**DNA POLYMORPHISM – SCIENCE & TECHNOLOGY**

NEWS: DNA Fingerprinting is a necessary tool for varied purposes which uses the DNA uniqueness due to **DNA Polymorphism.**

**WHAT'S IN THE NEWS?**

**DNA Fingerprinting**

1. **Definition**: DNA fingerprinting is a scientific technique used to identify individuals based on their unique genetic profiles.

2. **Process**: It involves analyzing specific DNA sequences, primarily short tandem repeats (STRs), which are highly variable among individuals.

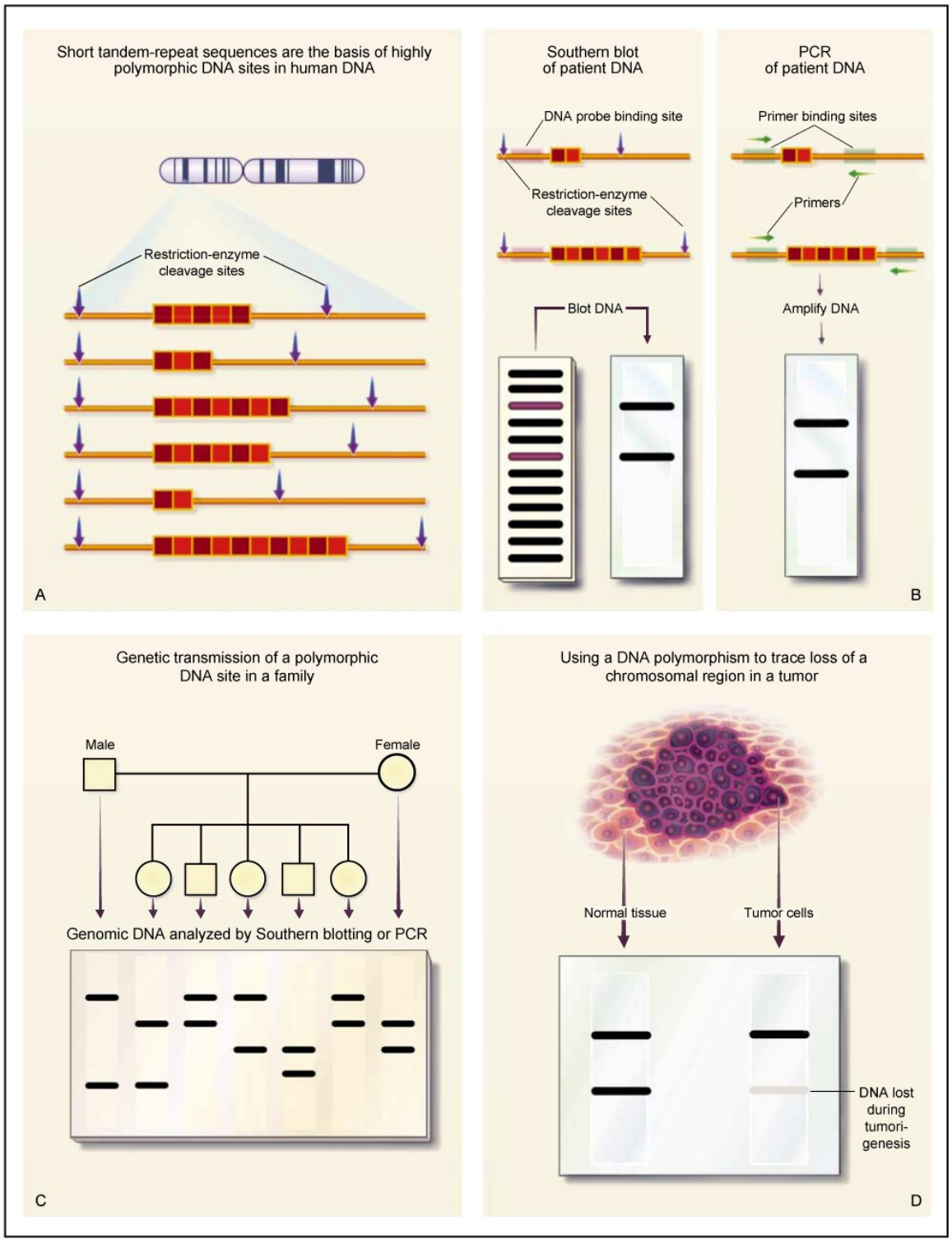
3. **Applications**:

    - Establishing genetic relationships (e.g., paternity testing).
    - Solving criminal investigations by matching DNA from crime scenes.
    - Forensic identification of victims and suspects.

4. **Biological Samples Used**: DNA fingerprints can be obtained from various biological samples, including:

    - Blood
    - Saliva
    - Sweat
    - Semen
    - Skin cells
    - Bones
    - Teeth

5. **Reliability**: DNA fingerprinting is highly reliable since every person (except identical twins) has a unique DNA profile.




## About DNA Polymorphism

1. **Definition**: DNA polymorphisms are small variations in DNA sequences that differentiate individuals from one another.
2. **Inheritance**: These variations arise due to differences in the genetic material inherited from both parents.
3. **Significance**: DNA polymorphisms are crucial for:
    - Tracing ancestry and evolutionary lineage.
    - Identifying individuals in forensic science.
    - Understanding genetic diversity within populations.

**Molecular Basis of DNA Polymorphism**

1. **Sources of Polymorphism**: DNA polymorphisms arise due to mutations such as:
    - **SNPs (Single Nucleotide Polymorphisms)**: Single base changes in the DNA sequence.
    - **VNTRs (Variable Number Tandem Repeats)**: Repeating DNA sequences that vary in number among individuals.
2. **Genetic Impact**: These variations occur in both:
    - **Coding regions** (genes) – affecting protein function and traits.
    - **Non-coding regions** – influencing gene regulation and expression.
3. **Causes**: DNA polymorphisms can result from:
    - Genetic recombination during meiosis.
    - Errors in DNA replication.
    - Environmental influences such as radiation and chemicals.

**Evolutionary Significance of Polymorphic DNA Sequences**

1. **Genetic Diversity**: Polymorphisms contribute to variations within populations, enabling species to adapt to environmental changes.
2. **Natural Selection**: Certain genetic variations may provide survival advantages, influencing evolutionary fitness.

3. **Tracing Ancestry**: Polymorphic DNA sequences help in studying evolutionary relationships among different populations and species.

4. **Disease Susceptibility**: Some genetic variations increase or decrease the risk of diseases, helping in medical research and drug development.

**About Short Tandem Repeats (STRs)**

1. **Definition**: STRs are repetitive DNA sequences where short nucleotide motifs (2-6 base pairs) are repeated multiple times at specific locations in the genome.

2. **Variability**: The number of repeats varies among individuals, making STRs useful for distinguishing genetic profiles.

3. **Role in DNA Fingerprinting**: STR analysis forms the basis of DNA fingerprinting, allowing forensic experts to match DNA samples accurately.

4. **Forensic Application**: STR analysis is widely used in criminal investigations and genetic identification.

**Comparison: DNA Copying (PCR Process) vs. DNA Fingerprinting**

| **Aspect** | **DNA Copying (PCR Process)** | **DNA Fingerprinting** |
|---|---|---|
| **Definition** | A technique to amplify (create multiple copies of) a specific DNA sequence. | A technique to identify individuals based on unique DNA patterns. |
| **Purpose** | Used for research, disease diagnosis, and forensic analysis. | Used for identity verification, paternity testing, and forensic investigations. |
| **Key Process** | Polymerase Chain Reaction (PCR). | STR analysis and Capillary Electrophoresis. |
| **Steps Involved** | - Denaturation (95°C): DNA strands separate.<br>- Annealing (60°C): Primers bind to target DNA.<br>- Extension (72°C): DNA polymerase synthesizes new strands. | - DNA extraction from biological samples.<br>- STR amplification via PCR.<br>- DNA fragment separation via Capillary Electrophoresis.<br>- Creation of a unique DNA profile. |
| **End** | Millions of identical copies of a | A unique DNA pattern (fingerprint) for an |

| Aspect | DNA Copying (PCR Process) | DNA Fingerprinting |
|---|---|---|
| **Product** | specific DNA segment. | individual. |
| **Use in Forensics** | Amplifies DNA from crime scene samples before analysis. | Compares crime scene DNA with suspect DNA. |
| **Use in Medicine** | Used in genetic research and disease detection. | Assists in organ transplant compatibility and hereditary disease identification. |
| **Data Output** | Large quantities of identical DNA for further studies. | A unique STR profile for distinguishing individuals. |

**Applications of DNA Fingerprinting**

1. **Forensic Science**:
    - Used to identify criminals by matching DNA evidence from crime scenes with suspects.
    - Helps solve cold cases and exonerate wrongly accused individuals.
2. **Paternity Testing**:
    - Establishes biological relationships between parents and children.
3. **Disaster Victim Identification**:
    - Helps identify bodies in mass disasters using DNA remains.
4. **Medical Applications**:
    - Used to determine genetic compatibility for organ transplantation.
    - Identifies hereditary diseases by analyzing DNA variations.
5. **Legal and Ethical Use**:
    - Used in court cases involving inheritance disputes, immigration, and criminal justice.

**Ethical and Legal Issues in DNA Polymorphism Studies**

1. **Genetic Privacy Concerns**:
    - DNA data can reveal sensitive personal information, raising concerns about privacy.
2. **Risk of Genetic Discrimination**:
    - Employers and insurance companies may misuse genetic information to deny jobs or coverage.
3. **Informed Consent and Data Ownership**:
    - Questions arise over who owns and controls an individual's genetic information.
4. **Legal Challenges in Forensics**:
    - DNA evidence in criminal cases must be handled carefully to avoid wrongful convictions.
5. **Ethical Concerns in Ancestry Testing**:
    - Ancestry DNA tests may unintentionally reveal sensitive family secrets or mislead individuals about their heritage.

Source: https://www.thehindu.com/sci-tech/science/what-are-dna-polymorphisms-and-how-do-they-differentiate-between-people/article69369159.ece