



Deoxyribonucleic acid (DNA) in crime investigation

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Abstract

DNA forensic laboratory is a laboratory that specializes in the analysis of DNA (deoxyribonucleic acid) for forensic purposes. DNA evidence can be collected from a variety of sources, including blood, hair, skin, and saliva, and can be used to identify individuals, link suspects to crimes, and exonerate the innocent. In a DNA forensic lab, the collected evidence undergoes a number of processes, including extraction, amplification, and analysis, in order to generate a unique DNA profile that can be compared to reference samples. The results of these analyses can be used in criminal investigations, court proceedings, and other legal matters. This paper will be discussing introduction, historical background DNA, types of DNA, problems, challenges, DNA importance, legal framework, DNA solve cases, remove challenges, conclusion.

Keywords: DNA, crime, investigation

Introduction

DNA (Deoxyribonucleic Acid) is a molecule that encodes the genetic information of living organisms. It is composed of four types of nucleotides, which are the building blocks of DNA, and arranged in a specific sequence to form the DNA chain. The sequence of nucleotides determines the genetic information contained in the DNA and controls the development and functioning of cells. DNA is located in the nucleus of eukaryotic cells and in the cytoplasm of prokaryotic cells. DNA replication and protein synthesis are the two main processes through which the information contained in DNA is used. DNA profiling, also known as DNA fingerprinting, is a forensic technique used to identify individuals by analysing their unique DNA patterns. It involves extracting DNA from a sample of blood, saliva, skin, or other tissues, and then comparing the DNA profile obtained from the sample to profiles from other individuals. DNA profiling can be used for various purposes, including criminal investigations, immigration and paternity testing, and identification of missing persons. DNA is widely used in criminal investigations to help identify suspects and solve crimes. DNA analysis can provide strong and reliable evidence that can link a suspect to a crime scene or eliminate someone as a suspect. The following are some of the ways in which DNA is used in criminal investigations:

Crime Scene Analysis

DNA evidence collected from a crime scene can be analysed to identify the suspect and provide a link between the suspect and the crime.

Suspect Identification

DNA samples collected from suspects can be analyzed and compared to DNA evidence collected from the crime scene to determine if the suspect was present at the scene.

Missing Persons Cases

DNA analysis can be used to identify missing persons, including those who have been abducted or are victims of mass disasters.

Cold Cases

DNA evidence from old, unsolved cases can be re-analysed using modern DNA techniques, leading to the identification of suspects and the resolution of the case.

Convicted Offender Databases

DNA samples collected from convicted offenders can be stored in databases, and these databases can be searched for matches to DNA evidence collected from crime scenes.

Historical Background DNA

The discovery and understanding of DNA has a rich and fascinating history that spans over a century.

1869

Swiss chemist Friedrich Miescher first isolated a substance he called "nuclein" from the nuclei of white blood cells.

1928

British biochemist Frederick Griffith performed experiments with *Streptococcus pneumoniae* bacteria that showed that some traits can be transferred from one bacterium to another.

1944

Oswald Avery, Colin MacLeod and Maclyn McCarty confirmed that DNA is the genetic material responsible for the transfer of traits observed by Griffith.

1952

Rosalind Franklin and Maurice Wilkins used X-ray crystallography to study the structure of DNA, providing crucial data for the discovery of its double helix structure.

1953

James Watson and Francis Crick proposed the double helix model of DNA structure based on the data obtained by Franklin and Wilkins.

1965

The genetic code was first deciphered, opening the door for the study of genetics at the molecular level.

1973

The first restriction enzyme was discovered, leading to the development of genetic engineering and recombinant DNA technology.

1977

The first DNA sequencing method was developed, marking the beginning of the Genomic Era.

Problems and Challenges DNA

DNA, being a fundamental part of all living organisms, is susceptible to various problems that can affect its structure and function. Some of the major problems associated with DNA include:

Mutations

Changes in the DNA sequence can lead to mutations, which can cause genetic disorders or increase the risk of developing certain diseases.

DNA damage

DNA can be damaged by various sources, such as exposure to radiation or toxic chemicals, errors during replication, or spontaneous chemical reactions. DNA damage can lead to mutations and other problems if not repaired.

Chromosomal abnormalities

Abnormalities in the structure of chromosomes, such as deletions, duplications, or rearrangements, can lead to genetic disorders.

Cancer

DNA mutations and other genetic changes can lead to the development of cancer, a group of diseases characterized by uncontrolled cell growth and the ability to invade other tissues.

Aging

The accumulation of DNA damage over time can contribute to the aging process and increase the risk of age-related diseases.

Epigenetic changes

Changes in the way DNA is regulated and expressed can lead to epigenetic changes that can affect gene expression and increase the risk of diseases.

Therefore, understanding the problems associated with DNA is essential for improving human health and for addressing various scientific and medical challenges.

DNA, or Deoxyribonucleic acid, is a molecule that contains the genetic instructions for the development and function of all living organisms. Some of the challenges in DNA research include:

Sequencing Complexity

Decoding the complete DNA sequence of an organism is a complex and time-consuming process, particularly for large and complex genomes.

Data Storage and Analysis

DNA data is huge and requires large amounts of storage and computational power to process and analyse.

Ethical and Privacy Concerns

The collection, storage, and use of DNA data raises important ethical and privacy concerns, such as potential misuse of genetic information by insurance companies and employers.

Interpretation of Genetic Information

Interpreting the vast amounts of genetic data generated by DNA sequencing is a significant challenge, as the role and function of many genes remain unknown.

Personalized Medicine

The development of personalized medicine, which tailors medical treatments to an individual's genetic makeup, faces technical, ethical, and regulatory challenges.

Gene Editing

Advances in gene editing technologies, such as CRISPR, bring the potential for both cure and harm, and raise important ethical and social questions about their use.

Types of DNA**Nuclear DNA**

This type of DNA is found in the nucleus of eukaryotic cells and is responsible for encoding the majority of an organism's genetic information. It is organized into structures called chromosomes.

Mitochondrial DNA

This type of DNA is found in the mitochondria of eukaryotic cells and is distinct from nuclear DNA in that it is inherited solely from the mother. Mitochondrial DNA encodes a small portion of an organism's genetic information, primarily involved in energy production.

In addition to these two main types of DNA, there are also other forms of DNA present in cells, including:

Chloroplast DNA

Found in chloroplasts of plant cells and responsible for photosynthesis.

Plasmids: Small, circular pieces of DNA found in bacteria and other microorganisms that can replicate independently of the main chromosome.

Extrachromosomal DNA

DNA found outside of the nucleus in eukaryotic cells, including in the cytoplasm, endoplasmic reticulum, and Golgi apparatus.

The Procedure for DNA Analysis

The procedure for DNA analysis typically involves the following steps:

Sample collection

DNA can be obtained from a variety of biological samples, such as blood, saliva, hair, or skin. The sample is usually collected using a non-invasive method and is processed to isolate the DNA.

DNA extraction

The DNA is extracted from the sample using a variety of techniques, including mechanical, chemical, or enzymatic methods. The goal of DNA extraction is to separate the DNA from other cellular components and purify it.

DNA quantification

The amount of DNA obtained is measured to ensure that there is enough DNA for analysis.

DNA amplification

In some cases, the amount of DNA obtained may be too small for analysis, in which case it needs to be amplified. The most commonly used method of DNA amplification is polymerase chain reaction (PCR).

DNA analysis

Once the DNA has been amplified or quantified, it can be analyzed using a variety of techniques, depending on the type of analysis being performed. These can include DNA sequencing, restriction fragment length polymorphism (RFLP) analysis, and single nucleotide polymorphism (SNP) analysis.

Data interpretation

The results of the DNA analysis are interpreted to generate a DNA profile or sequence that can be compared to other profiles or sequences to identify a match.

There are several methods used for DNA analysis, including**Polymerase Chain Reaction (PCR)**

A widely used technique for amplifying DNA in the laboratory. PCR is useful for generating large amounts of DNA from a small starting sample.

DNA Sequencing

A method for determining the order of nucleotides (A, C, G, T) in a DNA molecule. This can be used to determine the complete DNA sequence of an organism, or to analyse specific regions of DNA.

Restriction Fragment Length Polymorphism (RFLP)

A method for analysing differences in DNA sequences between individuals by cutting the DNA with restriction enzymes and separating the resulting fragments based on size.

Single Nucleotide Polymorphism (SNP) Analysis

A method for identifying single nucleotide changes in DNA sequences that can be used to study genetic variation and disease susceptibility.

Microarray Analysis

A method for analysing the expression of multiple genes simultaneously using DNA microarrays, which are small chips containing hundreds or thousands of DNA probes.

Next Generation Sequencing (NGS)

A high-throughput DNA sequencing technology that can generate large amounts of DNA sequence data in a single experiment.

Gel Electrophoresis

A method for separating DNA fragments based on size by applying an electric field to a mixture of DNA fragments in a gel matrix.

DNA Analysis

DNA analysis is commonly used to solve cases in various fields, including:

Forensic Science

DNA analysis is used in forensic science to identify individuals or to link them to a crime scene. This can be done by comparing DNA samples from a crime scene to DNA samples from suspects or by comparing DNA samples from different crime scenes.

Paternity Testing

DNA analysis is used to determine the biological father of a child by comparing the DNA of the child, the mother, and the alleged father.

Missing Persons

DNA analysis can be used to identify missing persons by comparing their DNA to samples from family members or to DNA databases.

Wildlife Conservation

DNA analysis is used to identify species and to study their population genetics, migration patterns, and relatedness.

Medical Research

DNA analysis is used to study the genetic basis of diseases and to develop new diagnostic tests and treatments.

Agriculture

DNA analysis is used to study the genetics of crops and livestock to improve breeding programs and to develop new varieties with improved characteristics.

Archeology

DNA analysis is used to study the genetics of ancient populations and to reconstruct evolutionary relationships.

Importance DNA

DNA is one of the most important molecules in biology as it contains the genetic information that determines an organism's physical characteristics and traits. The importance of DNA can be summarized in several key points:

Heredity

DNA is responsible for passing genetic information from one generation to the next, which plays a crucial role in the process of heredity.

Diversity

DNA allows for genetic diversity within species, which is essential for the survival and adaptation of populations to changing environments.

Evolution

DNA plays a central role in the process of evolution as it provides the genetic variation that allows populations to adapt to new environments over time.

Diagnosis and Treatment of Diseases

DNA analysis is used in the diagnosis and treatment of many diseases, including genetic disorders, cancers, and infectious diseases.

Agricultural and Environmental Science

DNA analysis is used in agriculture to improve crop and livestock breeding programs and in environmental science to study the genetics of ecosystems and the impacts of human activities.

Forensics

DNA analysis is used in forensic science to identify individuals and to link them to crime scenes, which is crucial in solving crimes and bringing perpetrators to justice.

Personalized Medicine

DNA analysis is used to develop personalized medicine, which takes into account an individual's genetic information to improve the accuracy and effectiveness of medical treatments.

Legal Framework

Indian Evidence Act, 1872

In India, the use of DNA evidence in legal cases is regulated by the Indian Evidence Act, 1872. This act governs the admissibility of evidence in courts of law in India. According to Section 45 of the Indian Evidence Act, the results of scientific analysis, including DNA analysis, are admissible as evidence in court if they are relevant to the case and if they have been conducted in accordance with established scientific principles and techniques. However, the Indian Evidence Act does not specifically mention DNA evidence or provide detailed guidelines for its use in legal proceedings.

The DNA Technology (Use and Application) Regulation Bill, 2019

In India, the use of DNA evidence in legal cases is governed by the DNA Technology (Use and Application) Regulation Bill, 2019. This bill provides for the regulation of the use of DNA technology for identification of individuals in legal proceedings, including criminal investigations and civil matters such as paternity disputes. The bill establishes a National DNA Data Bank and several regional DNA data banks, which will maintain DNA profiles of individuals for use in forensic investigations. The bill also lays down guidelines for the collection, analysis, and storage of DNA samples, as well as the accreditation of DNA laboratories. The bill aims to establish a legal framework for the use of DNA technology in India and to ensure that DNA evidence is used in a manner that is reliable, ethical, and in accordance with the principles of justice and privacy.

DNA Cases

The use of DNA evidence in judicial cases in India has helped to improve the accuracy and reliability of investigations and has played a crucial role in providing justice to victims and their families. However, it is important to ensure that DNA evidence is collected, handled, and analysed properly to avoid contamination and ensure the accuracy of results.

In India, DNA evidence has been used in various criminal and civil cases in the courts to provide scientific evidence in support of prosecution or defence cases. The use of DNA evidence in the Indian courts has been growing in recent years and has been instrumental in solving many high-profile cases. In India, the collection and analysis of DNA evidence is governed by the DNA Technology (Use and Application) Regulation Bill, 2019, which lays down the guidelines and standards for DNA testing and analysis in India. The bill provides for the establishment of a National DNA Data Bank, which will maintain records of DNA profiles generated in the country. The acceptance of DNA evidence in Indian courts is based on the principles of the Daubert standard, which lays down the criteria for the admission of scientific evidence in court. DNA evidence must be relevant, reliable, and have a scientific basis to be admissible in court. In India, DNA testing is conducted by accredited DNA testing laboratories, and the results of DNA tests are recognized by the courts as admissible evidence. The use of DNA evidence in the Indian courts has increased the accuracy and reliability of investigations and has helped to provide justice to victims and their families.

In India, DNA evidence is used to solve various types of cases, including criminal investigations, paternity disputes, and missing persons cases. The use of DNA technology has greatly increased the efficiency and accuracy of solving these cases, as DNA evidence can provide strong and reliable links between individuals and crime scenes or between biological parents and their children. For example, in criminal investigations, DNA evidence can be collected from crime scenes and compared to the DNA profiles of suspects or individuals of interest to determine their possible involvement in the crime. In paternity disputes, DNA analysis can be used to determine the biological relationship between a child and an alleged father. In missing person's cases, DNA analysis can be used to identify remains or to match missing individuals with their relatives.

In India, DNA evidence is used in courts of law as a means of establishing guilt or innocence, as well as to resolve other legal issues. The use of DNA evidence has greatly improved the administration of justice in India, and it continues to play an increasingly important role in solving cases and establishing the truth. These are just a few examples of the many cases where DNA evidence has played an important role in resolving legal disputes and establishing the truth in India. The use of DNA technology has greatly improved the accuracy and efficiency of the legal system and has helped to bring justice to many individuals and families.

N.D. Tiwari Case

In India, DNA evidence has been used in a variety of legal cases, including criminal investigations, paternity disputes, and missing persons cases, among others. Some of the notable cases where DNA evidence has played a key role are: The N.D. Tiwari paternity case, where a young man claimed to be the biological son of former Chief Minister N.D. Tiwari, and the dispute was resolved through DNA testing. The N.D. Tiwari case was a high-profile paternity dispute in India that was resolved through DNA testing. N.D. Tiwari was a former Chief Minister of the Indian state of Uttarakhand and a veteran politician. The case was initiated by a young man named Rohit Shekhar, who claimed to be Tiwari's biological son. To prove his paternity claim, Rohit Shekhar underwent a DNA test, which showed

that he was biologically related to N.D. Tiwari. The results of the DNA test were admitted as evidence in court, and the court ruled in favor of Rohit Shekhar, recognizing him as Tiwari's biological son. The N.D. Tiwari case was significant because it showed the importance of DNA evidence in resolving paternity disputes in India and demonstrated the efficacy of DNA technology in establishing biological relationships. The case also highlighted the role of DNA evidence in bringing to light the truth in sensitive and high-profile legal cases.

The Jessica Lal Murder Case

The Jessica Lal murder case was a high-profile criminal case in India where DNA evidence played a crucial role. Jessica Lal was a model and bartender who was murdered in 1999 at a party in Delhi. The case gained national attention due to the high-profile nature of the accused and the initial lack of progress in the investigation. Several years after the murder, DNA evidence was collected from the crime scene and used to link the accused, Manu Sharma, to the crime. The DNA evidence was instrumental in securing a conviction and bringing justice for Jessica Lal and her family. The Jessica Lal murder case is notable because it highlights the importance of DNA evidence in criminal investigations and demonstrates the efficacy of DNA technology in solving even complex and challenging cases. The case also helped to bring attention to the need for more robust and modern forensic technologies in India, which have since been developed and improved.

The Aarushi Talwar Murder Case

The Aarushi Talwar murder case was a high-profile criminal case in India that involved the murder of 14-year-old Aarushi Talwar and her domestic helper Hemraj Banjade in 2008. The case generated significant media attention and public interest due to the brutal nature of the murders and the involvement of the victim's parents as the prime suspects. DNA evidence was collected from the crime scene and analysed as part of the investigation. The DNA results were used to link the accused, Aarushi's parents, to the crime and to provide evidence of their involvement in the murders. However, the case was highly controversial and the evidence was disputed. Despite the DNA evidence, the case remained unsolved for many years, and the accused were eventually acquitted due to a lack of conclusive evidence. The Aarushi Talwar murder case highlights the challenges and limitations of using DNA evidence in criminal investigations, particularly in cases where there is significant public interest and media scrutiny. The case also highlights the need for careful and thorough investigation, as well as the importance of following established scientific protocols and standards when collecting and analysing DNA evidence.

The Sohrabuddin Sheikh Encounter Case

The Sohrabuddin Sheikh encounter case was a high-profile criminal case in India involving the alleged extrajudicial killing of Sohrabuddin Sheikh, a suspected criminal, by police officers in 2005. The case generated widespread public attention and controversy due to the nature of the encounter and the involvement of senior police officers and politicians. DNA evidence was collected from the remains of Sohrabuddin Sheikh and analysed as part of the investigation. The DNA results were used to identify the

remains and to provide evidence of the death of Sohrabuddin Sheikh. The DNA evidence was considered important in establishing the identity of the victim and in bringing to light the truth about the alleged encounter killing. The case led to a number of arrests and convictions of police officers and politicians, including some senior officials. The Sohrabuddin Sheikh Encounter case highlights the importance of DNA evidence in criminal investigations and in providing evidence in cases of human rights abuses and extrajudicial killings. The case also demonstrates the role of DNA technology in uncovering the truth and bringing justice in sensitive and high-profile legal cases.

Nirbhaya Rape Case

The Delhi gang rape case, also known as the Nirbhaya case, was a high-profile criminal case in India involving the brutal gang rape and murder of a young woman in 2012. The case generated widespread public outrage and led to significant changes in Indian laws related to sexual assault and violence against women. DNA evidence was collected from the crime scene and from the victim's body and was analysed as part of the investigation. The DNA results were used to link the accused to the crime and to provide evidence of their involvement in the rape and murder.

The DNA evidence was considered crucial in securing the conviction of the accused and in bringing justice for the victim and her family. The case also brought attention to the need for more robust and efficient forensic technologies in India, and led to improvements in the collection and analysis of DNA evidence in criminal investigations. The Delhi gang rape case highlights the importance of DNA evidence in criminal investigations and in providing strong evidence of guilt in cases of sexual assault and violence. The case also demonstrates the need for continued efforts to improve and reform the criminal justice system in India, particularly in cases involving violence against women.

Removing DNA from a sample can be a challenging process

Removing DNA from a sample can be a challenging process, and there are several factors that can impact the success of DNA removal. Some of the challenges include:

Sample Contamination

DNA can be easily contaminated by other sources, such as skin cells, hair, or clothing fibres, making it difficult to obtain a pure DNA sample.

Sample Type

The type of sample being analysed can impact the success of DNA removal. For example, plant tissue or blood samples may contain compounds that can interfere with DNA extraction.

Quantity and Quality of DNA

The quantity and quality of DNA in a sample can impact the success of removal, as low amounts of degraded DNA can be difficult to isolate and purify.

Method of DNA Extraction

The method used for DNA extraction can impact the success of removal, as different methods may be more or less effective depending on the type and condition of the sample.

Interfering Substances

Interfering substances, such as salts, detergents, or inhibitors, can impact the success of DNA removal and may need to be removed or neutralized before extraction.

Conclusion

DNA profiling is a powerful tool for forensic science and has revolutionized the way crimes are investigated and solved. DNA profiling involves analysing an individual's DNA sample to identify unique genetic markers that can be used for identification purposes. DNA profiling has many applications in forensic science, including identifying suspects in criminal cases, solving missing person's cases, and establishing paternity or maternity relationships. The use of DNA profiling has increased the accuracy and reliability of investigations, providing a more scientifically rigorous approach to criminal investigations. However, the use of DNA profiling also raises some concerns about privacy and ethical issues, as well as the potential for misuse of DNA information. To ensure that DNA profiling is used appropriately, it is important to have regulations in place to govern the collection, analysis, and use of DNA evidence. Overall, DNA profiling is a valuable tool for forensic science and has the potential to play a crucial role in the resolution of judicial cases and the delivery of justice to victims and their families.

References

1. Stuart H James, Jon J Nordby. Forensic Science: An Introduction to Scientific and Investigative Techniques (4th edition), 2019.
2. Robert R Ogle. Forensic Science: Principles and Applications (1st edition), 2014.
3. Keith Inman, Norah Rudin. Forensic Science: Methods and Techniques (3rd edition), 2018.
4. Watson, Crick's. "A Structure for Deoxyribose Nucleic Acid" Journal Nature, 1953.
5. Linus Pauling, Robert B Corey's. "A Proposed Structure for the Nucleic Acids" (1951), Journal Proceedings of the National Academy of Sciences of the United States of America, 1951.
6. Rosalind Franklin's. "Studies in Cell Microstructure I. The Technique of and Some Results with X-Ray Analysis of Heterogeneous Systems" Journal Proceedings of the Royal Society B: Biological Sciences, 1952.
7. Lalji Singh, Kumarasamy Thangaraj. "Genetic Variation in India: A Window to the Prehistory and Social Structure of the Indian Subcontinent" the Journal of Biosciences, 2007.
8. Shantha S Kumari, Nayak S. "Association of a Common Polymorphism in the Promoter Region of the XRCC1 Gene with DNA Repair Capacity and Cancer Susceptibility in India" the Journal of Human Genetics, 2007.
9. Megha D Jain, *et al.* "Development and Validation of a Real-Time PCR Method for Quantification of DNA Damage in Human Lymphocytes Exposed to Radiation" Journal of Radiation Research, 2010.
10. Thirumalai S, *et al.* "In Silico Studies on the Structural Characteristics of the Gene Encoding DNA Topoisomerase I in Indian Populations" Journal of Biosciences, 2011.