>200000	?	large-scale pair-wise genotype comparisons; low rate of body recovery; High DNA degradation; large number of family groups among the victims; lack of reference DNA samples; lack of technical resources?	(31-33)

*In the Yakolev-42 air crash accident case, 62 out of 74 total victims were Spanish military personnel on their way home from a peacekeeping mission in Afghanistan. Thirty out of 62 bodies were documented as unidentified, whereas 32 were positively identified by the Turkish forensic team. All bodies were given by the Turkish authorities to the Spanish military commission in charge to carry out the process of identification and repatriation of the corpses. Corpses were given to families in Spain without further (documented) identification analysis. One year later, comparative DNA analysis among post-mortem body samples taken by the Turkish authorities and reference samples from victims' relatives demonstrated that the thirty unidentified cases were mis-identified and consequently each family received a wrong body. A new DNA analysis from the exhumed bodies was carried out that confirmed all errors and offered concordance with the results obtained by the Istanbul Forensic Science Council from post-mortem body samples.

†In this case, a decision was taken only to perform DNA typing from autopsied bodies (62 samples) that were not identified by fingerprint analysis. This decision impeded later DNA re-association studies with more than 156 body fragments that were collected from the different train scenes.

Alonso A, Martin P, Albarran C, Garcia P, Fernandez de Simon L, Iturralde MJ, et al. Challenges of DNA profiling in mass disaster investigations. Croat. Med. J 46(4) (2005) 540-548.

Identifying Victims of Mass Disasters

Butler, J.M. (2005) *Forensic DNA Typing, 2nd Edition*, Chapter 24


POLICY FORUM

EPIDEMIOLOGY

DNA Identifications After the 9/11 World Trade Center Attack

Leslie G. Biesecker,* Joan E. Bailey-Wilson, Jack Ballantyne, Howard Baum, Frederick R. Bieber, Charles Brenner, Bruce Budowle, John M. Butler, George Carmody, P. Michael Conneally, Barry Duceman, Arthur Eisenberg, Lisa Forman, Kenneth K. Kidd, Benoit Leclair, Steven Niezgoda, Thomas J. Parsons, Elizabeth Pugh, Robert Shaler, Stephen T. Sherry, Amanda Sozer, Anne Walsh

***Science* (2005) 310: 1122-1123**

Largest Forensic Case in History

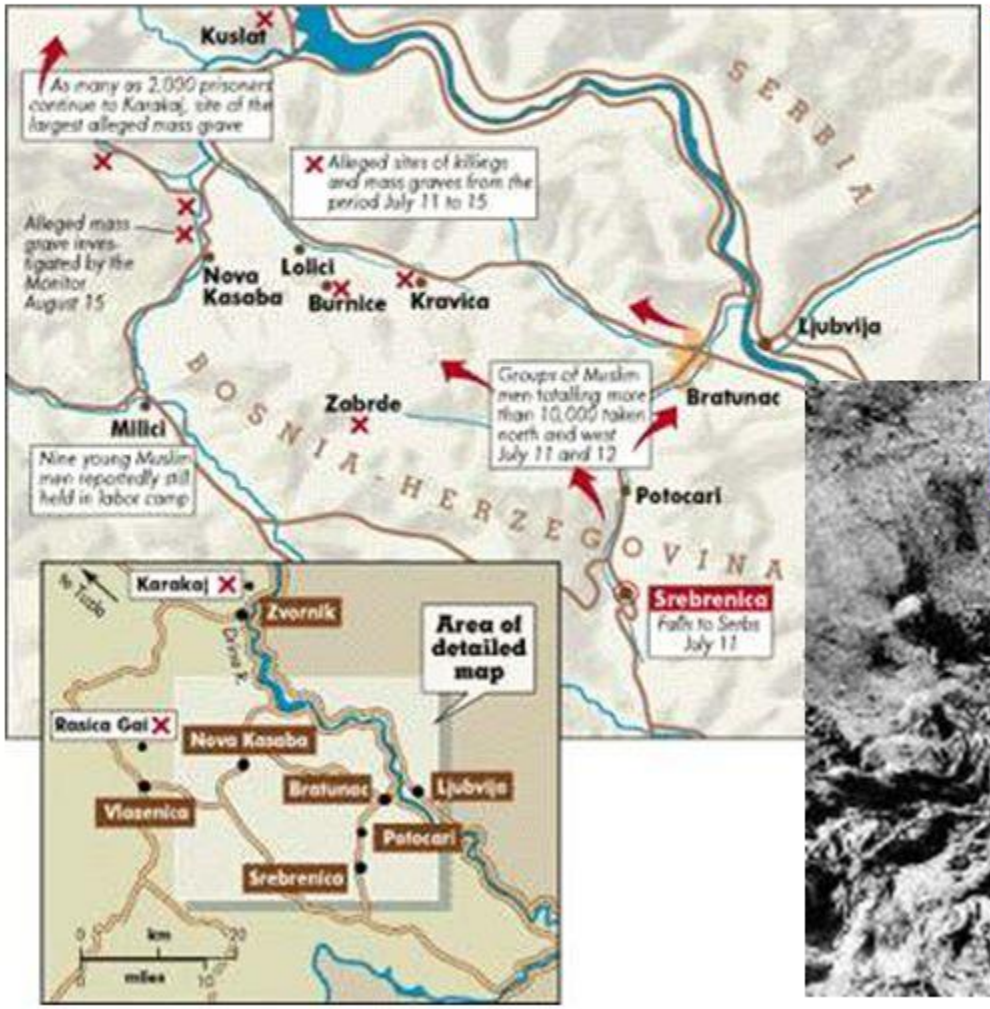
~20,000 bone fragments were processed

>6,000 family reference samples and personal effects samples were analyzed

Identification of Remains from Former Yugoslavia

>90,000 family reference samples collected

>17,000 bones identified as of April 2007



DNA testing is performed on 100s of bones collected each week from mass graves in Bosnia and Croatia to help in the re-association of remains

Nepal earthquake :

12/03/18

A plane carrying 71 passengers and crew has crashed on landing at Nepal's Kathmandu airport, killing 49 people, according to police.

Rescuers pulled bodies from the charred wreckage of the plane, operated by Bangladeshi airline US-Bangla, after a raging fire was put out.

The plane was carrying 67 passengers and four crew.

It is now known that 33 of the passengers were Nepalis, 32 were Bangladeshi, one was Chinese and one was from the Maldives.

Thank you

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