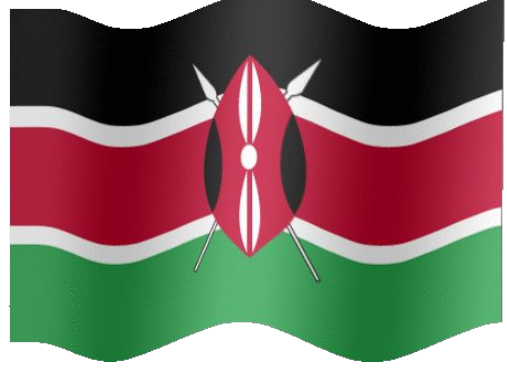


ADVANCES IN FORENSIC TESTING

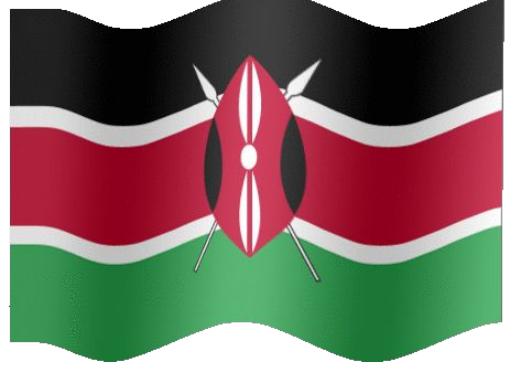
Dr Joseph Kagunda Kimani
Senior Deputy Government Chemist/ Head Forensic Division
Ministry of Interior and National Administration

04/10/2024



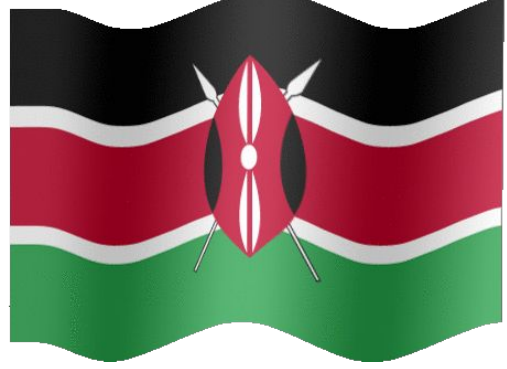
GOVERNMENT CHEMIST DEPARTMENT

- The central Government Forensic and Analytical Laboratory established in 1912 with branches in Nairobi, Mombasa and Kisumu.
- It has two distinct divisions : Forensic and Analytical.
- The Forensic Division has three distinct laboratories: Forensic Biology, Forensic & Clinical Toxicology and Forensic Criminalistics/ Narcotics analysis.
- It is also the National focal point of the OPCW under the CWC and the secretariat for the risk mitigation under the CBRN.



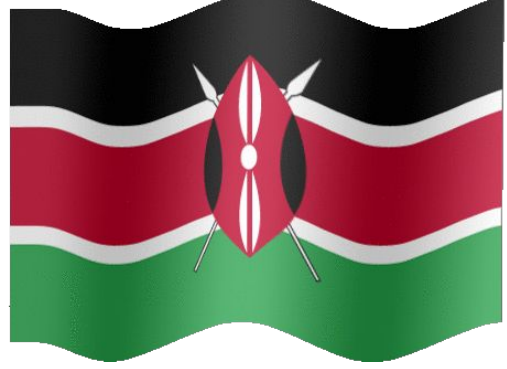
FORENSIC AND CLINICAL TOXICOLOGY

**Forensic and Clinical Toxicology;
Deals with analysis of specimen for
chemically toxic substances in biological
specimens**



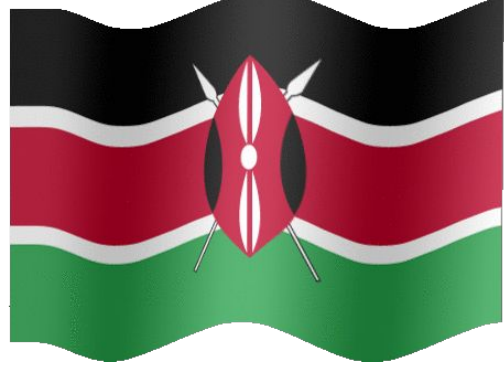
FORENSIC CRIMINALISTICS

Involves analysis and identification of chemical and related substances for purposes of administration of justice.



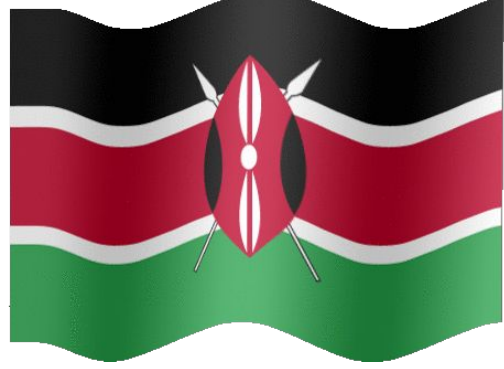
NARCOTICS AND PYSCHOTROPIC SUBSTANCES ANALYSIS

Involves analysis and identification of drugs of abuse and psychotropic substances under the Narcotic Drugs and Psychotropic Substances (Control) Act. for purposes of administration of justice.



FORENSIC BIOLOGY

- Deals with DNA analysis and other Serological procedures for purposes of administration of justice and general investigations. Biological samples and specimens are analysed by comparison of crime scene evidential material in relation to reference samples in the following specialty units;
 - Homicide and Violent Crimes;
 - Sexual related Offences; rape, defilement unnatural offences, bestiality and incest
 - Familial and Genetic Relationships; patrilineal determination, paternity, maternity, parentage, child stealing, trafficking, identification of human remains in mass fatalities and missing persons



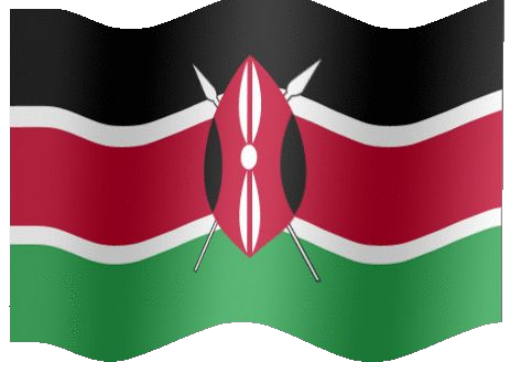
FORENSIC SCIENCE

“forensic science is science used for the purpose of the law”.

WHEN IS FORENSIC SCIENCE REQUIRED?

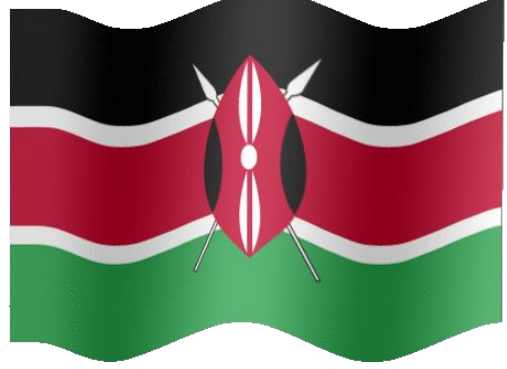
A police officer investigating an incident will seek clarification of three issues:

- Has a crime been committed?
- If so, who is responsible?
- If the responsible person has been traced is there enough evidence to charge the person and support a prosecution?



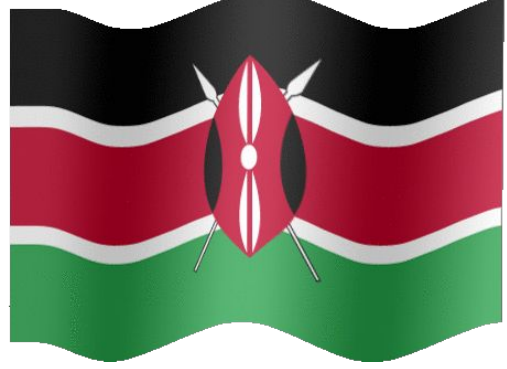
DUTIES OF THE FORENSIC SCIENTIST

- Examine material collected or submitted in order to provide information previously unknown or to corroborate information already available.
- Provide the results of any examination in a report that will enable the investigator to identify an offender or corroborate other evidence in order to facilitate the preparation of a case for presentation to a court.
- Present written and or verbal evidence to a court to enable it to reach an appropriate decision as to guilt or innocence.



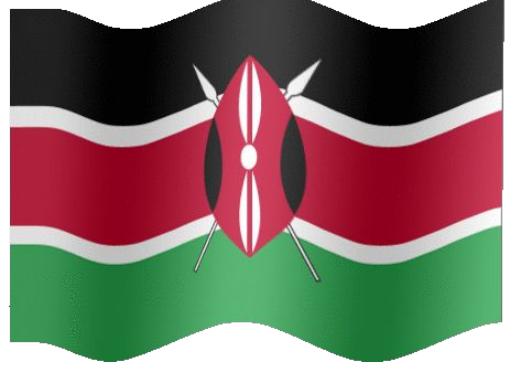
THE VALUE OF PHYSICAL EVIDENCE AND THE CONCEPT OF CHAIN-OF-CUSTODY

- Physical evidence can be anything from massive objects to microscopic items, generated as part of a crime and recovered at the scene or at related locations.
- Physical evidence, when it is recognized and properly handled, offers the best prospect for providing objective and reliable information about the incident under investigation.



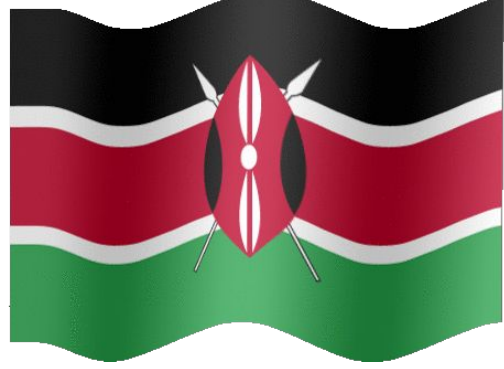
QUALITY AT THE SCENE - LABORATORY CHAIN

- The quality control system must clearly extend outside the laboratory environment and places a responsibility on all involved in an investigation to maintain, as often specified, a chain of custody.
- All involved will need to protect the items from the twin problems of deterioration and contamination.



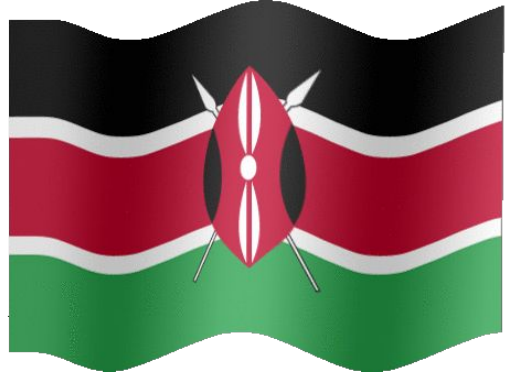
CHAIN OF CUSTODY

- It refers to the chronological and careful documentation of evidence to establish its connection to an alleged crime.
- From the beginning to the end of the forensic process, it is crucial to be able to demonstrate every single step undertaken to ensure “traceability” and “continuity” of the evidence from the crime scene to the courtroom.



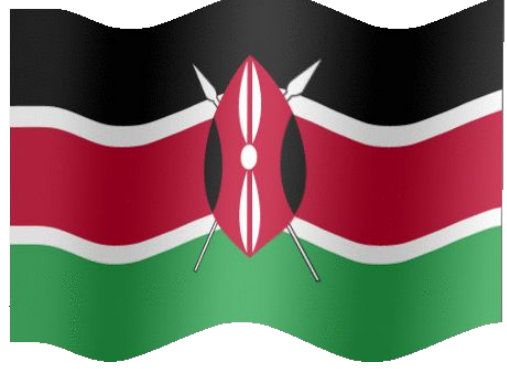
SPECIALITIES IN FORENSIC SCIENCE

Forensic Medicine
Forensic Odontology
Crime Scene Management
Forensic Biology.
Drug Chemistry.
Ballistics
Document Examination
Footwear/Tire Tracks.
Fingerprinting
Forensic Toxicology.
Trace Chemistry.
Forensic Entomology



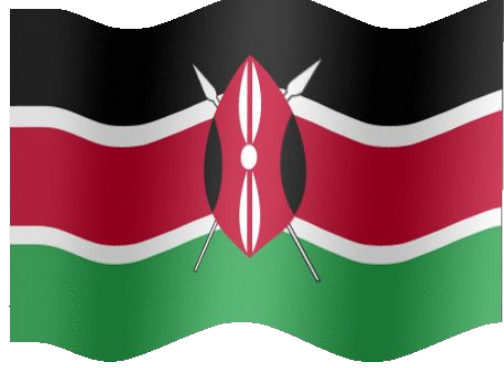
ADVANCEMENT IN FORENSIC SCIENCE

Innovation in forensic science involves the development and testing of new technologies and techniques that improve the scientific foundation of the field and the objective collection, analysis, and interpretation of evidence.

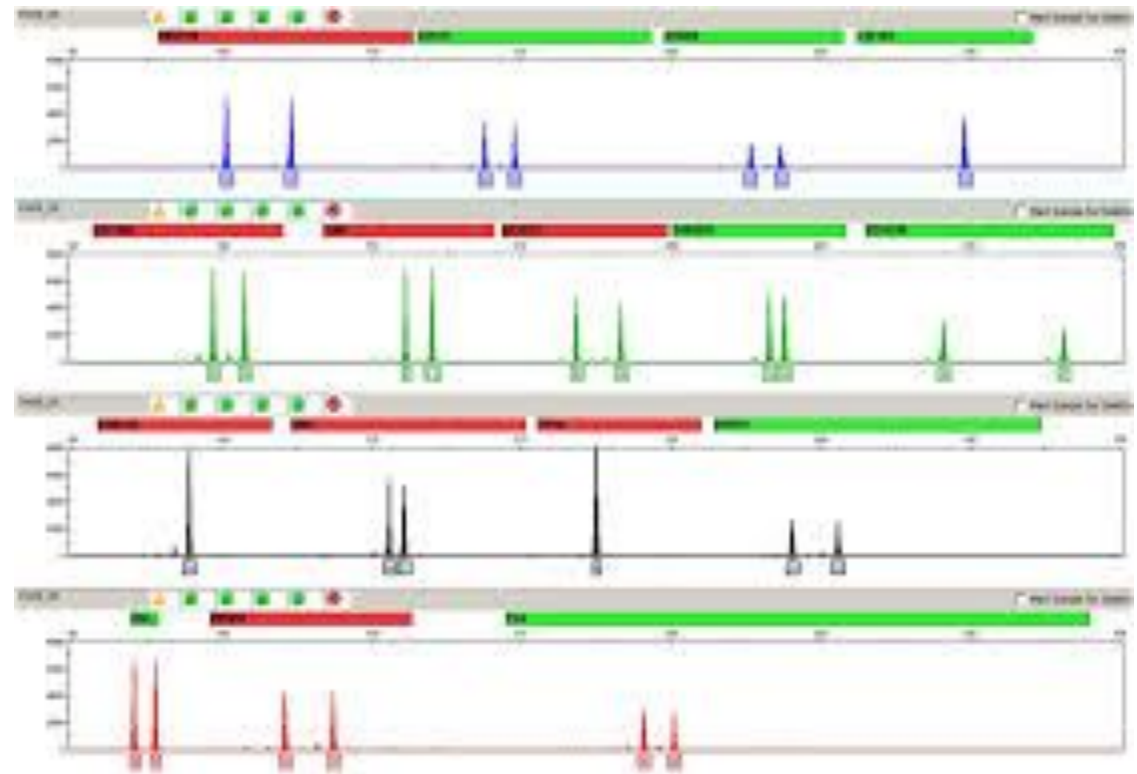
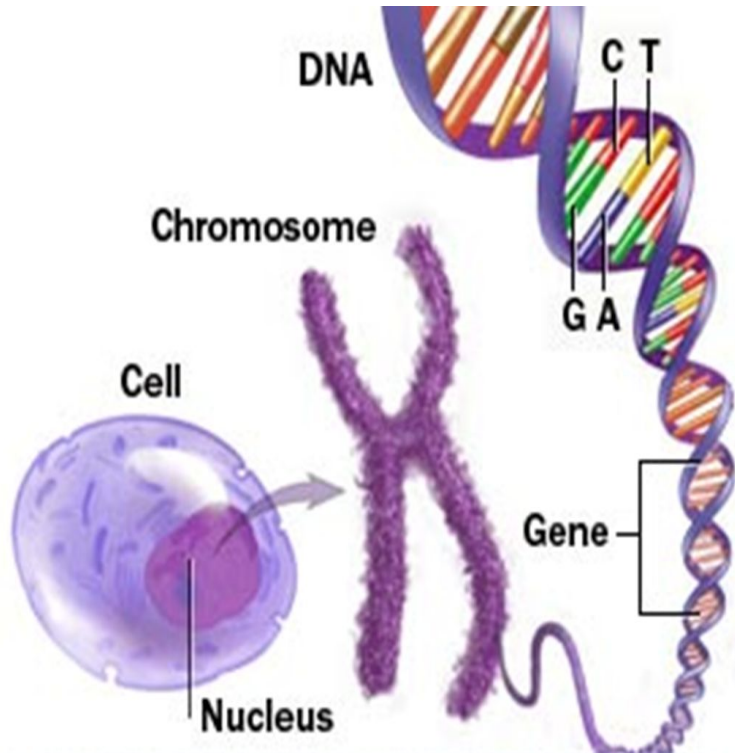


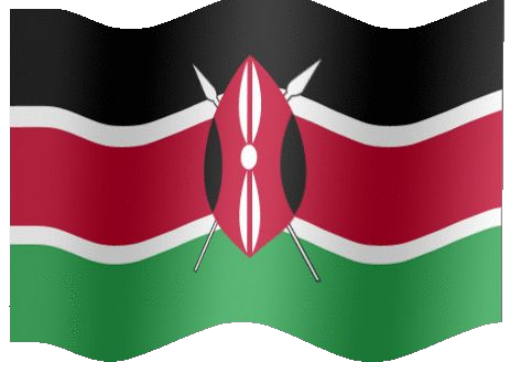
Emerging Technologies And Trends In Forensic Science

Application of cutting-edge technologies such as rapid DNA testing, Next Generation Sequencing (NGS), automated fingerprint and facial identification, cloud forensics, facial reconstruction, alternative light photography, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), Digital Forensics in cybercrime, Forensic nanotechnology and microscopy



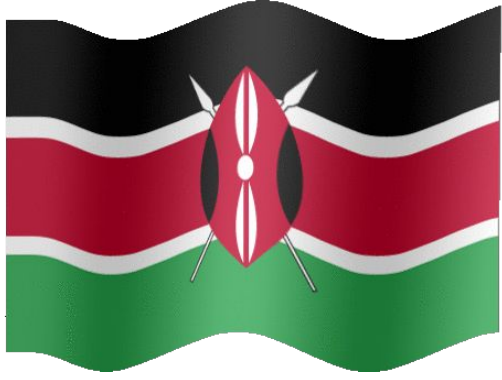
DNA ANALYSIS



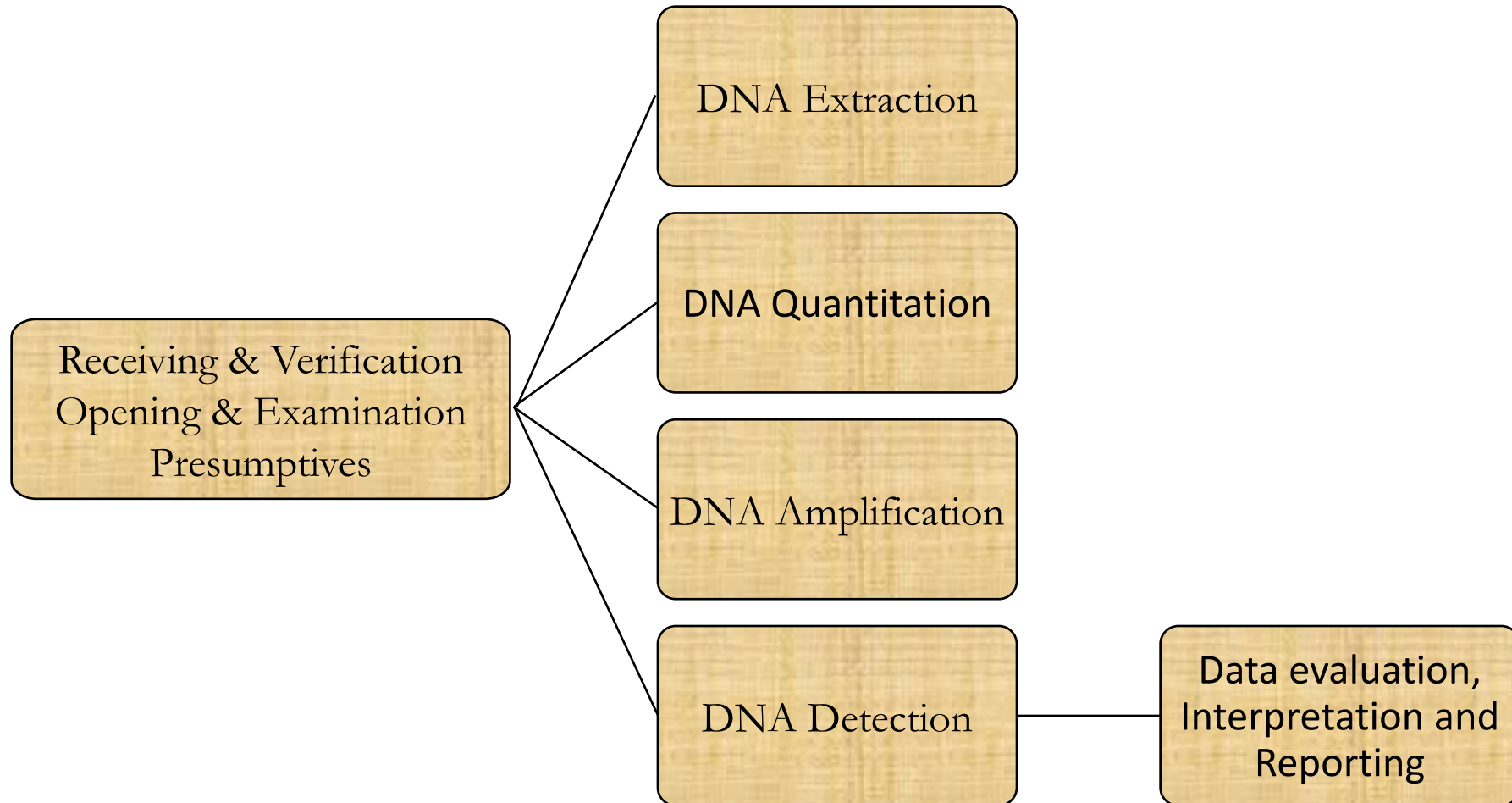


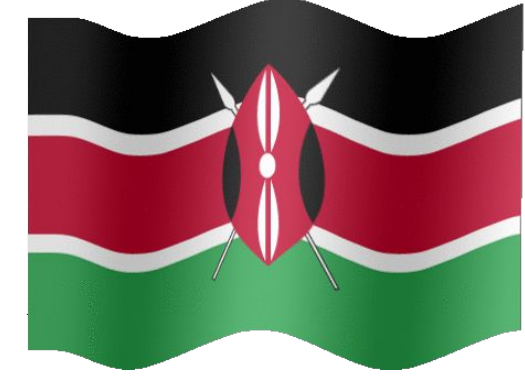
EVOLUTION DNA TECHNOLOGY

- Karl Landsteiner discovered of ABO blood group system in 1900, used extensively in Transfusion and parentage
- Restriction fragment length polymorphism (RFLP) is a technique invented in 1984 by the English scientist Alec Jeffreys
- Kary Mullis invented the PCR technique in 1985 while working as a chemist at the Cetus Corporation, a biotechnology firm in Emeryville, California.



DNA LAB WORK FLOW

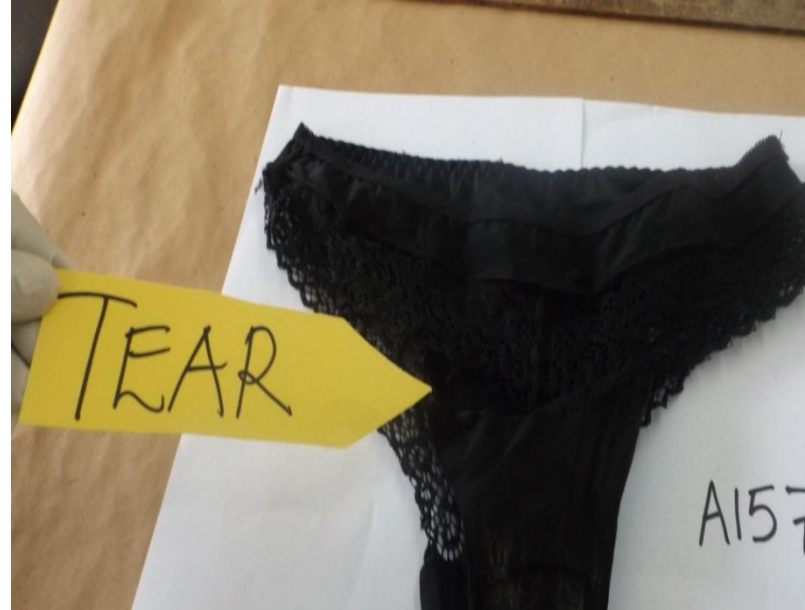
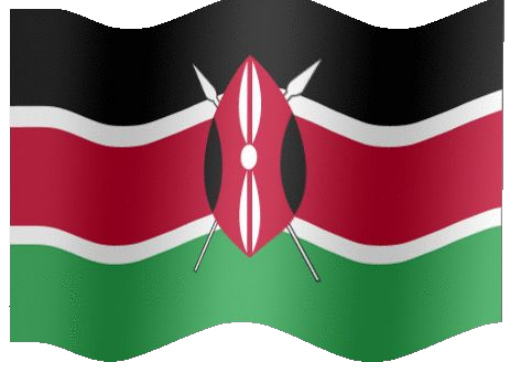


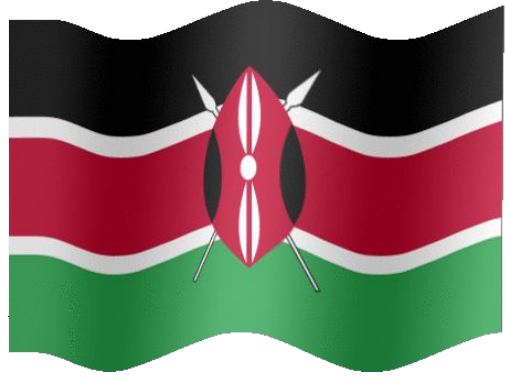


Paternity/ maternity/ Kinship determination

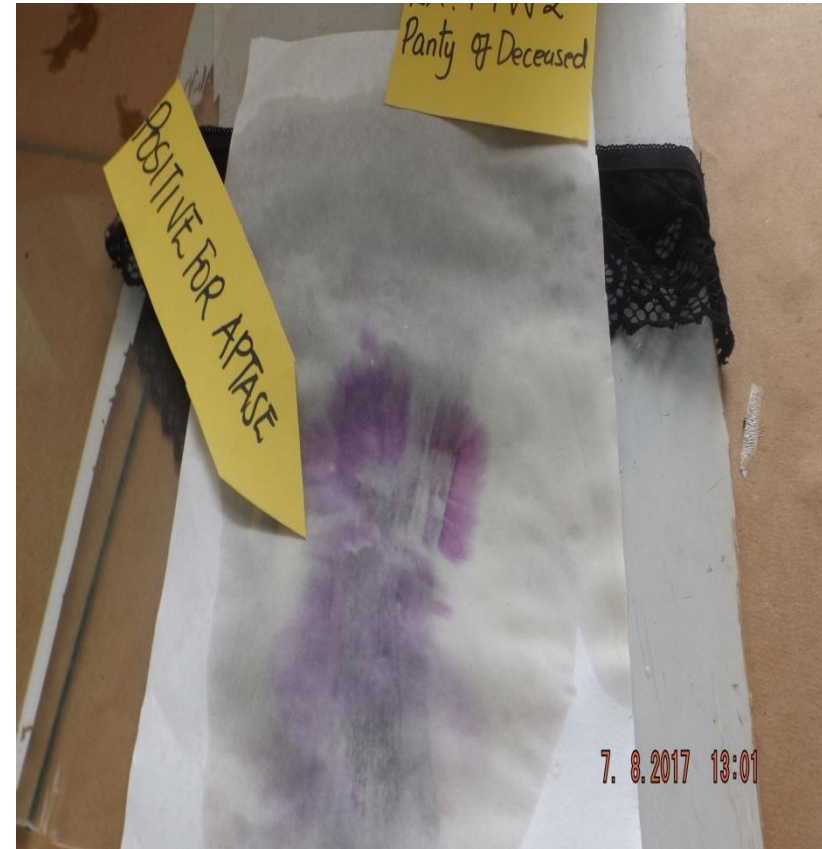


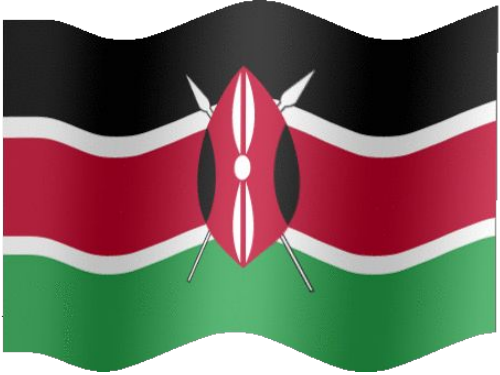
Sexual and gender based violence cases



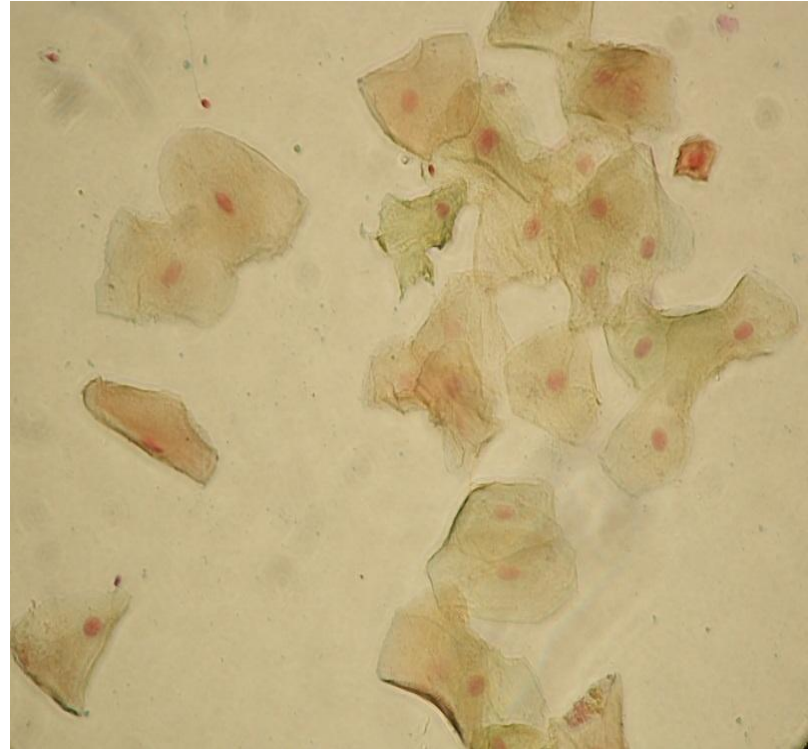
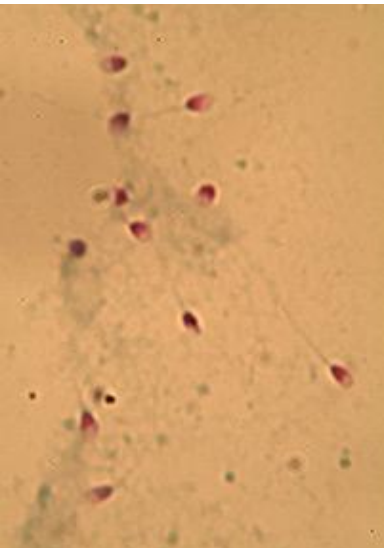
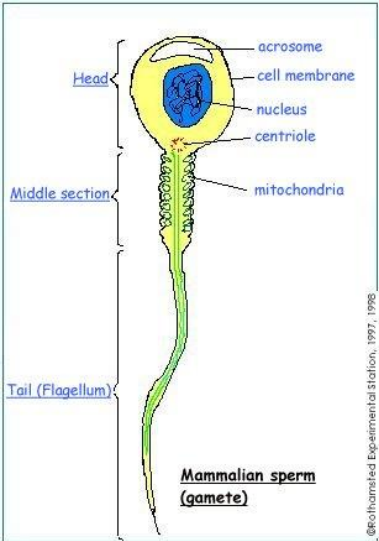


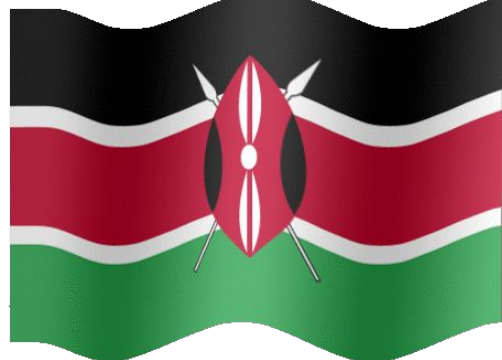
Presumptives



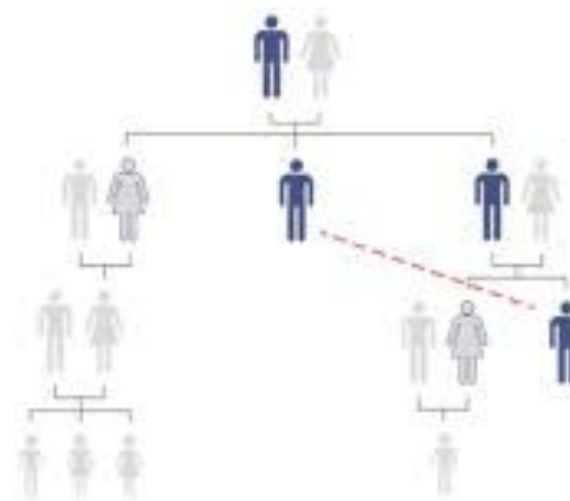
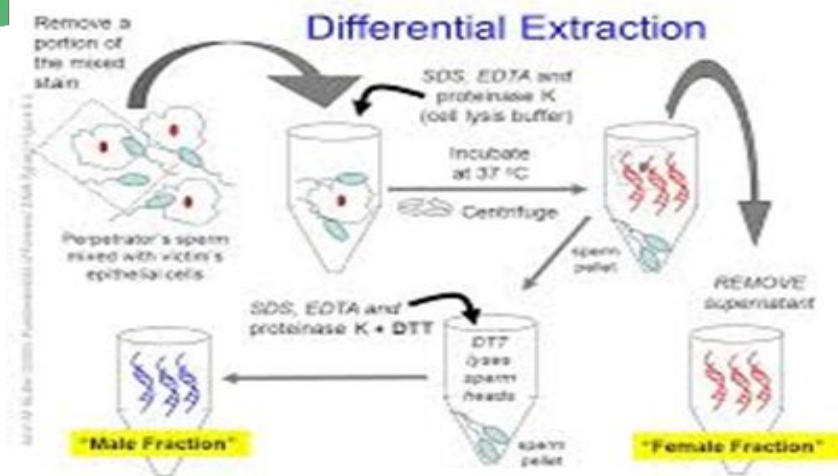


Sperm & epithelial cell microscopy

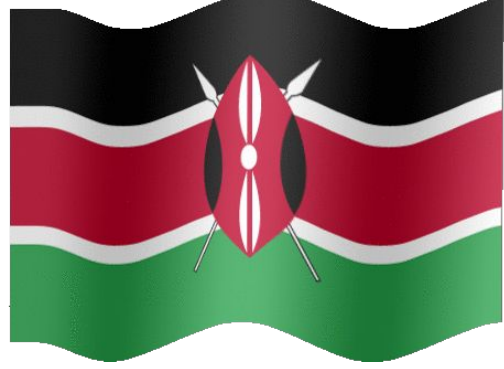




CONFIRMATORY

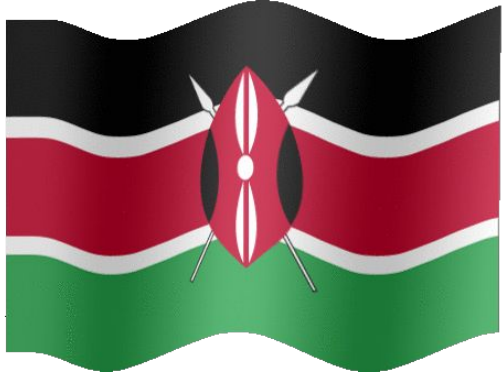


Y-CHROMOSOME

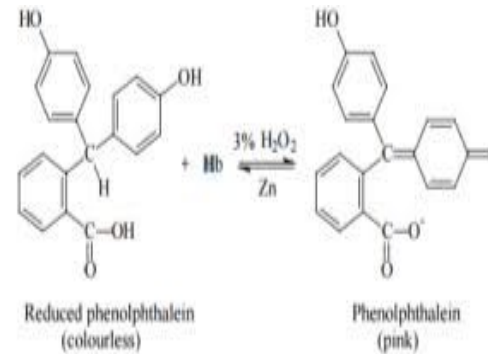


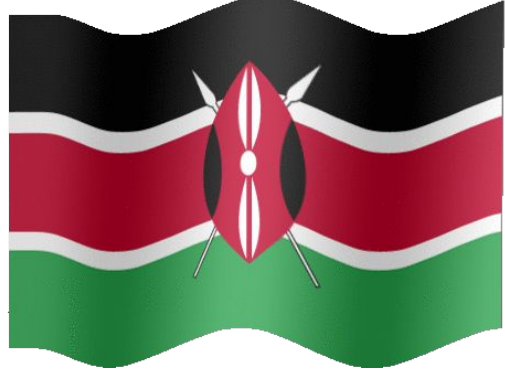
HOMICIDE





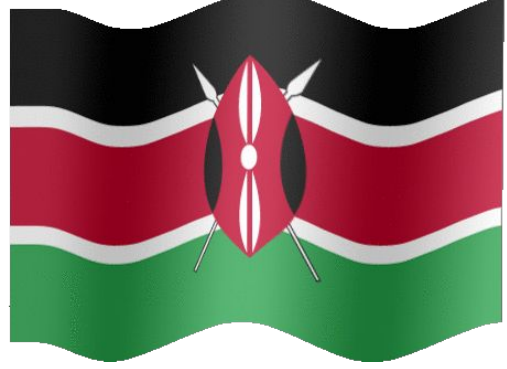
Presumptives and documentation





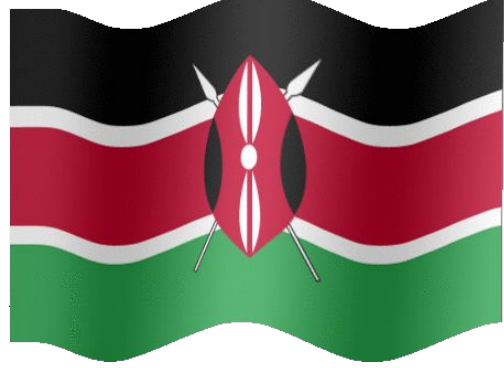
OTHER APPLICATIONS

- Missing persons investigations
- Military DNA “dog tag”
- Exonerations – cold cases, There have been 337 post-conviction DNA exonerations in the United States.
- Genetic genealogy & Kinship



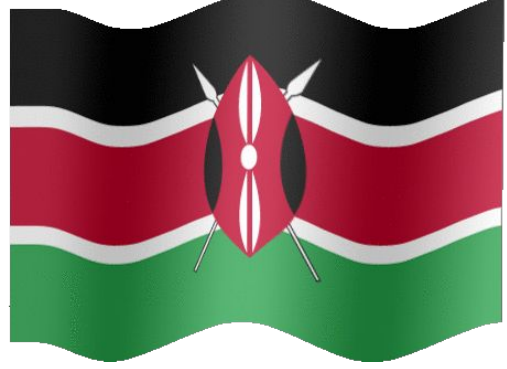
Human identification on mass fatalities and missing persons

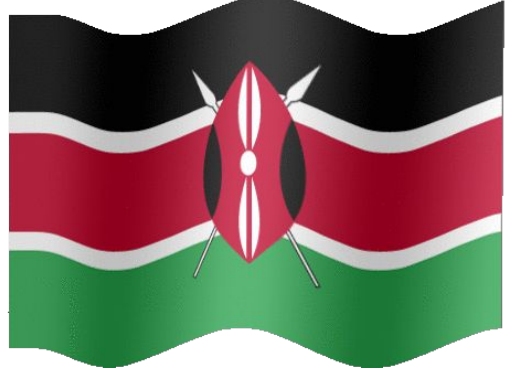




NAIVASHA – KARAI DISASTER



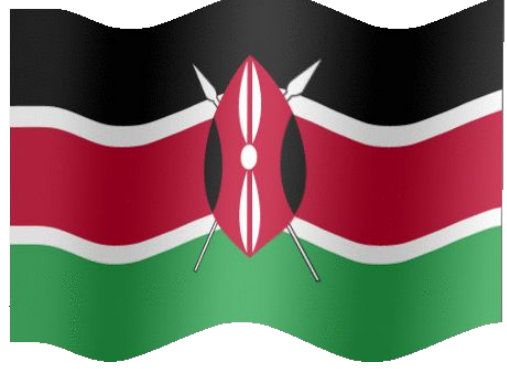




NEW TECHNOLOGIES IN FORENSIC DNA ANALYSIS

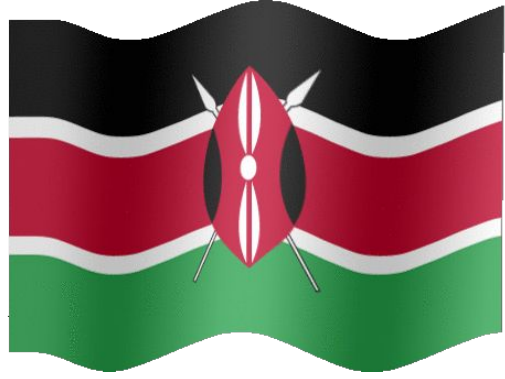
Today, the majority of forensic DNA tests employ PCR and capillary electrophoresis (CE)-based fragment analysis methods to detect length variation in short tandem repeat (STR) markers.





RAPID DNA

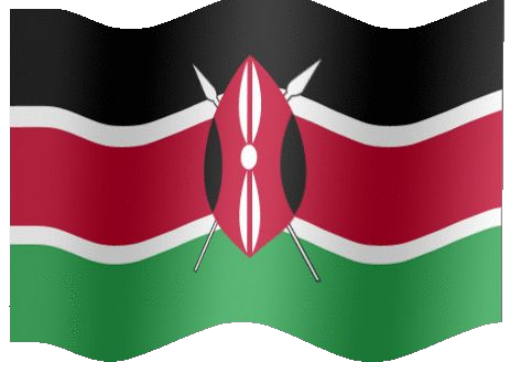




TOUCH DNA

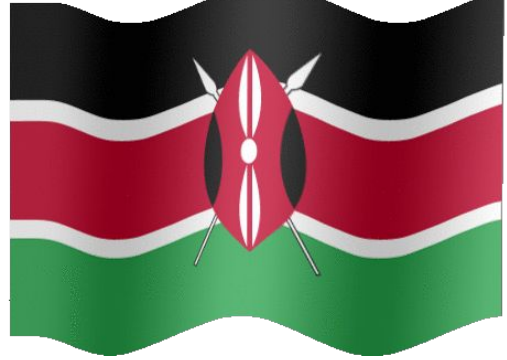
“Touch” DNA refers to the collection of minute biological samples at the crime scene or extracting tiny amounts of material from a sample in a forensic laboratory. Touch DNA” is DNA obtained from shed skin cells and other biological material transferred from a donor to an object or a person during physical contact.



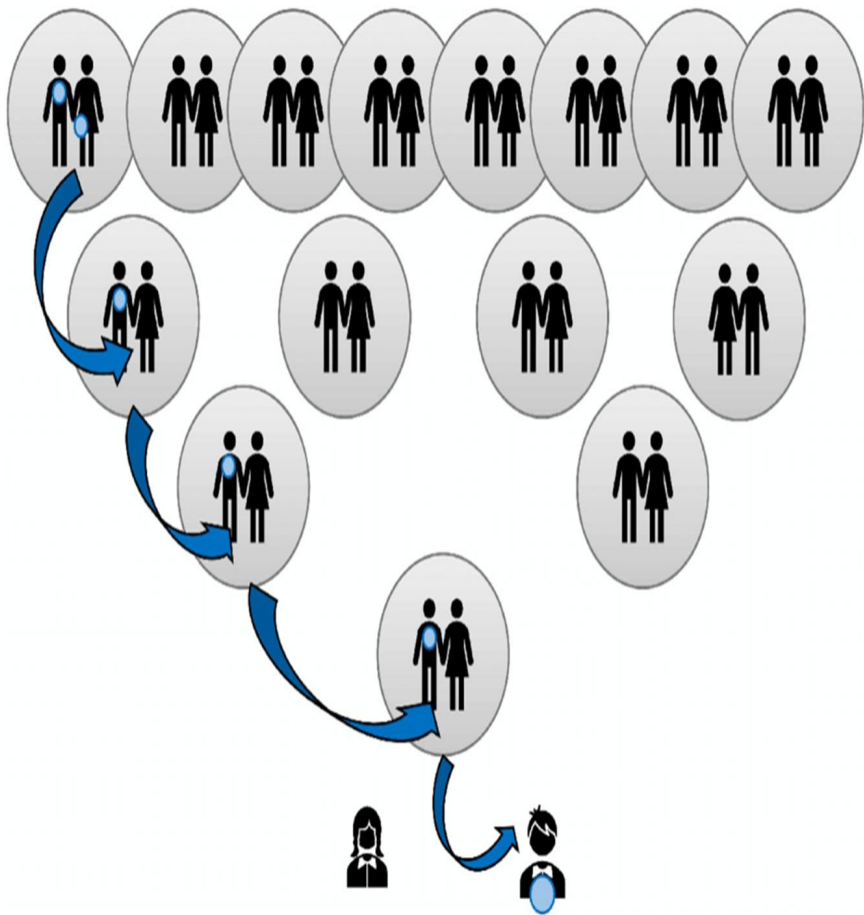


Y CHROMOSOME DNA IN FORENSICS

- Genetic markers on the Y chromosome have assumed a valuable role within forensic molecular biology. Most commonly, Y-STRs are used to unambiguously resolve the male component of DNA mixtures when a high female background is present, or to reconstruct paternal relationships between male individuals.
- Using NGS technology, more than 10 million nucleotides of the Y chromosome were compared between two male individuals who shared the same ancestor 13 generations ago.
- Four genetic differences were detected, suggesting that Y chromosome sequencing could solve the problem of distinguishing between mixed male samples from the same parent

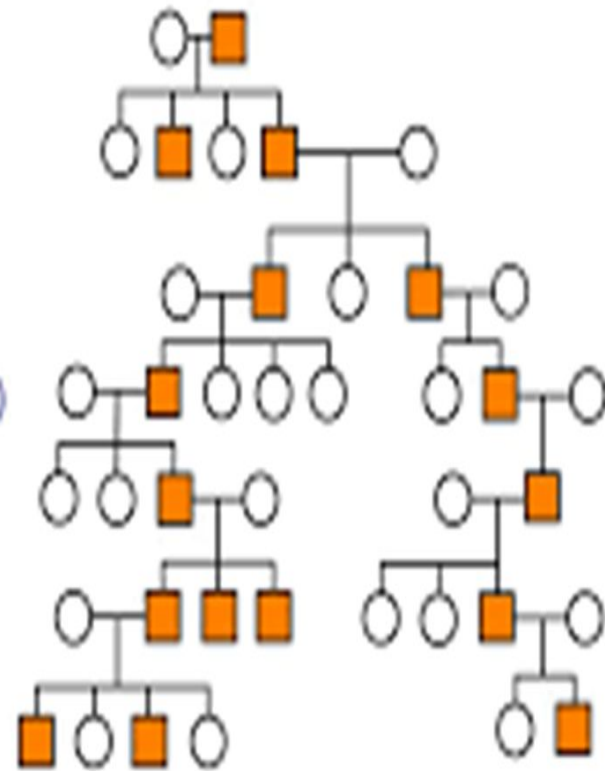


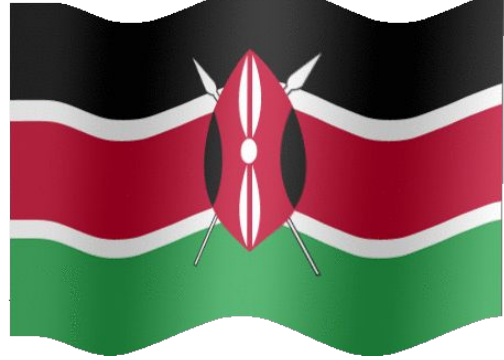
Y CHROMOSOME INHERITANCE



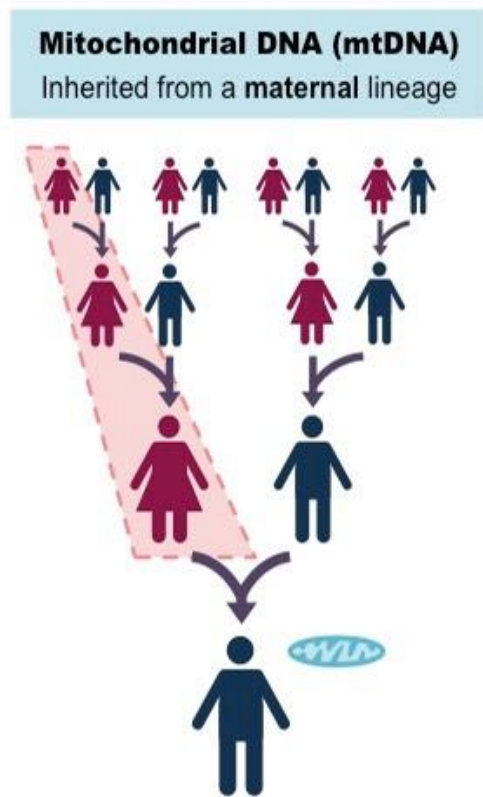
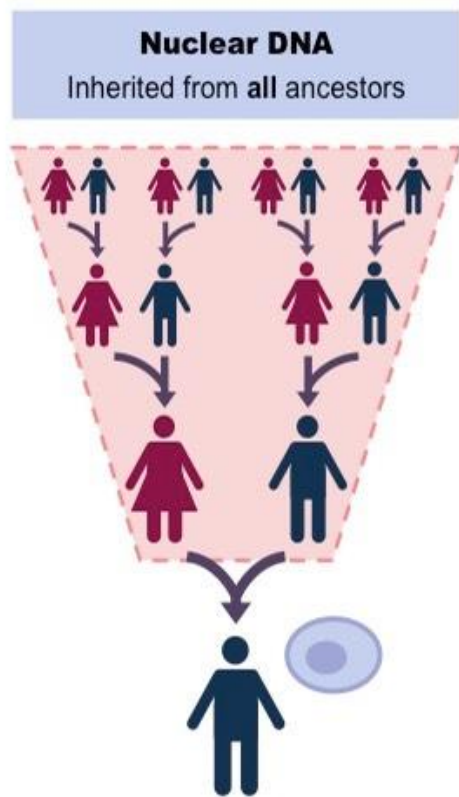
Y-STR DNA

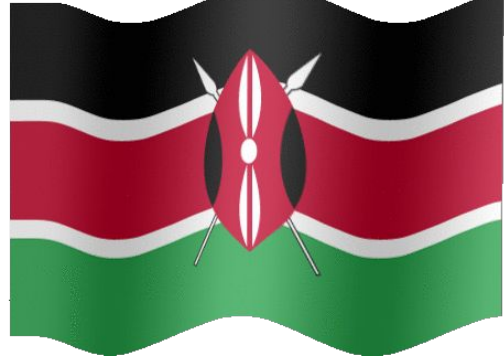
Pedigree
(7 generations)





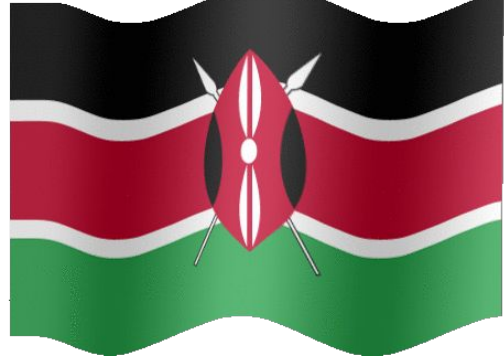
MITOCHONDRIAL DNA





INVESTIGATIVE FORENSIC GENETIC GENEALOGY (IFGG)

- Narrowing down to potential suspects by using ancestry studies and phenotypic inference derived from a DNA sample.
- Use by law enforcement of genetic genealogy combined with traditional genealogy to generate suspect investigational leads from forensic samples in criminal investigations.
- Recently, the technique of finding genetic relatives using commercial databases has been applied to finding the perpetrators of unsolved criminal cases. Identify someone related to the offender
- In the 2004 Madrid train bombings, the explosions killed 193 people and injured around 2,050. Source population of the suspects was inferred by using 34 autosomal SNPs related to the ancestry of population.
- DNA scraped off a toothbrush from the bombed apartment almost certainly belonged to someone of North African ancestry, Conventional DNA testing later confirmed the accuracy of the ancestry test when a relative's DNA in a crime database was matched to Daoud Ouhnane, an Algerian who is suspected of planning the attacks and is still at large. Two other samples were assigned to North Africans, one to a European.



I FAMILIA

DNA kinship matching

Family tree/pedigree

I-Familia

Unidentified bodies or remains

- Autosomal STR profile (up to 25 loci)
- Y-STR and mtDNA optional
- From 1 biological relative (or as many as possible)
- International and national matches reported
- Single manual or automated input / Mass uploads
- Interpretation of potential matches performed by INTERPOL

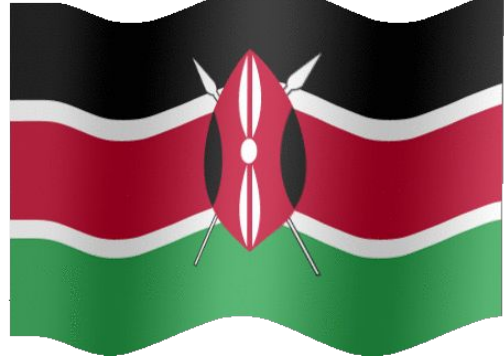
The 3 components of I-Familia

I-Familia DNA database

DNA kinship matching software

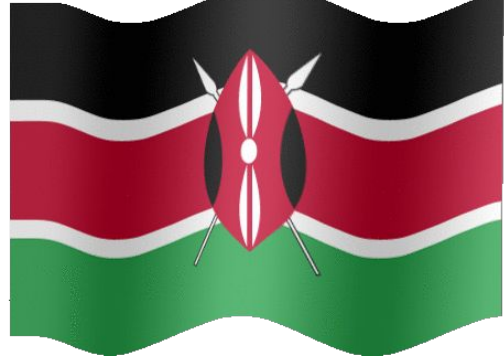
Statistical interpretation

- No criminal DNA data
- No nominal information (only biological relationships, date and DNA profiles)
- Only accessible to the INTERPOL DNA Unit
- Retention period: 5 years for family DNA and 15 years for unidentified human remains
- Compare ante-mortem and post-mortem DNA data
- All pedigrees accepted
- Calculation of likelihood ratio (LR)
- Propose a list of potential biological associations
- Interpretation tables developed by INTERPOL
- Quickly evaluate the statistical relevance of the proposed associations
- Report to countries / Reject / Additional information required



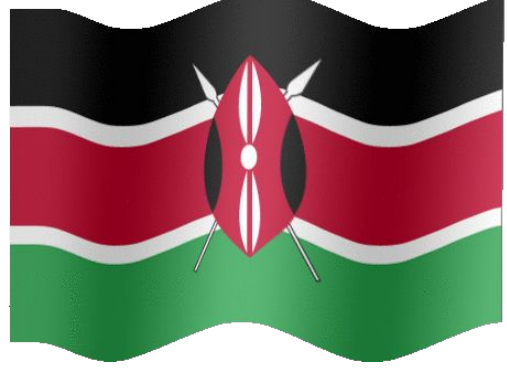
NEXT GENERATION SEQUENCING





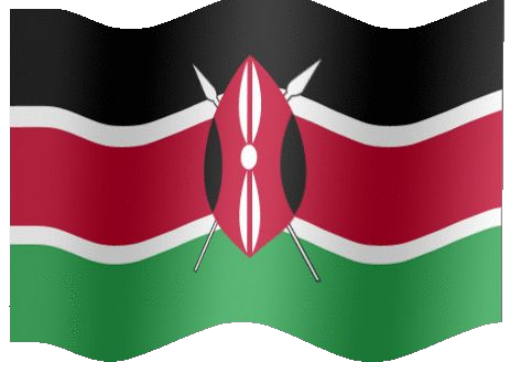
NGS TECHNOLOGY

- In the forensic field, one of the main problems is the limited amount of sample available, as well as its degraded state.
- NGS technologies are going to be crucial for DNA human typing in cases like mass disasters or other events where forensic specimens and samples are compromised and degraded.
- use of NGS has made it possible to achieve the simultaneous analysis of the standard autosomal DNA (STRs and SNPs), mitochondrial DNA, and X and Y chromosomal markers.
- NGS technology can also have potential applications in many other aspects of research. These include DNA database construction, ancestry and phenotypic inference, monozygotic twin studies, body fluid and species identification, and forensic animal, plant and microbiological analyses.



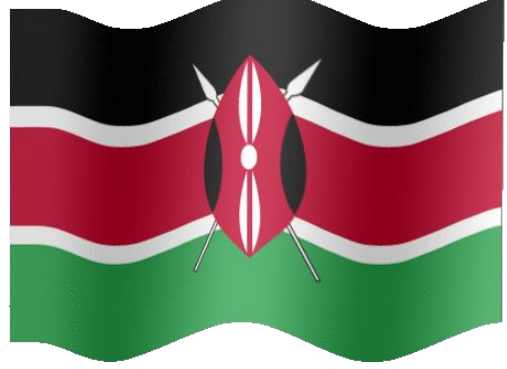
FORENSIC DNA DATABASE

- A centralised database for storing DNA profiles of individuals that enables searching and comparing of DNA samples collected from a crime scene against stored profiles.
- National DNA database is a DNA database maintained by the government for storing DNA profiles of its population.
- They are generally used for forensic purposes which includes searching and matching of DNA profiles of potential criminal suspects
- When a match is made from a national DNA database to link a crime scene to an offender who has provided a DNA sample to a database that link is often referred to as a *cold hit*. A cold hit is of value in referring the police agency



OBJECTIVES OF DNA DATABASES

DNA databases are used in criminal investigations to identify suspects by comparing DNA collected at crime scenes with profiles in the database, locate missing persons, link multiple crimes through matching DNA, and exonerate innocent individuals by proving they do not match DNA evidence.



DATABASES

A DNA database is a collection of stored genetic profiles that can be used for matching DNA from crime scenes, identifying missing persons, or researching genetic diseases. These profiles typically consist of unique genetic markers extracted from an individual's DNA.

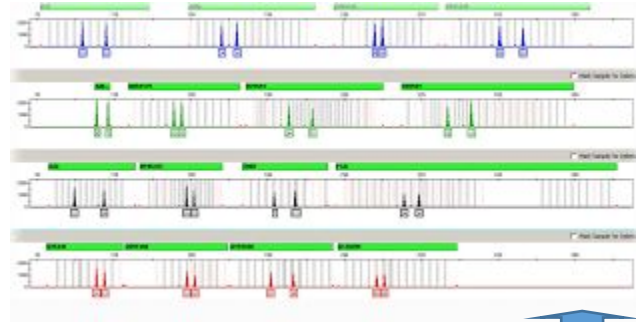
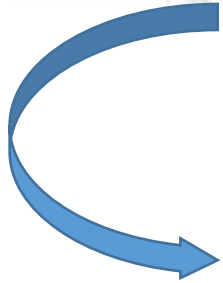
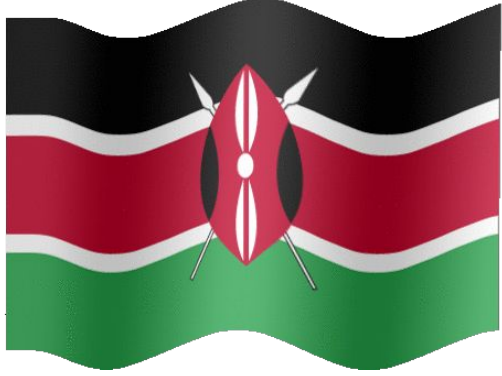
DNA databases operate by collecting and storing genetic profiles derived from samples. These samples can come from diverse sources, including crime scene evidence, convicted offenders, arrestees, and voluntary donors.

Key aspects of DNA databases include:

Genetic Identification: Using unique DNA markers to distinguish individuals.

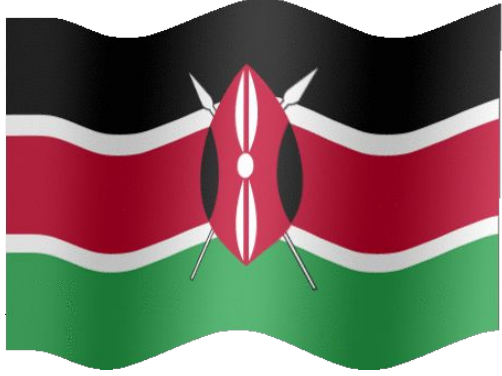
Data Storage: Systematically archiving profiles for future retrieval and analysis.

Privacy and Ethics: Ensuring the responsible use and security of stored genetic data.



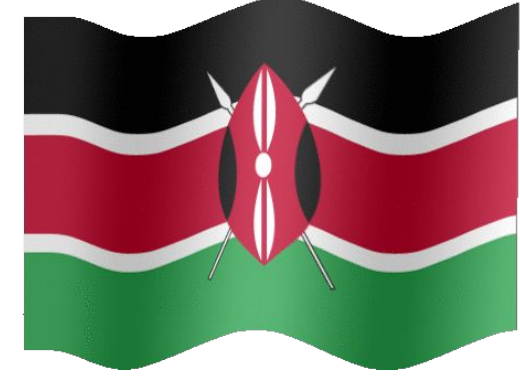
Fazul Abdullah Mohammed





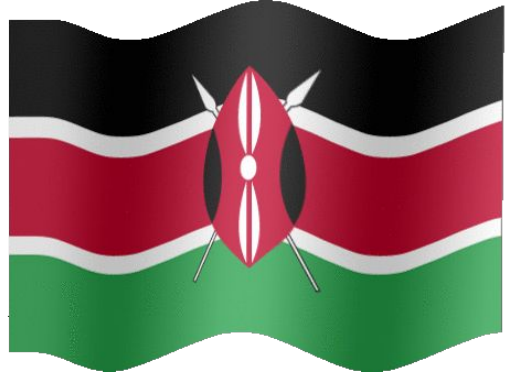
URGENT DATABASE

- Two tourists raped in Ongata Rongai in 2004
- DNA of perpetrator profiled, unknown male
- January 2008, Mugabe Were killed, suspects apprehend and their DNA profiled.
- Main suspect James Omondi alias Castro DNA matches that generated in the 2004 case.



MILESTONE CASES ANALYSED

- Bombolulu dormitory fire (1998) – 26 students charred
- Kyanguli dormitory inferno (1999) – 59 students charred, UN peace keepers buried in Sierra Leone
- Kikambala terrorist attack (2002)
- Mt Kenya air crash (2003)
- Miracle babies saga (2004), Pumwani twin babies saga
- Marsabit helicopter crash (2006) – lost five members of parliament
- Terrorism case involving Fazul (2010/ 2011)
- Liboi helicopter crash (2011), KDF soldiers buried in mass graves in Somalia(2012)
- Identification of remains in West Gate terror attack (2013)
- Sinai fire tragedy
- Garrissa university and Elwak attacks
- Dusit2 terrorist attack
- Naivasha Karai, Moi Girls, Gikomba fire tragedies
- Shakahola Massacre (452 remains), Endarasha fire tragedy (21 victims)



THANK YOU