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Unit 1: Forensic Science: Fundamentals and Legal Framework

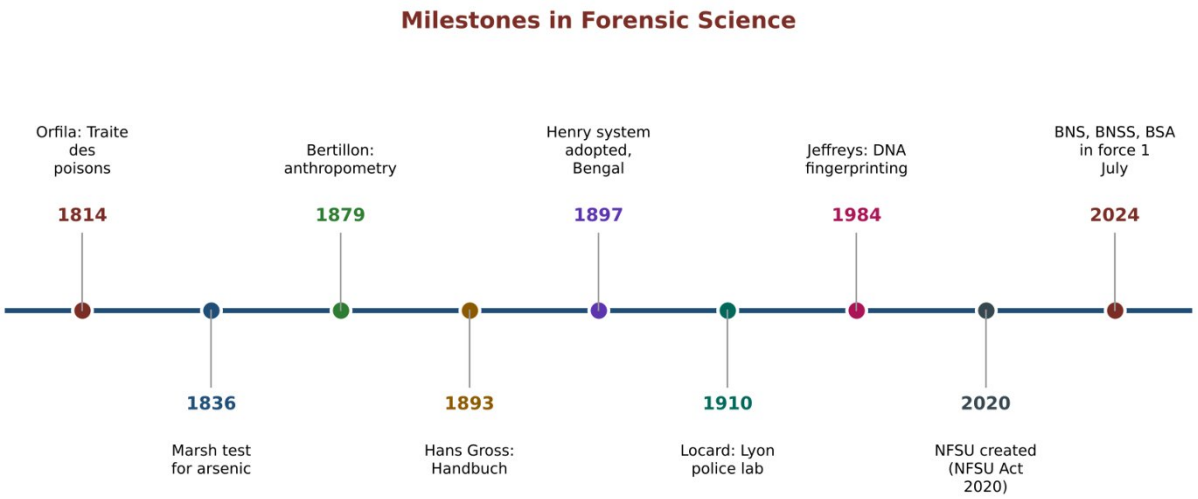
2026 Revision Note: New criminal laws. From **1 July 2024** the Indian Penal Code, 1860 (IPC), the Code of Criminal Procedure, 1973 (CrPC) and the Indian Evidence Act, 1872 (IEA) were replaced by the **Bharatiya Nyaya Sanhita, 2023 (BNS)**, the **Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS)** and the **Bharatiya Sakshya Adhiniyam, 2023 (BSA)**. Old section numbers are kept in these notes because case law and many NET questions still use them; the new equivalent is shown in square brackets the first time a section appears in a topic, e.g. Section 45 IEA [now s. 39(1) BSA], Section 293 CrPC [now s. 329 BNSS]. Offences committed before 1 July 2024 continue to be tried under the old codes.

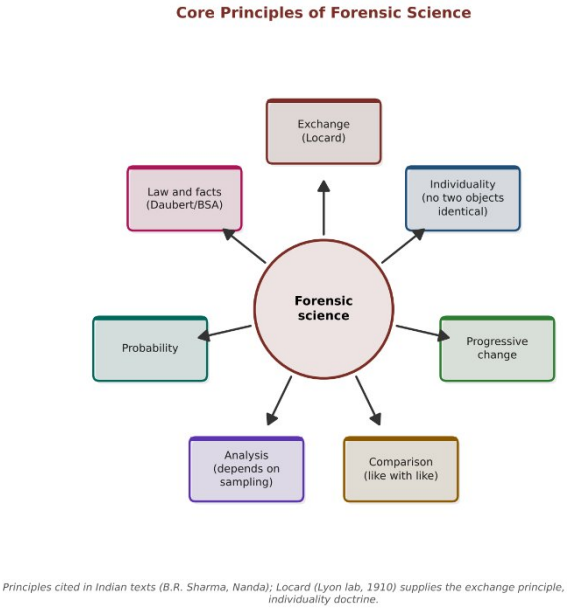
UGC NET/JRF, Assistant Professor, UPSC, State PCS, PGT | Definitive Reference Manual | English Medium

Fundamentals of Forensic Science

Think of **forensic science** as the meeting point of science and law. When a crime happens, this field uses scientific methods — chemistry, biology, physics — to examine physical evidence and help courts decide what truly occurred. It does not prove guilt directly, but provides objective facts that strengthen or weaken a case. Every piece of trace evidence, from a single hair to a tire mark, can become a crucial silent witness.

Etymology & Core Meaning





Principles cited in Indian texts (B.R. Sharma, Nanda); Locard (Lyon lab, 1910) supplies the exchange principle, Kirk (1953) the individuality doctrine.

The word forensic comes from the Latin **"forensis"** meaning "of the forum." In ancient Rome, the forum was the central public space where legal disputes were argued and decided. So literally, forensic science means "science of the forum" — science used in courts and public debate. This root tells you the essence: forensic science is not a pure laboratory discipline; it exists to serve the justice system. Its findings must withstand cross-examination, meet legal standards of admissibility, and assist the trier of fact (judge or jury).

Clear Definition & Scope

Formal definition – Forensic science is the application of scientific principles, methods, and techniques to matters of criminal and civil law, particularly during the investigation of a crime and the presentation of evidence in court.

In simpler words – It is what happens when a biologist, chemist, or physicist puts on gloves and helps a police officer figure out "who, what, when, where, and how" by examining objects left behind.

Scope – Forensic science is not one subject but a family of specialised branches, each dealing with a different type of evidence:

- **Forensic Biology** – analysis of blood, semen, saliva, hair, bones, and other biological fluids; includes DNA profiling.
- **Forensic Chemistry** – identification of unknown substances such as drugs, explosives, accelerants, poisons, and gunshot residue.
- **Forensic Toxicology** – detection and quantification of drugs, alcohol, and poisons in body fluids and tissues; often used in

poisoning or drunk-driving cases.

- **Forensic Anthropology** – study of human skeletal remains to determine age, sex, stature, and cause of death; also helps in identifying victims of mass disasters.
- **Forensic Odontology** – analysis of dental records and bite marks for identification.
- **Forensic Entomology** – study of insect activity on a corpse to estimate time of death.
- **Forensic Ballistics** – examination of firearms, bullets, cartridge cases, and gunshot patterns.
- **Forensic Document Examination** – analysis of handwriting, signatures, ink, paper, and alterations.
- **Digital Forensics** – recovery and examination of data from computers, phones, and digital storage devices.
- **Forensic Psychology** – assessment of criminal behaviour, competence to stand trial, and eyewitness memory.

Exam point – UGC NET often asks to match a branch with its description or to identify which branch deals with a specific type of evidence (e.g., bone analysis → anthropology).

Historical Evolution

Forensic science did not appear overnight. It evolved slowly as both science and law matured.

Ancient roots – The earliest recorded use of forensic-like reasoning comes from China (circa 1248 CE): a book called Hsi Duan Yu ("The Washing Away of Wrongs") described how to distinguish drowning from strangulation by examining the lungs and throat. In ancient Rome, the physician Antistius examined Julius Caesar's body and concluded that among 23 stab wounds, only one had been fatal — a primitive autopsy for legal purposes.

Key milestones in the modern era (19th–20th centuries):

1. Hans Gross (1847–1915) – An Austrian criminal investigator and professor. In 1893, he founded the first **forensic journal** (Archiv für Kriminalanthropologie und Kriminalistik), which published systematic studies of crime scene evidence. He also wrote the seminal book Handbuch für Untersuchungsrichter (Handbook for Examining Magistrates), stressing that investigators must use science to interpret clues. Gross is often called the "father of criminalistics."

2. Edmond Locard (1877–1966) – A French criminologist who established the first dedicated crime laboratory in Lyon, France (1910). He is best known for **Locard's Exchange Principle** (detailed later). His work transformed forensic science from guesswork into a systematic discipline.

3. Other pioneers – Sir Francis Galton (fingerprint classification, 1892), Karl Landsteiner (ABO blood groups, 1901), Sir Alec Jeffreys (DNA fingerprinting, 1984). Each added a new layer of scientific precision.

Development in India – The Indian forensic system grew primarily after independence, though some laboratories existed earlier.

- **1930s** – The first chemical examiner's laboratory was established in Calcutta (Kolkata) for analysis of poisons and narcotics.
- **1950s** – The **Central Forensic Science Laboratory (CFSL)** was set up by the Government of India in Kolkata, later followed by CFSLs in Chandigarh, Hyderabad, and New Delhi. CFSLs handle complex cases referred by central investigating agencies (CBI, NIA).
- **State Forensic Science Laboratories (SFSLs)** – Each state has at least one SFSL, which handles routine crime cases. For example, the Delhi SFSL, the Maharashtra SFSL (Mumbai), and others.
- **National Crime Records Bureau (NCRB)** – Founded in 1986 to compile and maintain a national database of crime statistics and fingerprints (under the Ministry of Home Affairs). It also coordinates the **Central Fingerprint Bureau**.
- **Bureau of Police Research and Development (BPR&D)** – Promotes forensic training for police officers.

Landmark Indian cases that shaped forensic jurisprudence:

- State of Bihar v. Radha Krishna (1971) – The Supreme Court upheld the admissibility of expert evidence on handwriting, but cautioned that it must not be conclusive alone.
- Selvi v. State of Karnataka (2010) – The Supreme Court ruled that narco-analysis, polygraph, and brain-mapping tests violate Article 20(3) (right against self-incrimination) if conducted without the accused's consent.
- State of Punjab v. Baldev Singh (1999) – Laid down guidelines for the admissibility of evidence obtained through search and seizure; emphasised the importance of proper forensic handling.

Major Theories & Thinkers

Locard's Exchange Principle

Core statement – **"Every contact leaves a trace."** In plain English: whenever two objects or persons come into contact, they transfer minute material between them. For example, if you walk across a clean floor, your shoes leave behind dirt or dust, and they pick up fibres or particles from the floor.

What it means for crime – The perpetrator always brings something to the crime scene and takes something away from it. A burglar leaves shoe prints, transfers his sweat, and picks up carpet fibres. The crime scene investigator must locate, collect, and preserve these traces before they are lost.

Three types of transfer:

1. Simple transfer – Direct contact (e.g., handprint on a window).

2. Secondary transfer – Evidence moved from one object to another by a third medium (e.g., fibres from a rug adhere to a shoe, then from the shoe to a car seat).

3. Gradual decay – Traces degrade over time due to environment, handling, or deliberate cleaning.

Exam example – A window is broken. The suspect denies being near the scene. But glass fragments found in his clothing match the refractive index of the broken glass. Locard's principle explains why: contact transferred the glass.

Other Core Principles

Forensic science rests on several fundamental axioms:

1. Principle of Individuality – Every object has unique characteristics that distinguish it from all others. No two fingerprints, no two bullets from the same mould, are exactly alike. The goal of forensic comparison is to demonstrate that two items (e.g., a suspect shoe and a crime-scene print) share a common origin to the exclusion of all others.

2. Principle of Progressive Change – All objects change over time. A body decays, a paint chip weathers, a footprint gets distorted. The forensic scientist must understand these changes to reconstruct the original condition and to date the evidence.

3. Principle of Comparison – The core analytical method: compare known samples (from suspect, victim, or tool) with questioned samples (from the crime scene). The degree of similarity determines the probative value. This principle is applied in fingerprint matching, DNA profiling, ballistics, and document examination.

Ethics in Forensic Science

A forensic scientist's work has enormous consequences. A wrong result can send an innocent person to prison or let a guilty person go free. Therefore, ethics are not optional — they are foundational.

- **Impartiality** – The scientist must remain neutral, not favouring the prosecution or the defence. The duty is to the science, not to the client who pays for the test. In court, expert evidence is admissible under **Section 45 of the Indian Evidence Act, 1872 [now s. 39(1) BSA]** (opinion of experts), but only if the expert is unbiased.
- **Confidentiality** – Case details, personal data, and test results must be kept secure. Breaches can jeopardise the investigation or violate a victim's privacy.
- **Conflict of interest** – A scientist must not take a case where personal relationships, financial interests, or prior involvement in the same case could influence the analysis.
- **Integrity in reporting** – Results must be reported accurately, including limitations and uncertainties. Overstating the strength of a match ("the DNA matches the suspect 100%") is unethical; the correct phrasing is a likelihood ratio or random match probability.
- **Chain of custody** – Every piece of evidence must be documented from collection to court presentation to prevent tampering or allegations of contamination.

Legal maxim – In dubio pro reo (when in doubt, favour the accused) also applies to forensic evidence: if the analysis is ambiguous or contaminated, the benefit must go to the accused.

Development in India (Further Detail)

- **Central Forensic Science Laboratory (CFSL)** – There are seven CFSLs: in Kolkata, Chandigarh, Hyderabad, New Delhi, Guwahati, Bhopal, and Pune. They provide advanced training and analysis.
- **State Forensic Science Laboratories (SFSLs)** – Each state has at least one; some states (like Maharashtra) have regional branches. They handle about 90% of crime-case examinations.
- **National Crime Records Bureau (NCRB)** – Maintains the **Automated Fingerprint Identification System (AFIS)**, the **DNA database**, and the **Crime and Criminal Tracking Network & Systems (CCTNS)**.
- **Directorate of Forensic Science Services (DFSS)** – Under the Ministry of Home Affairs, it oversees policy and coordination among all forensic labs in India.
- **NFSU (National Forensic Sciences University)** – Established in 2020 by merging the Gujarat Forensic Sciences University and the DFSS. It offers degrees and training, and is the nodal university for forensic education in India.

Role in Criminal Justice System

Forensic science does not decide guilt; it provides **scientific evidence** that courts evaluate alongside other evidence. Its roles include:

- **Crime scene investigation** – Collecting, preserving, and packaging physical evidence.
- **Laboratory analysis** – Examining evidence and producing a report (expert opinion).
- **Court testimony** – The forensic analyst may be called as an expert witness under **Section 45, Indian Evidence Act, 1872**. The testimony must be understandable to a non-scientist judge or jury.
- **Corroboration** – Scientific evidence can corroborate or contradict witness testimony, confession, or circumstantial evidence.
- **Exculpation** – Often overlooked: forensic evidence can also exonerate the innocent. DNA testing of older cases (the "Innocence

Project" model) has freed many wrongly convicted people.

Example – In a murder case, the prosecution might have an eye-witness. But forensic analysis of blood spatter patterns and DNA from a cigarette stub could place the accused at the scene with high probability, strengthening the case. Conversely, if the DNA does not match, the defence can use it to create reasonable doubt.

Comparison Table: Branches of Forensic Science

Branch	Focus Material	Typical Analysis	Legal Relevance
Forensic Biology	Blood, semen, saliva, hair, bones	DNA profiling, serology, species identification	Linking suspect to scene/victim; paternity disputes
Forensic Chemistry	Drugs, explosives, accelerants, paint	GC-MS, FTIR, chemical spot tests	Provenance of controlled substances; arson investigation
Forensic Toxicology	Body fluids (blood, urine, vitreous humor)	Drug and alcohol quantification; poison detection	DUI cases; overdose deaths; poisoning
Forensic Anthropology	Human skeletal remains	Age, sex, stature estimation; trauma analysis	Identification of unknown remains; mass disaster
Forensic Ballistics	Firearms, bullets, cartridge cases	Striation matching, calibre determination, gunshot residue	Link gun to crime; range-of-fire estimation
Digital Forensics	Hard drives, phones, cloud data	File recovery, metadata analysis, network logs	Cybercrime; evidence of intent (search history)

Analytical Frameworks & Application

Chain of Custody – A documented chronological record of each person who handled the evidence, from collection to court. It answers the questions: "Who collected it? When? Where? How? Who stored it? Who took it for analysis?" Breaking the chain makes the evidence inadmissible.

Evidence Classification – Forensic evidence is typically divided into:

- **Class evidence** – Can be associated only with a group (e.g., blood type "A" – millions of people share it). Not definitive but can narrow a suspect pool.
- **Individual evidence** – Can be linked to a single source with a high degree of certainty (e.g., DNA profile, fingerprint, bullet striations from one gun barrel).

Bayesian Reasoning – Modern forensic statistics uses Bayesian updating: the strength of evidence is expressed as a likelihood ratio (LR) comparing the probability of seeing the evidence if the suspect is the source versus if a random person is the source. For example, a DNA profile with LR = 1 billion means it is a billion times more likely under the prosecution hypothesis.

Examination Booster Zone

Exam Focus: NET/JRF and Assistant Professor

- **Thinker–Concept pairs frequently tested**:
- Hans Gross → father of criminalistics / first forensic journal (1893)
- Edmond Locard → Exchange Principle (every contact leaves a trace)
- Sir Alec Jeffreys → DNA fingerprinting (1984)
- Sir Francis Galton → fingerprint classification system
- **Dates to commit**:
- 1893 – Hans Gross founds first forensic journal
- 1910 – Locard establishes first crime lab in Lyon
- 1986 – NCRB established in India
- 2020 – NFSU established
- **Answer**: Assertion true, Reason false. The absence of evidence does not prove absence of contact; traces may have been lost or never existed.

PGT & Subjective Focus

- **Write short notes on**: Ethics in forensic science, Chain of custody, Landmark cases on admissibility of scientific evidence.