DIRECTOR OF DISTANCE & CONTINUING EDUCATION

MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI-627012

OPEN LEARNING AND DISTANCE LEARNING (ODL) PROGRAMME

(for those who joined the programmes from the academic year 2023-2024)

B.Sc Chemistry

Course material- NMC –Forensic Science

Course code- JNCH41

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UNIT I: Poisons

Poisons - types and classification - diagnosis of poisons in the living and the dead -clinical symptoms - postmortem appearances. Heavy metal contamination (Hg, Pb, Cd) of seafoods - use of neutron activation analysis in detecting arsenic in human hair. Treatment in cases of poisoning – use of antidotes for common poisons.

Unit-II: Crime Detection

Accidental explosion during manufacture of matches and fireworks (as in Sivakasi). Human bombs - possible explosives (gelatin sticks and RDX)- metal detector devices andother security measures for VVIP-composition of bullets and detecting powder burns.

UNIT-III: Forgery and Counterfeiting

Documents - different types of forged signatures - simulated and traced forgeries -inherent signs of forgery methods - writing deliberately modified - uses of ultraviolet rays - comparison of type written letters – checking silver line water mark in currency notes – alloy analysis using AAS to detect counterfeit coins – detection of gold purity in 22 carat ornaments – detecting gold plated jewels -authenticity of diamond.

UNIT-IV: Tracks and Traces

Tracks and traces - small tracks and police dogs - foot prints - costing of foot prints -residue prints, walking pattern or tyre marks – miscellaneous traces and tracks – glass fracture - tool marks - paints - fibres - Analysis of biological substances - blood, semen, saliva, urine and hair – Cranial analysis (head and teeth) DNA Finger printing for tissue identification in dismembered bodies - detecting steroid consumption in athletes and racehorses.

UNIT-V: Medical Aspects

Aids - causes and prevention - misuse of scheduled drugs - burns and their treatment by plastic surgery. Metabolite analysis using mass spectrum – Gas chromatography-Arson - natural fires and arson - burning characteristics and chemistry of combustible materials - nature of combustion. Ballistics - classification - internal and terminal ballistics - small arms –laboratory examination of barrel washing and detection of powder residue by chemical tests

UNIT I- POISONS & THEIR CLASSIFICATION

Poison: A substance which on ingestion, inhalation, absorption, application or development within the body, may cause structural damage or functional disturbances. Poisonous substance arising from various sources like bacteria (toxins), industrial pollutions, burning of fossil fuels (CO), radionuclide, air pollutants, food and water contaminated with pesticides, viruses, plasticizers etc.

The diagnosis of poisoning is difficult due to various reasons:

1. Usually, patient is unconscious.
2. Conscious patients many times not willing to admit self poisoning.

Classification of poisons:

A. Poisons are classified according to ***their mode of action***. Accordingly, poisons are classified into three main groups. 1. Corrosive 2. Irritants 3. Neurotics

1. **Corrosive:** A corrosive poisons is simply a highly active irritant and not only produces inflammation but also acute ulceration of tissue. Ex:
   a. Strong acids like sulfuric acid, nitric acid, hydrochloric acid
   b. Organic acids like oxalic acid, carbolic acid
   c. Concentrated alkalis like caustic soda, caustic potash and carbonates of sodium, calcium and potassium.
2. **Irritants:** Irritant poisons produce symptoms of pain in the abdomen, vomiting and purging. Corrosive in dilute solutions act as irritants. Ex:
   a. Inorganic:Non-metallic like phosphorus, chlorine, bromine, boron and iodine. Metallic poisons consist of arsenic, antimony, iron, copper, bismuth, mercury, silver and lead.
   b. Organic: Organic poisons can be divided into two types,
      i. Vegetable poisons like castor oil, castor oil seeds, croton oil, colocynth, ergot, marking nut and aloes.
      ii. Animal poisons like cantharides, snake venom, scorpions venom and poisonous insects.
   c. Mechanical: This includes powdered glass chopped hair, sponge and diamond dust.

3. Neurotics:

These poisons primarily act on CNS. The chief symptoms of this type of poisoning include headache, drowsiness, giddiness, delirium, stupor, comma and sometime paralysis. These are classified as,

a. Poisons acting on cerebrum:

These poisons may have a somniferous, inebriant or delirium effect. The somniferous poison includes opium and its alkaloids, the inebriant include alcohol, anaesthetics (ether, chloroform), sedatives and hypnotics (chloral hydrate and barbiturates) and insecticides (organophosphorus compounds, coal tar, insecticides and naphthalene).

The delerius include dhatura, belladonna, hyoscymus and cocaine.

b. Poisons acting on spinal cord:

This include Nux vomica and its alkaloids a gelsemium.

c. Poisons acting on periphery:

Poisons acting on peripheral nerve includes conium and curare.

B. Poisons are classified **according to their effect**

Poisoning may also be classified into

1. Acute poisoning
2. Chronic poisoning

1. Acute poisoning:

Symptoms appear suddenly soon after consumption of the poison. The symptoms rapidly increase in severity and are followed by death or recovery. Poison can be detected in the ingested food, medicine or fluid or vomit, urine, or stool of the victim.

2. Chronic poisoning:

Symptoms develop more gradually. There is an aggravation of symptoms after the suspected food, medicine or fluid is administered. There is remission or even complete disappearance of symptoms on the removal of patient from his usual surroundings. Main symptoms in chronic poisoning are usually malaise, chronic ill health, and increasing cachexia (condition of abnormally low weight, weakness and general bodily decline). Repeated attacks of undiagnosed gastrointestinal irritation should arouse suspicion of homicidal poisoning.

GENERAL PRINCIPLES OF POISONING TREATMENT

The treatment of poisoning should be prompt and drug should be used very carefully. Over treatment of the intoxicated patient with large doses of sedatives or stimulants and antidotes can causes more damage than the poison itself. Other therapeutic measure also play role in saving life of the patients. The steps involved in the treatment of poisoning are,

1. Removal of unabsorbed poison from the system
2. Use of antidote
3. Elimination of the absorbed poison
4. Treatment of general symptoms
5. Maintenance of the patient general condition

1. Removal of unabsorbed poison from the system

a. **Inhaled poisons**:

When poison like carbon monoxide or a gas from septic tank is inhaled by the patient, he must be immediately removed to fresh air. Artificial respiration must be given.

b. **Injected poisons:**

If a poison has been injected, tourniquet must be applied proximal to site of injection. Unabsorbed poison can be removed by means of incision and suction.

c. **Contact poisons**:

If a poison is split or sprayed on skin, eye or wound, or be inserted into vagina, rectum or bladder, it must be washed with plain water. If specific antidote is known, it should be used for neutralizing that poison.

d. **Ingested poison:**

The most important thing is to remove the ingested poison. It can be brought about vomiting and /or by washing the stomach.

Emetics: It can be used to remove poison from stomach by vomiting. Following emetics can be used,

Mustard powder (2-3 teaspoonful) or salt (3 teaspoonful) in a glass full of water, Ipecac (1-2 gm) or ammonium carbonate (1-2 gm) dissolved in water.

Gastric lavage:

In case the patient is in coma, there is a risk of the poison entering inn the bronchial tree. At the time gastric lavage method used to remove the poison. This is a best method as it can be done even above 4-6 hours after the ingestion of poison. The method to perform this is

i. Stomach tube or rayle's tube must pass inside through the mouth.
ii. After checking that the tube is not in the trachea, most of the stomach contents should be removed first by mechanical suction, if available.
iii. After this, first washing with the warm water.
iv. The process is repeated either with warm water or antidote until the retuning fluid becomes clear.
v. When the poison has been removed from stomach, some of the antidote or other suitable solution may be left in the stomach. Ex magnesium sulfate, sodium sulfate, activated charcoal.

General principles of poison treatment are as follows:

1. Stabilization of patient: vital functions like respiration, blood pressure are supported.
2. Removal of the poison from stomach, except where contraindicated: It can be done by administering fluid, then simulating pharynx by figure or using emetics or by gastric lavage.
3. Identification of responsible chemicals by evaluating samples of blood, urine, vomit as early as possible.
4. Symptomatic and supportive therapy by using antidepressants, anticonvulsants, CNS stimulant or non-systemic antidote etc, correction of body fluids.
5. Administration of an antidote if available and known.
6. To hasten removal of absorbed intoxicants from the body.

2. Use of antidotes

Antidotes are substances which oppose the effects of toxicants specifically or nonspecifically. They are mainly classified as: 1. Mechanical 2. Chemical 3. Systemic 4. Universal

i. **Mechanical antidotes**: These are the substances which prevent the absorption of poison by their presence. Ex. Activated charcoal. Useful in adsorbing alkaloidal poisons, fats, oil, egg albumin used for forming coat over the mucus membrane of stomach.

ii. **Chemical antidotes**: These are the substance react with poison to form non-toxic substances. Ex. Magnesium oxide used for neutralizing acids, tannins form insoluble complex with alkaloids.

iii. **Systemic antidotes**: These antidotes act as physiologic or pharmacologic antagonists to specific intoxicants systemically. The commonly used are listed as follows,

S. No	Drug or Toxin	Antidote
1.	Narcotics (Opioids)	Naloxon (0.4-2mg/kg adult, 0.01-0.1mg/kg child)
2.	Organophosphates	Atropine (2mg as needed), Pralidoxine (1gm)
3.	Heavy metals: Hg, Au As; Pb, Zn, Cr, Cu, Cd, Mn, Ni	Dimercaprol BAL (100 mg/ml-10% solution in peanut oil 2.5-3 mg/kg 1M), Calcium Disodium Edetate (20% solution maximum does 50 mg/kg, daily; 1-4 gm/day in four divided doses), penicillamine
4.	Iron	Desferroxamine (10-15 mg/kg/hr for 8 hrs)
5.	Bromide	NaCl
6.	Cyanide	Amylnitrile, Gelatinous pills, Sodium nitrile (300mg, 10 mg/kg), Sodium thiosulphate (12.5 gm, 0.3-0.5 gm/kg)
7.	Nitriles	Methylene blue (1-2 ml/kg of 1% solution)
8.	Methanol	Etanol (loading 1ml/kg of 95%)
9.	Anticholinergics (Belladonna alkaloids)	Physostigmine (1-2 mg adult and 0.5 mg child)
10.	Carbon monoxide	Oxygen
11.	Acetoaminophen (Paracetamol)	N-acetyl cystein (oral 140 mg/kg)

12.	INH (isoniazid)	Pyridoxine (2-5 gm slowly)
13.	Barbiturates	Activated charcoal, sodium lactate
14.	Ammonia gas inhalation	Acids
15.	Endrin and DDT	Phenobarbitone
16.	Charas poisoning	Chlorpromazine
17.	physostigmine	Tannic acid
18.	Quinidine	Tannic acid
19.	Pentozocine	Naloxone
20.	Unknown	Universal antidote

Certain chemical agents are commonly used as specific antidotes against some heavy metals. These compounds form stable, soluble, non-toxic complexes with heavy metals. The important among them are dimercaprol (BAL), Sodium edentate (EDTA), cuprimine (penicillamine), Desferrioxamine.

Dimeecaprol (BAL):

- It has great affinity to heavy metals like arsenic and mercury and inactivates them.
- Hence it is a used as antidote for arsine and mercury heavy metal poisoning.
- It is given intramuscularly as a 5% solution in arachis oil with benzyl benzoate.
- In severe poisoning a does of 3 mg/kg is administered at 4 hourly intervals for the first 2days, at hourly intervals thereafter for about 10 days.

EDTA (Ethylene Diamine Tetraacetic Acid):

- It has great affinity for lead and inactivates it.
- Therefore it is now used in poisoning caused by inorganic lead and tetraethyl lead.
- The usual does is 1 gm twice daily for periods upto 5 days.
- After an interval of 2days this course of treatment may be repeated.
- EDTA can also be used in poisoning by arsenic and mercury.

Penicillamine:

- It is used in copper, lead and mercury poisoning.
- It possesses a stable –SH group which is required for chelation.

- The usual does is 30 mg/kg body weight upto a 2gm/day in four divided doses orally.

Desferrioxamine:

- It is used in acute iron poisoning.
- It accelerates the removal of iron from the body.
- The usual does in acute iron poisoning is 2 gm in 40-60 ml of distilled water, to prevent systemic absorption of iron.

Universal antidote:

It is used as an antidote in cases where the nature of the poison is not known or a combination of poison is administered. It consist of,

S.No	Ingredients	Quality	Use
1.	Powdered chemical	2 parts	Absorb alkaloids
2.	Magnesium oxide	1 part	Neutralizers acids
3.	Tannic acid	1 part	Precipitates alkaloids

3. **Elimination of absorbed poison:**

   Forced dieresis is using intravenous chlorthiazixe poisoning, mannitol infusion is useful in aspirin and barbiturate poisoning.

4. **Treatment of general symptoms:**

   Treatment is given to patient according to their symptoms of poison effect.

   Ex. Morphine should be given for pain,

   Oxygen for respiratory failure

   ORS saline for dehydration

   Cardiotonics for cardiac depression

5. **Maintenance of the patient general condition:**

   The patient should be kept warm and comfortable. In cases of poisoning, especially in elderly patients, there is a possibility of upper respiratory tract infection. To avoid this, prophylactic administration of antibiotics is desirable.

TYPES OF POISONING

INSECTICIDE POISONING

Insecticides are developed to kill insects and pests but they are absorbed from skin and GIT and are also toxic to human beings. They all are CNS stimulants and cause convulsions.

a. Organophosphorus compounds

The compounds belonging to this category are Hexaethyl Tetraphosphate (HETP), Tetraethyl Phyrophosphate (TEPP), Octamethyl Pyrophospharamide (OMPA) and Malathion.

Signs and symptoms:

- ✓ The poison affects involuntary muscles and secretary glands first.
- ✓ Then it affects the voluntary muscles, and finally vital brain centers.
- ✓ Initial complaint is headache, malaise and possibly sence of constriction in the chest, cramps, vomiting, diarrhea, profuse sweating, salivation and muscular twitching.
- ✓ If poisoning is severe, pulmonary edema, convulsions and possibly death may occur.

Treatment:

- ✓ **Decontamination**: The patient must be removed from the source of poison. The skin and mucus membrane should be decontaminated by washing with tap water and soap. Vomiting should be induced if the poison is ingested by the patient.
- ✓ **Clearing of air ways**: Artificial respiration may be necessary to clear the airway, intubation or rarely tracheotomy may be required.
- ✓ **Antidote:** Atropine can antagonize the peripheral action of organophosphoric compounds, but can not block the effects on CNS and neuromuscular effects. The patient should be fully atropinised by a does of 2 mg every 15-30 minutes IM or IV till atropine effects appear (flushed face, dry mouth, dilated pupils, false pulse and warm skin).
- ✓ **Administration of cholinesterase reactivation**: The auxin compounds like pralidoxin chloride and pyridine aldoxymethiodate in a does of 1-2 gm IV for

adults and 25-30 mg/kg for children given as 5% solution in isotonic saline, repeated after every 12 hours, should be given.

b. DDT

Signs and symptoms:

- ✓ Salivation, vomiting and abdominal pain.
- ✓ If the poison is absorbed through the skin or by inhalation, the symptoms include irritation of eyes, nose and throat, blurring of vision, cough, pulmonary edema and dermatitis.
- ✓ Nervous symptoms are clonic and tonic convulsions, hyper irritability, paralysis of limb muscles, collapse, cyanosis and labored respiration.

Treatment:

- ✓ On ingestion, poison must be removed by gastric lavage and saline cathartics.
- ✓ Artificial respiration may be required in some cases.
- ✓ In cases of skin contamination, skin must be washed with soap and water.
- ✓ If muscular tremors develop, barbiturates may be required.

c. Endrin:

Signs and symptoms:

- ✓ Abdominal pain, vomiting, tremors, oozing of white foamy froth, occasionally blood stained from both mouth and nostril.
- ✓ Gradually the convulsions become sever and continuous followed by coma which may terminate in respiratory failure and death.

Treatment:

- ✓ It is largely symptomatic. Detoxication must be carried out.
- ✓ To control convulsion barbiturates can be used.
- ✓ Calcium decreases toxicity of endrin. It should be given in a does of 10 ml of 10% solution IV every 4-6 hours. It can be also given in the form of calcium lactate orally.

HEAVY METAL POISONING

A. Arsenic

Signs and symptoms:

a. **Acute poisoning**:

- ✓ The symptoms are initiated by nausea, faintness, burning pain in the stomach and epigastrium, which is increased by pressure.
- ✓ Vomit initially consist of stomach contents but latter blackish or greenish due to presence of bile and finally consist of mucus mixed with altered blood in varying quantity.
- ✓ Diarrhea accompanied by tenesmus is common. Stools contain shreds of mucus membrance and is tinged with blood. It is watery rice like in consistency.
- ✓ Painful cramps in legs may develop due to dehydration of tissues.
- ✓ Collape sets in with a cold clammy skin, pale anxious face, sunken eyes, dilated pupil, weak pulse and sighing respiration.

b. Chronic poisoning:

The symptoms are divided into four stages,

i. Stage of nutritional and gastrointestinal disturbances: loss of weight, malnutrition, loss of appetite, nausea, mental and physical fatigue.

ii. Catarrhal changes: mucus membranes are inflamed, resulting in conjunctivitis, running of the eyes, coughing and bronchial catarrh.

iii. Skin rashes: rain drop type or patchy brown pigmentation skin. Hyperkeratosis of palm and soles occur. There is irritation of the skin and vesicular irruptions also seen.

iv. Nervous disturbances: tingling and numbness of the hands and feet. Tenderness of the muscle is observed. The other symptoms are headache, drowsiness and impairment of vision.

Treatment:

a. **Acute poisoning**:

- ✓ The stomach must be repeatedly washed with warm water.
- ✓ Then freshly prepared hydrated ferric oxide should be administered.

- ✓ 15 grains in 100ml of sterile water for inj. Of sodium thiosulfate must be given every 4-6 hours in the first 24 hours.
- ✓ Dimercaprol 3 mg/kg in only solution is administered at 3 hours interval for the first two days, at 6 hours intervals during the third day and at 12 hours intervals thereafter for 10 days IM.
- ✓ Parenteral fluids must be given to counteract dehydration.
- ✓ Morphine can be used to control pain and reduce the thirst.

b. **Chronic poisoning**:

- ✓ The patient must be removed from further exposer to the poison.
- ✓ Sodium thiosulphate in a does of 15 grains in 10ml of sterile distilled water 2-3 times/week over a period of several weeks should be used.
- ✓ Dimercaprol should be used as per acute poisoning.

B. Lead

Signs and symptoms:

a. **Acute poisoning**:

- ✓ Metallic taste noticed.
- ✓ Patient has cramps in legs and arthralgia.
- ✓ Headache drowsiness and paralysis of limb occur.
- ✓ Sometimes cerebral symptoms predominate, which are called lead encephalopathy, characterized by headache, sleeplessness tremors of eyes, mouth and fingers, loss of vision, paralysis, hallucinations and delirium.

b. **Chronic poisoning**:

- ✓ Facial pallour.
- ✓ Anemia with punctuate basopilia.
- ✓ Encephalopathy
- ✓ Paralysis of extensor muscles of wrist. It is due to degeneration of nerves and atrophy of the tissue.
- ✓ Colic and constipation
- ✓ Lead line: This is a bluish black line due to sub epithelial deposit of lead sulphide on the gums at the junction with teeth.
- ✓ Arteriosclerosis nephritis

Treatment:

a. Acute poisoning:

- ✓ The stomach should be washed with sodium or magnesium sulphate.
- ✓ Morphine and atropine can be used to relieve colic
- ✓ Calcium versenate (EDTA) is a valuable chelating agent for lead.

b. Chronic poisoning:

- ✓ Patient must be removed from the source of exposer and the stored lead in the body must be excreted.
- ✓ EDTA is used as chelating agent.
- ✓ The preparation is administered in 5% glucose saline and inn a concentration not more than 3% of versene.
- ✓ The adult does is sodium or magnesium sulfate.
- ✓ Morphine and atropine can be administered 1 gm, twice daily for period up to 5days.
- ✓ BAL in a dosage of 4 mg/kg body weight, every 4 hours is also effective.

C. Mercury

Signs and symptoms:

a. Acute poisoning:

- ✓ Metallic taste in the mouth with a feeling of constriction in throat and a pain radiating inn abdomen.
- ✓ There is vomiting and the vomit consists of long stringy masses of white mucus, mixed with blood, followed by profuse purging, often bloody and painful.
- ✓ If the patient doses not die in 3-5 days, on the 2^{nd} or 3^{rd} day salivation may develop, the gums may become swollen or inflamed and breathe foul.
- ✓ Some loosening of teeth occurs.
- ✓ There also may be a renal lesion.

b. Chronic poisoning:

- ✓ Excessive salivation and metallic taste in mouth, loosening of teeth with painful inflamed gums.

- ✓ Erethism, which is a disturbance of nervous system, which consists of shyness, irritability, tremor, hallucinations, delirium, mania and insomnia, may occur.
- ✓ Tremor is called as halter's shake.

Treatment:

a. Acute poisoning

- ✓ Removal and inactivation of mercury present in the body. Stomach should be washed. Egg albumin should be given as it forms a coat over the stomach. Charcoal can be used to adsorb the poison.
- ✓ Administration of BAL to form a nontoxic complex with the mercury which has already being absorbed.
- ✓ Penicillamine is effective as an antidote against mercury.
- ✓ Parenteral transfused fluids should be given to maintain the volume and composition of body fluids.

b. **Chronic poisoning**:

- ✓ The patient must be removed from source of exposure.
- ✓ The treatment is similar to acute poisoning.
- ✓ Dry extract of belladonna 30 mg thrice daily relives the excessive salivation.
- ✓ A course of IM injection of BAL is also effective.

NARCOTIC DRUG POISONING

A. Opium poisoning

Signs and symptoms:

- ✓ **Stage of excitement:** initially there is pleasant mental excitement, usually of very short duration. Laughter, hallucinations and rapid heart rate occur.
- ✓ **Stage of stupor**: there is weariness, headache, giddiness, a sense of weight in the limbs, diminution of sensibility and strong tendency to sleep from which in the patient can be roused by external stimuli. The pupils are contracted and face is cyanosed.
- ✓ **Stage of narcosis**: the patient passes into the deep coma. Pupils are contracted, to pinpoint. There is a fall in blood pressure. The breathing is slow, the rate being 2-4 per minute and stertorouse, later heart beats reduced,

when coma deepens and then gradually fails. The muscles are relaxed and reflexes abolished.

Treatment:

- ✓ The stomach must be washed with immediately with taped water and then with potassium permanganate solution of strength of 1:1000. The intestine must be cleared out by an enema or by purgatives.
- ✓ The patient must be keep awake i.e. he should not pass into comatose state. Injections of atropine dose 1.5 mg is useful. Injection of warm saline and glucose may be valuable.
- ✓ Adrenaline exhibits an antitoxic effect.
- ✓ Artificial respiration may be given.
- ✓ Nalorphine specific antidote of morphine administered by IV in doses of 5-10 mg every 15 minutes till respiration become normal.
- ✓ Antibiotics must be administered in cases of prolonged unconsciousness.

B. Cannabis poisoning

Signs and symptoms:

- ✓ It initially acts as stimulant and then depressant of the CNS.
- ✓ At first the higher cerebral functions of intellect, attention and judgment are increased.
- ✓ Sense of fatigue is abolished. Restlessness, excitement and delirium may appear.
- ✓ The face is flushed, the pupils are dilated, the vision blurred, heartbeats faster and there is increases in the rate of respiration.
- ✓ There may be an increase in the body temperature followed by muscular twitching and convulsions.
- ✓ Depression then follows excitement, ending inn death due to cardiac or respiratory failure.

Treatment:

- ✓ The stomach washed with dilute solution of potassium permanganate or tannic acid.

- ✓ Medicinal charcoal may also be employed excitement can be controlled by barbiturates.
- ✓ Cardio respiratory stimulants and artificial respiration may be required.

BARBITURATE POISONING

Signs and symptoms:

- ✓ There is prolonged coma, with respiratory depression, low blood pressure and oliguria.
- ✓ There may be mental confusion, in co-ordination and muscular weakness. It is followed by stupor.
- ✓ The limbs are flaccid and the reflexes are lost, face becomes cyanotic.
- ✓ Death is due to respiratory failure.

Treatment:

- ✓ Artificial respiration should be given using a mixture of 95% oxygen and 5% CO_2.
- ✓ Gastric lavage should be performed using potassium permanganate.
- ✓ If patient is in coma, a 5% glucose solution must be given to the patient.
- ✓ Amphetamine sulfate in a dose of 10 mg every half an hour must be given IV till improvement.
- ✓ Recently post osmotic dieresis (urea) with large amount of fluid and alkalinisation.
- ✓ Sodium lactate has been used to treat severe cases.

DIAGNOSIS OF POISONING

Diagnosis of poisoning is time and again challenging and has to be finished on the available evidences. In several cases, slight or not at all toxicity occurs and the patient, parents or relatives are relieved. On occasion, the history may not be available or may be perhaps unreliable. Various cases of poisoning presents ambiguous symptoms and in some fatal acute poisoning, symptoms may be delayed for many hours or even days. Some poisons develop misleading symptoms, for example gastro-intestinal type of arsenical poisoning may be mistaken for symptoms of cholera or food poisoning. Hence, an operational diagnosis has to be made based on clinical features as well as the laboratory examinations. The articles or the containers recovered from the scene of crime or from the

possession of the victim may provide assistance in case of suspected poisoning when the diagnosis is not immediately apparent.

There are several symptom patterns which are typical for different types of poisoning and can be useful guide to the nature of poison, the laboratory tests needed and the treatment required. The examinations should also include the exploration for signs of trauma and systemic disease because many organic illnesses enter into the differential diagnosis of poisoning. The symptoms, clinical examinations and the patterns of poisoning by some commonly used drugs and poisons are discussed here and may help to identify the agent and severity of the problem. Post-mortem toxicology is used to determine whether alcohol, drugs or other poisons may have caused or contributed to the death of a person.

Signs and Symptoms of Poisoning

Symptoms	**Poisons involved**
Vomiting	Irritant poisons like arsenic acids, alkalis excess of liquor and some metallic salts
Diarrhea	Usually poisons causing vomiting also cause diarrhea.
Cramps	Metallic poisons like arsenic, lead, antimony, mercury etc.
Delirium	Dhatura, cannabis, alcohol, atropine, hyocine, LSD etc.
Convulsions	Strychnine, nicotine, cyanides, tricyclic antidepressants, Phenothiazines, carbon monoxide, ethylene glycol, opioids, organophosphate insecticides, salicylates.
Paralysis	Lithium, amphetamines, lead, arsenic, aconite, snake venom etc.
Coma	Barbiturates, carbon monoxide, chloroform, trichloro-ethanol, opioids and excess of liquors.

Clinical Diagnosis of Poisoning

Clinical Findings	**Poisons involved**
Skin color	Cherry Pink: Carbon monoxide Flushed pink skin: Alcohol, cocaine, cyanide and anti-cholinergic agents Jaundice: Hepatotoxic agents like paracetamol

	Central cyanosis: A sign of hypoxia but methaemoglobinaemia also causes similar colour.
Skin changes	Cutaneous bullae: Barbiturates, glutethimide, sedative overdoses, tricyclic antidepressants and carbon monoxide. Organic conditions like hypoglycemia, Sweating: Myocardial infarction and pyrexia due to infarctions and poisoning by salicylates, Organo phosphates, or monoamine oxidase inhibitors.
Pupils	Dilated: Pupils dilate in severe hypoxia and in hypothermia. Drugs such as tricyclic antidepressants also cause dilation. Glutethimide and monoamine oxidase inhibitors produce wide dilation. Constricted: Opioids typically cause pin point pupils. Organophosphate insecticides and trichloroethanol poisoning cause very small pupils. In barbiturate poisoning the pupils may vary in size at times being small, at others dilated.
Body temperature	Hypothermia: Comatose condition for some time may cause hypothermia. Sedative and hypnotic drugs, trichloroethanol, ethanol and opioids cause hypothermia. Hyperthermia: Hyperthermia may be caused by heat stroke and meningitis and poisoning by anti-cholinergic agents, tricyclic anti-depressants, monoamineoxidase, inhibitors, carbon monoxide, Dhatura, phenols and salicylates.
Breadth odour	Alcohol, acetone (diabetic ketoacidosis and starvation) solvents such as toluene, trichloroethane, ether, turpentine, petrol, kerosene, cyanide and methyl salicylate.
Appearance of blood, urine and vomit	Blood: Red venous blood may suggest cyanide or carbon monoxide poisoning. Brown arterial or venous blood may suggest methaemoglobinaemia. Vomitus: Vomit or gastric lavage containing blood may suggest repeated vomiting, corrosives, paraquat, coumarin, anticoagulant,

	irritants, iron and non-steroidal anti-inflammatory drugs. Many drugs turn urine black e.g. metronidazole. Urine: Urine may be cloudy or red or brown due to hematuria, haemoglobinuria or myoglobinuria.
Blood pressure	Hypotension: Almost all sedatives, hypnotics, dehydration, lengthy coma, vomiting and sweating may cause hypotension Hypertension: Amphetamines, cocaine, phencyclidine, sympathometics and anti-cholinergic agents.
Cardiac arrhythmias	Changes in heart rate or rhythm may be caused by beta blocking drugs, organophosphates, theophylline, tricyclic antidepressants, sympathometics, barbiturates, etc.
Pulmonary oedema	Petroleum products, organophosphates, ethylene glycol, irritant gases (metal vapours), salicylates, opioids etc.
Rhabdomyolysis	Patient lying in coma for a long time on hard surface may develop it due to pressure necrosis of muscle, which may lead to renal failure. The agents mostly responsible for the same are barbiturates, opioids, ethanol and carbon monoxide. Rhabdomyolysis can also occur after prolonged and severe muscle spasm, due to poisoning by strychnine, phencyclidine and monoamine oxidase inhibitors.

Pattern Diagnosis of Poisoning

Coma, Hypotension, Flaccidity	Barbiturates, benzodiazepines, glutethimide, trichloro-ethanol, ethanol, opioids etc.
Coma, Hypertension, Tachycardia, Dilated Pupils	Tricyclic antidepressants, anti-cholinergic agents, Phenothiazines.
Malaise, Restlessness, Nausea, Weakness	Carbon monoxide, solvents, insecticides, lead, mercury, arsenic.
Restlessness, Hypertonia, Hyper Reflexia, Pyrexia	Monoamine oxidase inhibitors, anti-cholinergic agents, strychnine, phencyclidine, amphetamines.
Behavioral Disturbances	Psychotropic drugs, anticholinergic drugs,

	corticosteroids, solvent abuse, psilocybin-mushrooms.
Burns In Mouth, Dysphagia, Abdominal Pain, Distension.	Corrosives, caustics, paraquat
Renal Failure	Paracetamol, mercurial compound, acids (phosphoric, oxalic, formic), phenols, arsine, stibine, lead.
Jaundice, Hepatic Failure	Paracetamol, carbon tetrachloride, phosphorous, organic lead.

Diagnosis of Poisoning In Dead Person

Evidence of poisoning will depend on postmortem examination, chemical analysis, experiments on suitable animals and circumstantial evidence.

Post Mortem Examination: It is done by the doctor externally & internally to find out the cause of death.

Especially the alimentary system should be examined as signs of corrosive and irritants poisons likely to be found. These signs may manifest as hyperemia, softening, ulceration and perforation may be present. In case of doubt histological examination should be done.

i. External Findings:- it consists:
   - Surface of body & clothes are examined for any evidence of stain, struggle& injury mark, Injectionsmark/ Insect bite.
   - Natural orifices- examine for the presence of poisonous substance (mouth, nostrils, anus, vagina, urethral, orifice.)
   - Color of Skin & Mucous Membrane is examined to identify the specific poisoning agent.--yellow skin color indicate- phosphorous poisoning, bright cherry red indicates carbon mono oxide poisoning, gray & black color indicates—sulphuric acid, hydro chloric & Acetic Acid, Brown & Yellow Color in – nitric acid, graywhite color in- carbolic acid & caustic alkalis. Grayblack color in- oxalic acid, bluish white color in mercuric chloride, whitish color in zinc-chloride.
   - Color of Post Mortem Staining- Cherry red color in carbon monoxide, deep blue color in carbon dioxide, bright red/pink in cyanide poisoning, dark

brown/yellow in phosphorus or copper and black color in opiates poisoning.

- Odor / Smell: Smell or Odor indicates about the substance which is used for poisoning. Garlicky Smell - Phosphorus, arsenic, parathion, Malathion, aluminum Phosphide (Celphos), sweet & fruity smell—ethyl alcohol, chloroform, and nitrites. Acrid smell—Chloral hydrate, formal-dehyde, rotten egg smell - disulphiram, hydrogen sulphide, bitter almond odor – indicates- hydro-cyanic acid (prussic acid).

ii. Internal Findings - It is done during process of postmortem of the body.

- Odor / Smell- In suspected case of poisoning skull should be opened first to detect unusual odor in the brain because body mask such odors
- Mouth-& Throat - Mouth & Throat examine for any evidence of inflammation, erosion, or staining.
- Upper respiratory tract- Corrosive—may cause edema, of glottis & congestion of mucous membrane of trachea & bronchi.
- GIT- (Esophagus, Stomach, Intestine)- Irritant poison produce marked inflammation, hyperemia of mucous membrane of G.I. Tract & Corrosive may cause perforation of stomach.
- Liver- Hepato-toxic-poisons- Arsenic, phosphorus, chloroform, Alcohol, chlorpromazine, thallium, aluminum Phosphide, zinc Phosphide. Fatty Liver in arsenic poisoning.
- Kidney- Nephro Toxic poisons-- Arsenic, mercury, Oxalic Acid, Carbolic Acid, Thallium, Aluminum Phosphide, Zinc Phosphide, Turpentine, and Cantharides.
- Spleen, urinary bladder, rectum seen for any changes
- Heart & brain- are examined properly for any inflammation, ulcer, staining or any changes if present noted clearly. Sub endo cordial Hemorrhage in Lt. ventricle seen in poisoning with Arsenic, Mercury, Phosphorous, Viper bite, Heat stroke, traumatic Asphyxia, Influenza.

Chemical Analysis:

In every case of death due to poisoning, an attempt must be made to demonstrate the presence of poison by standardised analytical methods. For this purpose, the

pathologist conducting the autopsy must collect certain of the viscera and body fluids, and despatch them through the police to the nearest Forensic Science Laboratory. While submitting the samples for analysis it must be ensured that the correct quantity has been preserved in appropriate preservative in suitable, sealed containers. Since poisons can cause degenerative changes in target organs, histopathological evidence of such damage can be a valuable corroborative adjunct. Microscopic examination of tissues may also sometimes help to substantiate a suspicion of long standing abuse which could have contributed to the cause of death. Tissues submitted for histopathology must always be preserved in formalin. An important proof of poisoning is the detection of poisons in the excreta, blood and viscera. The finding of the poison in the food, medicines act as a corroborative but not a conclusive proof.

The medical practitioner must preserve all the viscera and get it sealed in his presence for onward transmission to the police officer who will forward it to the Forensic science lab for chemical analysis. The viscera along with certain body fluids should be collected, preserved and sent to the Forensic Science laboratory for chemical analysis by the forensic pathologist. The presence of poisons should be demonstrated by standardized analytical methods. The preservative for the viscera is rectified spirit or saturated saline solution. The blood can be preserved in potassium oxalate or sodium fluoride and urine should also be preserved with sodium fluoride.

Analytical Techniques of Diagnosis

The analytical techniques for the detection of poisons, drugs and various chemicals are more dependable and satisfactory than the usual chemical and biochemical methods. The common analytical techniques employed in toxicological analysis are

Spectrophotometric methods of analysis

It is based on the absorbance or transmission of light from a colour reaction at a specific wavelength. It includes the following techniques:

- Calorimetric
- Fluorimetric
- Automation

Chromatographic techniques of analysis

It is based on the migration of compound on adsorbent (solid phase) by a mobile phase. It includes:

- Thin layer chromatography (TLC)
- Gas liquid chromatography (GLC)
- High pressure liquid chromatography (HPLC)
- Gas liquid mass spectrometry (GL-MS).

Competitive binding assay or Immunoreactive assay

It includes:

- Radioimmunoassay (RIA)
- Enzyme immunoassay (EIA)
- Fluorescent Polarization immunoassay (FPIA)
- Immunotubidimetric assay

Experiments on Animals: The Suspected material (food, medicine, fluid or poison) extracted from viscera can be fed to domestic animals, such as dogs, cats- and signs are noted. The poison affects these animals in the same way as human beings.

HEAVY METAL DECTECTION

Activation analysis has, in a few decades, become one of the most important methods for determination of minor, trace, and ultra-trace elements in solid samples. The main advantages of activation analysis are its accuracy and sensitivity. The method is applied in the semiconductor industry, medicine, biology, criminology, archaeology, geochemistry, and environmental studies or quality control. Neutron Activation Analysis (NAA) is a sensitive analytical technique used for qualitative and quantitative multi-element analysis of major, minor, and trace elements in samples. Neutron Activation Analysis (NAA) is significantly different from other spectroscopic analytical techniques in that it is based on nuclear transitions instead of electronic transitions. Neutron activation analysis was discovered in 1936 by Hevesy and Levi when they observed that samples containing certain rare earth elements became highly radioactive when they were exposed to a source of neutrons and employing for measurement of the induced radioactivity to facilitate both qualitative and quantitative identification of the elements present in the samples. Neutron

activation analysis (NAA) is a nuclear process used for detecting the presence and determining the concentration with great sensitivity most chemical elements without destroying the sample to be analyzed.

It permits identification and measurement of concentrations of elements which are present in only minute or trace quantities of concentrations < 0.01%. Under appropriate circumstances, Neutron Activation Analysis (NAA) can also identify both large and small pieces of material by precisely analysing their trace element concentrations.

Principle of Neutron Activation Analysis

The principle of activation analysis is that a particle such as neutron, proton, α - particle, or γ - rays, bremsstrahlung (radiations from accelerated particles) induces a nuclear reaction in an atom of a target element. Then the product is detected and quantified by photon or particle emission or, if radioactive then by its decay properties. The method being based on neutron activation and thus requires a neutron source. To carry out a Neutron Activation Analysis (NAA) analysis, the specimen is placed into a suitable irradiation facility and neutrons are bombarded onto the sample, allowing the elements to form isotopes. After irradiation, the artificial radioisotopes decay with emission of particles or, gamma rays, which are main characteristic of the element from which emitted. The radioactive emissions and radioactive decay paths for each element are known allowing to study the spectra of the emissions of the radioactive sample, and to determine the concentrations of the elements within it.

Advantages of Neutron Activation Analysis

The major advantages of NAA, particularly Instrumental Neutron Activation Analysis (INAA) are:

- The relative freedom from matrix effects and interferences
- High accuracy
- Very low or zero blank contributions

Applications of Neutron Activation Analysis

Neutron Activation Analysis (NAA) measures the total amount of an element, even in extremely low concentrations (parts per trillion or lower), in a material without regard to chemical or physical form. Samples analyzed can be liquids or solids and do not have to be

put in a solution. Theoretically, every element can be neutron activated. Yet, some conditions are required.

- First, the element must have an isotope with a high cross-section that is able to fix the incoming neutrons.
- Second, if delayed-NAA is used, the half-life of the isotope has to be long enough so the amount of activity is measurable.
- Third, the isotope itself must be relatively easy to get in sizeable quantities.
- Lastly, gamma rays must be produced that are reasonably intense and in a limited energy range.

Applications of NAA includes environmental studies to characterize pollutants, semiconductor materials analysis to measure ultra-trace element impurities, archaeological studies of the distribution of the chemical elements and fossil materials, forensic studies as a non-destructive method (suspect chemical agents), pharmaceutical materials analysis to measure ultra-trace element impurities, etc. Unfortunately, facilities for using this method do not exist everywhere.

Forensic Significance of Neutron Activation Analysis

Evaluating the evidence

The result of the subjecting a piece of material to neutron activation analysis is that the material is found to contain certain elements in the measured concentrations, within experimental error. The next step is to determine the relevance of the result in solving legal issues. Sometimes the legal issue depends directly on the amount of a selected element in the material. For example, if the question is whether a particular death was due to arsenic poisoning, the activation analyst might measure the amount of arsenic in the victim's hair or in other tissues, and if the amount exceeds the normal amount by a considerable value, then death by arsenic poisoning has a high probability. In other cases the legal issue is whether a given piece of evidence came from a particular source-the identification problem. For example, a hair found on the body of a victim might be compared in its trace element concentrations to the hairs of a suspect. Then the crucial question is the degree to which the comparison singles out the suspect as the guilty party. In neither of these cases is the NAA evidence sufficient in itself. Additional data are needed to evaluate the significance of the chemical analyses done by neutron activation techniques. In the first case it is

necessary to know the normal amount of arsenic in the tissue or hair measured. Knowledge of the distribution of arsenic concentrations in hairs of the living general population is required so that one can calculate the probability that a person chosen at random would have an arsenic concentration equal to what was measured in the tissue or hair of the deceased.

In the second case more information is needed to determine how much more likely the hair found on the victim is of the suspect than from a person chosen at random from the general population. Although the detailed considerations are different in the different type of cases, the analysis in each case depends on the existence of sufficient background information with which the evidence at hand could be compared; only then the evidence can be interpreted properly.

Heavy metals	EU	USFDA	Codex	India
Mercury	Fishery products - 0.5 Certain fishes-1	All fishes (methyl mercury) -1	Fishes –0.5 Predatory fishes -1	Fishes –0.5 Predatory fishes - 1
Cadmium	Crustaceans –0.5 Bivalves –1 Cephalopods –1 Fishes –0.05 to 0.1	Crustaceans –3 Bivalves –4	Bivalves –2 Cephalopods –2	Fish –0.3 Crustaceans –0.5 Bivalves –2 Cephalopods –2
Lead	Crustaceans –0.5 Bivalves –1 Cephalopods –1 Fishes –0.2 to 0.4	Crustaceans – 1.5	Fish -0.3	Fish –0.3 Crustaceans –0.5 Bivalves –1.5 Cephalopods –1
Arsenic	NIL	Crustaceans – 76 Bivalves –86	NIL	Fish –76 Crustaceans –76 Bivalves –86

Complications of identification

A criminal often leaves some materials in the area of a crime, such as a shirt button or a hair from his head or any other part of his body or he may carry away something from the

vicinity of a crime, such as a hair of the victim or a piece of glass from a window broken in the case of a burglary. Although all hairs, for example, show similarity in the major constituents, there is great variation in the minor constituents from one person to another because of differences in diet, body metabolism, occupation, and environment. Because of the great sensitivity of activation analysis, the question arises whether materials can be unambiguously characterized by their trace element concentrations. If it could be shown, for example, that every hair on a person's head was identical to every other one, and that they were all different from the hairs on a different person's head, the procedure would provide an extremely powerful method of identification.

Revelation of Gunshot Residues (GSR)

NAA technique is used for the revealing mineral gunshot residues. These indicial traces after picked up from the crime scene are used as material proofs for judicial investigations. Samples of metallic powder residue can be realized after several shots by different kind of weapons with local and foreign ammunitions.

DRUG / POISON & ANTIDOTE

S.No	Drug / poison	Antidote
1.	Arsenic	Dimercaprol (BAL)
2.	Mercury	Dimercaprol (BAL)
3.	Lead	N-Penicillamine, Dimercaprol, Calcium gluconate, Versanate (Calcium diethyl tetraacetate)
4.	Copper	N-Penicillamine
5.	Iron	Desferrioxamine (DFM)
6.	Ammonia gas inhalation	Acids
7.	Organophosphorous compounds	Atropine
8.	Endrin & DDT	Phenobarbitone
9.	Opium/Morphine/Narcotic analgesic poisoning	Naloxone, Nalorphane
10.	Ethylene Glycol	Alcohol (Ethanol)

11.	Barbiturate Poisoning	Sodium lactate
12.	Charas Poisoning	Chlorpromazine
13.	Physostigmine	Tannic acid
14.	Qunidine	Tannic acid
15.	Pentozocine	Naloxan
16.	Paracetamol/Acetaminophen	N-acetyl cysteine
17.	Unknown	Universal antidote

Poison and antidotes:

A poison may be defined as any substance administered in whatever way (by mouth, injection, inhalation, skin, mucous, membrane) produces ill health, disease or death. The diagnosis of poisoning is often difficult. But acute poisoning may be accidental, occupational, suicidal or criminal. Self-medicine is also a major cause of drug poisoning.

The poisoning either accidental or intentional requires immediate support and symptomatic management to avert any threat to life. The perfect management and treatment solely depends upon the identification of ingested poison or corrosive substance so that specific antidote which counteracts that poison, can be used.

Classification of poisoning:

1. Intentional poisoning: A person taking or giving a substance with intention of causing harm to that person. E.g. suicide, assault.
2. Unintentional poisoning: If the person taking or giving a substance without knowing its toxic effects. E.g. accidentally.
3. Undetermined: when the distinction between intentional and unintentional is not clear. E.g. poisoning due to insecticides or pesticides.

Other causes:

1. Most common cause of poisoning is heavy metals which occur by metallic contamination of food and water by leaching process.
2. Due to overdose of drug inhalation.
3. Intentionally cyanide poisoning.

Signs and symptoms of poisoning:

1. Reduced breathing rate

2. Nausea, vomiting and diarrhea
3. Increased or decreased heart rate.
4. Dilated or shrunken pupils.
5. Muscle cramps
6. Partial consciousness.

Antidotes:

Antidotes are the substances which react specifically with the ingested poison or toxic substance or with potent drugs in case of overdose. They are used to neutralize the effect of poison in the body.

Classification: According to their mechanism of action, they are classified as;

1. **Physiological Antidotes**: They are also called antagonists. They produce the effect opposite to that of the poison. They are used after some of the poison is absorbed in the circulation. E.g. sodium nitrate (used in cyanide poisoning), Atropine and physostigmine are two antidotes for each other.
2. Chemical Antidotes: They react by combining with the poison and change its chemical nature by converting the poison into inactive or harmless compounds. E.g. Sodium thiosulphate (with convert the systemic toxic cyanide into non-toxic thiocyanate), EDTA (chelating agent for heavy metal poisoning).
3. **Mechanical Antidotes**: They act by preventing the absorption of poison into the body or expel out the poison by emesis or eliminate through urine, E.g. Activated charcoal absorbs the poison and sodium monohydrogen phosphate (Na2HPO4) inactivated the poison prior to absorption and precipitate the toxic material as insoluble salt.

Antidotes for selected unabsorbed inorganic poisons and drug overdoes

Poison/Drug in overdose	Antidote	Mechanism
Acid (Corrosive)	Antacid or weak alkali (Milk of Magnesia), Avoid inducing vomiting.	Chemical antagonism. Acid-base neutralization.
Alkalis (Caustics)	Weak acid (lemon juice or diluted vinegar)	Chemical antagonism. Acid-base neutralization.

Iron salts	Desferroxamine, sodium carbonate, 1% lavage	Chelation
Copper and lead salts	Penicillamine	Chelation
Mercury salt	Dimercaprol (BAL)	Chelation

SODIUM NITRATE INJECTION

Molecular Formula: $NaNO_2$

Molecular Weight: 69 g

Synonyms: Nitrous acid Sodium Salt, Etinitrit

Standards: It contains not less than 97% and not more than 101% of sodium nitrite calculated on dried basis.

Methods of Preparation:

1. It is prepared by strongly heating sodium nitrate.

   2NaNO3 2NaNO2 + O2
2. It can also be prepared by heating sodium nitrate with lead.

   NaNO3 + pb NaNO2 + pbO

Physical Properties:

1. It is yellow or white crystalline powder.
2. It has saline taste and freely soluble in water but less soluble in alcohol.
3. It is odourless in nature.
4. When it is exposed to air, it readily forms sodium nitrate.

Assay: 1 gm of sodium nitrite is dissolved in 100 ml of water, pipette out 10 ml of the solution and transfer to another solution containing KMnO4, 100ml of water and 5 ml of H2SO2. The solution is warmed to 40degree C and allowed to stand for 5 minute. To this 25 ml of 0.1N oxalic acid is added and again heated to 80degree C. The excess oxalic acid is titrated with 0.1N potassium permanganate. At the end point, colour changes from colourless to pink.

$$NaNO_2 + H_2SO_4 \longrightarrow HNO_2 + NaHSO_4$$

$$HNO_2 + [O] \longrightarrow HNO_3$$

Each 1 ml of 0.1N KMnO4=3.450 gm of NaNO2

Uses:

1. Nitrite ions release the smooth muscle of blood vessels and give the vasodilator action.
2. It is mainly used in cyanide poisoning.
3. It is also used in anti-rust solution to prevent the rusting of surgical instruments.

Mechanism of Antidote Action:

In cyanide poisoning, the injection of sodium nitrite is given primarily, which causes the oxidation of ferrous ions (Fe2+) of haemoglobin to ferric ion (Fe3+) of methhaemoglobin. This methhaemoglobin then combines with the serum cyanide and produce cyanometh haemoglobin and protect the enzyme from harmful cyanide ions.

$$Hb\ (Fe_2^{+}) \longrightarrow M.Hb(Fe_3^{+})$$ (Meth haemoglobin)

$$M.Hb(Fe_3^{+}) + CN^{-} \longrightarrow M.Hb(Fe_3^{+}).CN^{-}$$

(Cyanometh haemoglobin Inactive cyanide ion)

The sample is tested for the presence of heavy metals not more than 0.002% and loss on drying not more than 0.25%.

Incompatibilities:

It is incompatible with acetanilide, antipyrene, phenazone, caffeine citrate, chlorate, hypophosphite, iodide, mercury salt, permanganate, tannic acid, vegetable decoction, infusion or tincture.

Dose of Injection: 10-15 ml of 3% solution i.v.

SODIUM THIOSULFATE INJECTION

Molecular Formula: Na2S2O3.5H2O

Molecular Weight: 248.18 g

Synonyms: Sodium hyposulfite, Anti-chlor.

Standards: It contains not less than 99% and not more than 101% of Na2S2O3.5H2O

Methods of Preparation:

1. It can be prepared by boiling sodium sulphite with sulphur.

   Na2SO3 + S Na2S2O3

2. It can also be prepared by passing SO2 gas in a mixture of sodium sulphide (8%) and sodium carbonate (6%).

$$2Na2S + Na2CO3 + 4SO2 \quad 3Na2S2O3 + CO2$$

3. Sodium thiosulphate is also prepared by reacting sodium hydroxide with sulphur.

$$6NaOH + 4S \quad Na2S2O3 + 2Na2S + 3H2O$$

4. It can also be prepared by passing sulphur dioxide into sodium sulphide solution.

$$2Na2S + 3SO2 \quad 2Na2S2O3 + S$$

Physical Properties:

1. It occurs as large, transparent prismatic crystalline powder.
2. It effervesces in dry air.
3. It is practically soluble in water and insoluble in alcohol.
4. It starts melting at 50degree C and at 100degreen C, loses its all moles of water.

Chemical Properties:

1. Its aqueous solution decomposes slowly
2. Sodium thiosulphate is used to dissolve silver halide that is why it is used in photography and is also known as 'hypo'.

$$2Na_2S_2O_3 + AgBr \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

3. Barium chloride reacts reacts with sodium thiosulphate solution to give white precipitates of given white precipitates of barium thiosulphate.

$$Na_2S_2O_3 + BaCl_2 \longrightarrow BaS_2O_3 + 2NaCl$$

Mechanism of Antidote:

After 5 min. of injection of sodium nitrite, a slow i.v. infusion of sodium thiosulfate is given which causes dissociation of cyanometh haemoglobin and set free cyanide ion. This cyanide ion (CN-) is converted into thiocyanate ion (SCN-) by sodium thiosulphate in the presence of enzyme Rhodanese and thiocyanate ion (SCN-) is then excreted out from body by kidney.

$$Na_2S_2O_3 + CN^- \longrightarrow SCN^- + Na_2SO_3$$

Identification Tests:

1. Acid few drops of iodine solution to 10% w/v solution of sodium thiosulphate. The solution will appear colourless.
2. A solution (1 in 20) gives the reaction of sodium and thiosulphate ion.

Assay: Its assay is based upon iodometric titrations.

Take about 0.5 gm of the sample and dissolve in 20 ml of water, and the solution is titrated against 0.05 M iodine using starch solution as an indicator, when at the end point, the excess iodine reacts with starch solution as an indicator, when at the end point, the excess iodine reacts with starch paper turning it to a blue colour.

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$

Each 1 ml of 0.05 M iodine=0.02482 gm of sodium thiosulphate.

Test for Purity:

The sample is tested for the presence of following impurities:

1. Heavy metals not more than 10 ppm.
2. Absence of sulphide and suphite.
3. Sulphates must not be more than 0.2%
4. The pH of aqueous solution of 10% w/v of sodium thiosulphate is 6.0 – 8.4.

Incompatibility: Mixing it with solutions containing other metal cation is a sources of incompatibility due to the precipitation of metal thiosuphate. In acidic medium, these precipitates may darken due to the formation of respective sulphides.

Uses:

1. Its use as an antioxidant is limited to solution containing iodides.
2. It is used as a standard titrant in iodimetric analysis.
3. It is basically used as antidote in cyanide poisoning intravenously after the injection of sodium nitrite.
4. Topically, it is used as an anti-fungal agent.
5. It is also effective antidote in lead, bismuth, mercury and iodine poisoning.
6. It is also used as a fixer photographic work.
7. In textile industry, it is used as antichlor in bleaching process.

Dose: The I.P. recommended dose of injection which is equivalent of 0.3-1.0 gm (3-10 ml) and is administered by i.m. and i.v. route.

Storage: Sodium thiosulphate injection should be stored in tightly closed containers and container must be of single dose.

ACTIVATED CHARCOAL

Charcoal is a dark grey residue consisting of carbon and any remaining ash obtained by removing water and other volatile constituent from animal and vegetable substances.

Methods of Preparation:

1. It is prepared by burning wood in absence of air. The residue obtained consists of nearly pure carbon.
2. Activation of Charcoal: The absorptive power of charcoal could be tremendously increased by treating it with various substances such as steam, air, carbon dioxide, oxygen, zinc chloride, sulphuric acid, phosphoric acid or a combination of these substances, as temperature ranging from 500degree-9000degree C. In this process, the activating substance presumably removes substances previously absorbed on charcoal and in some instances at least, breaking down the granules of carbon into smaller ones having a greater total surface of approximately 100 m2.
3. Other sources: Sucrose, lactose, rice, starch, coconut, pericarp, bone, blood and various industrial wastes can be used for preparing charcoal.

Properties:

1. It is fine, black, odourless and tasteless powder.
2. It is free from gritty matter.
3. It is insoluble in water and other organic solvents.

Uses:

1. It is used as an emergency antidote in many forms of poisoning.
2. It is used as protective and absorbent.
3. It is also used as a burning fuel.
4. Due to its high surface area, it is also used as a filter-aid.
5. It is also a constituent for gum powder.
6. It is used as disinfectant in wounds.
7. It is used to filter toxins from blood and kidney diseases.
8. It is used to purity blood transfusions.
9. It is used in overdose of aspirin.
10. Its antidote activity is also reported in case of snake, spider and insect bitte.

ASTRINGENTS

The 'Astringent' word is derived from the Latin word adstringere meaning 'to bind fast'. These are the compounds which bring about protein precipitation and form a protective layer on the surface and hence stop bleeding by constricting the blood vessels. Astringents protect from external irritation and reduce cellular permeability. It also has local styptic and antiseptic action. Astringents applied over the wound in small quantity to stimulate the growth of new tissues but in higher concentrations it produces irritation or corrosive effect. This corrosive property is useful in removal of warts (undesired tissues). Astringents are normally used in much diluted forms and are used topically to:

- ✓ Clean the face and prevent acne breakouts.
- ✓ Stop bleeding.
- ✓ Treat haemorrhoids.
- ✓ Relieve the discomfort and itching of insect bites.

Mechanism of Action:

Transition metal cations have protein precipitation action and if a very dilute solution of such metal cation is used over a tissue, a mere surface action specially leading to "shrinkage" of "firming up" of the skin take place and this is called as astringent action. The metal would form complex with various polar groups present on the protein or an enzyme. This complexation of important functional groups at the action site of protein causes a drastic change in the properties of proteins. It hardens the epidermis and create a barrier against infection.

Unit II- EXPLOSIVES

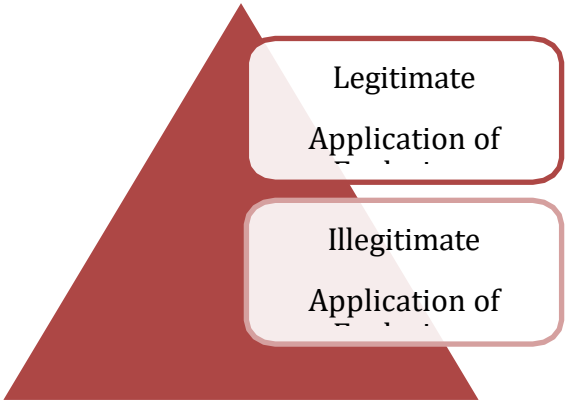
An explosive is a substance, an element, a compound or a mixture, which is capable of exerting pressure on its surroundings on explosion/transformation.

Role of Forensic Science in Explosives Examination

Forensic Science plays a role in relation to explosives. Explosives studied by forensic personnel mainly relate to mass destruction episodes wherein bombs are used for illicit activities. The explosive residues collected from the crime scene are examined for such causes specially as the constitution the explosive material, the source and intention of explosion.

Applications of Explosives

An explosive have many applications, which are legal and do not cause harm to anyhuman, animal or any other living being.



Legitimate Uses: An explosive might be used in blasting rocks for mining, oil explorations, in satellite and space craft propulsions, in constructingroads, railwayline etc, in firework displays, and may also be used for military purposes.

Illegitimate Uses: The criminals are using the explosives for causing destruction to individuals or a nation by blasting bombs. The illegitimate use of explosives causes large scale destruction, as well as a threat to the integrity of any nation a disseverely punishable under Indian Penal Code, Explosive Act and The Explosives Substance Act.

Some common examples of explosives are RDX, TNT, TETN, ANFO, and Dynamite etc.

Role of Forensic Science in Explosives

Forensics plays an important role in the investigation of explosions where explosive substances / materials are the main ingredients. Explosives can be detected prior to

explosions (during trafficking) and also after the explosion by forensics pot tests and also by hi-tech forensic analytical tools.

EXPLOSION

In simplest term we can define an explosion as a rapid increase in volume of gaseous substances and release of energy along with the generation of high temperature and release of gases.

Types of Explosion

An explosion may be exotic or chemical. The common examples of exotic explosion are nuclear explosion and the use of high intensity laser arc to heat a substance to its plasma state. Laser and electric energy are presently used only to start reactions rather than producing energy.

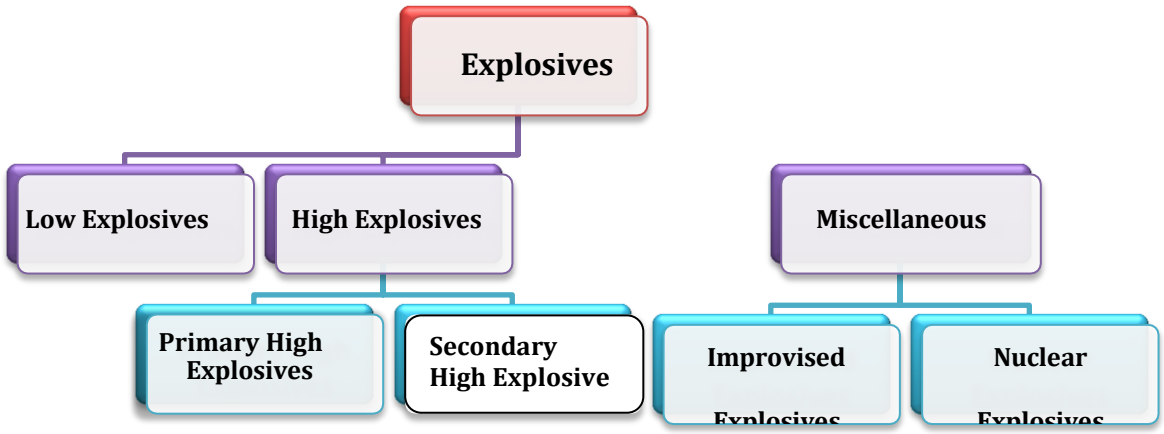
Due to the existence of organic compounds containing $-NO_2$, $-ONO_2$ and $-NHNO_2$ groups and others an explosion is a impulsive chemical reaction which is driven by enormous release of heat and energy. This type of eruption is known as chemical explosion.

The chemical explosion is of three types:

- ✓ Decomposition: The chemical decomposition of an explosive is a gentler process which occurs during its storage. This can happen over years or days or hours or may be within a fraction of a second. Deflagration and Detonation are two spontaneous types of Chemical decomposition
- ✓ Deflagration: Deflagration of the explosive substance is proliferated by a blaze front which travels gradually through the explosive substance. Low explosive experiences the process of Deflagration.
- ✓ Detonation: In Detonation, the explosion is propagated by shock waves navigating through the explosive material. Detonation happens in high explosives..

CLASSIFICATION OF EXPLOSIVES

The Explosives can be classified on the basis of composition, velocity, sensitivity and physical forms. But broadly explosives are of three types: Low explosives, high explosives and miscellaneous. The latter sub-divided into homemade explosives, nuclear explosives.



Low Explosives

Low explosives are solid flammable materials that deflagrate. Low explosives liberate enormous quantity of gases that generate sufficient pressure to force a projectile in a specific direction upon ignition and decomposition. The proportion of burning of explosive depends on combustion gas pressure, grain size and form, and composition.

Low explosives experience deflagration at amounts that fluctuate from a few centimeters per second to about 400 metres per second. Gunpowder or black powder, smokeless powder, flash powder, Pyrotechnics are few common examples of low explosives.

- GunPowder

  Gunpowder was the first chemical explosive. Gunpowder is an admixture of sulfur, charcoal, and potassium nitrate. The sulfur and charcoal acts as fuels, while the potassium nitrate works as an oxidizer. Gunpowder has been extensively used as a propellant in fire arms and as a pyrotechnic composition in fireworks owing to the extent of heat and gas volume that it produces.

- Pyrotechnics

  Pyrotechnics is a methodical technique involving the use of constituents skilled of undertaking self-contained and self-sustained exothermic chemical reactions for the generation of heat, light, gas, smoke and/or sound. Pyrotechnics has the propensity to change a fire into either a burst of striking fireworks or a dense cloud of clogging smoke. The fireworks are a blinking, fiery, short-lived burst of glowing, colored aerial lights.

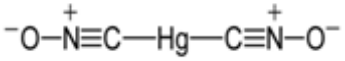
High Explosives

The explosives that detonate, meaning that the explosive shock front passes through the material at a supersonic speed. These are commonly used in carrying out the activities involving mining, destruction, and military applications. The high explosives may be further grouped into primary and secondary high explosives. High explosives experience detonation with explosive velocity ranging from 3 to 9 km/s. RDX, PETN, TNT, ANFO are the examples of high explosives.

Primary High Explosives

The explosives which are extremely sensitive to mechanical shock, friction, and heat, to which they will respond by burning rapidly or detonating are known as primary high explosives. Lead Azide, lead styphnate, DDNP and tetrazene are some of the examples of primary high explosives.

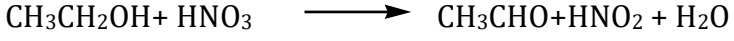
Mercury Fulminate



Mercury fulminate is prepared by dissolving mercury in nitric acid and then pouring into ethanol. A vigorous reaction takes place, which is accompanied by the evolution of white fumes, followed by brownish red fumes and finally again by white fumes. At the same time crystals of mercury fulminate are formed. The grayish colored crystals are recovered and washed with water until all of the acid is removed.

The mechanism for the formation of mercury fulminate and the intermediate steps are as follows:

i. Oxidation of ethanol to ethanol



ii. Formation of nitroso ethanal (nitrosation)

$CH_3CHO+HNO_2 \longrightarrow NOCH_2CHO+H_2O$

iii. Isomerization of nitroso ethanal to isonitroso ethanal

$NOCH_2CHO \longrightarrow HON=CH-CHO$

iv. Oxidation of isonitrosoethanal to isonitroso ethanoicacid

$HON=CH-CHO \longrightarrow HON=CH-COOH$

v. Decomposition of isonitroso ethanoicacid to fulminic acid and methanoic acid

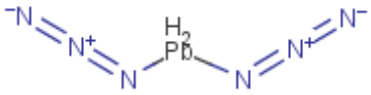
$HON=CH-COOH \longrightarrow C=NOH+ HCOOH$

vi. Formation of mercury fulminate

$2C=NOH+ Hg(NO_3)_2 \longrightarrow (C=NO)_2Hg+2HNO_3$

Lead Azide

Lead Azide is a form of primary explosive. It is prepared by dissolving lead nitrate in a solution containing dextrin, with the pH adjusted to 5 by adding one or two drops ofsodium hydroxide. This solution is heated to 60-65 degree Celsius and stirred. Sodium azide dissolved in a solution of sodium hydroxide is then added drop wise to the leadnitrate solution. The mixture is then left to cool to room temperature with continuous stirring. Lead azide crystals are filtered, washed with water and dried.



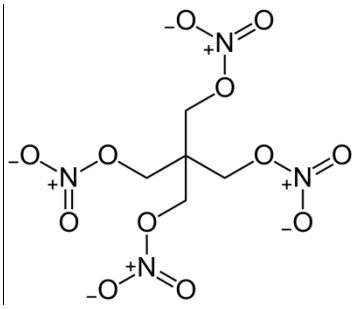
Secondary explosives

Secondary high explosives are also known as base explosives. They are comparatively unresponsive to shock, resistance, and heat. They may ignite when exposed to heat or flame in trivial, liberated quantities. These are sometimes added in small amounts to blasting caps to boost their power. The secondary high explosives may further divide into Boosters (RDX) and Main Charge (Dynamite).

Secondary High Explosives- Boosters

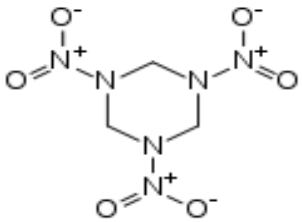
An explosive booster acts as a bridge between a low energy explosive and a low sensitivity explosive such as TNT. It increases the explosive shockwave from an initiating explosive to the degree sufficient to detonate the secondary charge. PETN and RDX are categorized as Boosters.

PETN (Pentaerythritol tetranitrate)



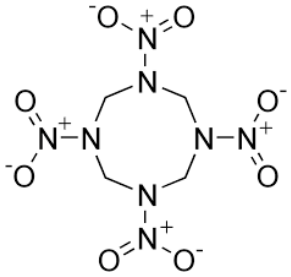
PETN is prepared by nitrating penta erythritol, which in turn is made by mixing formaldehyde with calcium hydroxide in an aqueous solution held at 65-70 degree Celsius. Nitration of pentaerythritol is achieved by adding it to concentrated nitric acid at 25-30 degree Celsius to form PETN. The crude PETN is then removed by filtration, washed with water and then neutralized with sodium carbonate solution and finally recrystallized from acetone. This results in 95% yield of PETN.

RDX (Cyclotrimethylenetrinitramine, 1,3,5-Trinitroperhydro-1,3,5-triazine)



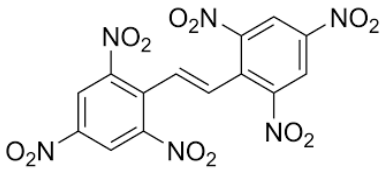
RDX is synthesized by adding hexamethylenetetramine to excess concentrated nitric acid at 25 degree Celsius and warming it to 55 degree Celsius. RDX is precipitated with cold water and the mixture is then boiled to remove any soluble impurities. Finally purification of RDX is carried out by recrystallization from acetone.

HMX (cyclotetramethylenetetranitramine)



HMX is formed as a by-product during the manufacture of RDX by the Bachman process. Hexamethylenetetramine, acetic acid, acetic anhydride, ammonium nitrate and nitric acid are mixed together and heated at 45 degree Celsius for 10 minutes. Ammonium nitrate, nitric acid and acetic anhydride are then slowly added and left on a steam bath for 12 hour. A precipitate forms which contains 27% RDX and 73% HMX.

HNS (Hexanitrostilbene)/ 1,1'-(1,2-ethenediyl) bis [2,4,6-trinitrobenzene]



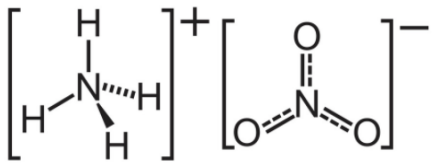
HNS stands for hexanitrostilbene and can be prepared by many methods. For example:

i. By the reaction of nitro derivatives of toluene with benzaldehyde, by the reaction of nitro derivatives of benzyl halgenides with alkaline agents
ii. By removing hydrogen halogenide and also
iii. By the oxidation of nitro derivatives of toluene

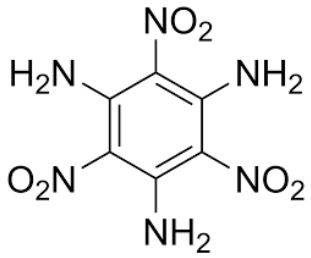
- The first reaction involves heating a mixture of trinitrotoluene with trinitrobenzaldehyde at 160-170 degree Celsius and then cooling the mixture for 2 hours. The product is a low yield of HNS explosive. The increased yield of HNS can be achieved by reacting 2,4,6-trinitrobenzyl halogenide with potassium hydroxide in methanol.
- Another method of forming HNS is the oxidation of TNT with sodium hypochlorite. Ten parts of 5% sodium hypocholride solutions are mixed with a chilled solution of one part TNT in ten parts methanol. The solution is then allowed to stand at ambient temperature until HNS precipitates as a fine crystalline product. The HNS precipitate is then recrystallized from nitrobenzene to give pale yellow-colored needles.

Ammonium Nitrate

Ammonium Nitrate is formed by injecting gaseous ammonia into 40-60% nitric acid at 150 degree Celsius. Dense ammonium nitrate crystals are formed by spraying droplets of molten ammonium nitrate solution (>99.6%) down a short tower. The spray produces spherical particles known as 'prills'. These crystals are non-absorbent and used in conjunction with nitroglycerine

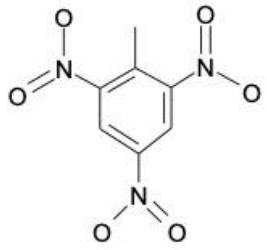


TATB- 1,3,5-Triamino-2,4,6-trinitrobenzene



Another explosive formed by C-nitration process is TATB. It is produced by the nitration of 1,3,5-trichloro-2,4,6-trinitrobenzene, where, 1,3,5-trichloro-2,4,6-trinitrobenzene is prepared by the nitration of tri-chlorobenzene with a mixture of nitric acid and sulfuric acid. 1,3,5-trichloro-2,4,6-trinitrobenzene is then converted to 1,3,5-trinitro-2,4,6-triaminobenzene (TATB) by nitrating with ammonia. The yellow brown crystals of TATB are filtered and washed with water.

TNT-(2,4,6-trinitrotoluene)



TNT is also produced by the C-nitration process. It is formed by the nitration of toluene with mixture nitric and sulphuric acids. Toluene is first nitrated to mono-nitrotoluene and then to di-nitrotoluene and finally to crude tri-nitrotoluene.

Dynamite

Dynamite is basically divided into gelatine and non-gelatine classification. Gelatine dynamite is prepared by dissolving nitrocellulose in nitroglycerine at 45-50 degree Celsius to form a gel. The mixture is stirred by large, vertical mixer blades. Once the gel is formed the other ingredients are added. The explosives mixture is then extruded or pressed into long rods, which are cut into smaller pieces and packaged into paper cartridges coated with paraffin. The manufacture of non-gelatine dynamite is similar to gelatine dynamite except that nitrocellulose is not used in the formulations.

Gelatine dynamites are basically of four types:

- Gelatine dynamite
- Semi gelatine dynamite
- Gelignite and
- Ammonia gelignite

Gelatine dynamite, gelignite and ammonia gelignite contains 25-55% Nitroglycerine, 1% to 5% nitrocellulose, woodmeal as a fuel whereas semi gelatine dynamite contains 15-20% nitroglycerine, 1-5% nitrocellulose and woodmeal act as a fuel. They all differ in the use of oxidizer. Inorganic nitrates are the oxidizer in gelatine dynamite and Semi-gelatine dynamite whereas sodium/ potassium nitrate and ammonium nitrate act as an oxidizer in gelignite and ammonia respectively.

Non gelatine dynamite is of following two types:

- Non gelatine dynamite: Sodium nitrate or potassium nitrate act as an oxidizer
- Ammonia Dynamite: Ammonium nitrate act as an oxidizer

Characteristics of Explosives

The following are some of the important characteristics of an explosive which are very important to determine whether the explosive is suitable for a particular use:

- Availability and cost
- Sensitivity
- Sensitivity to initiation

- Velocity of detonation
- Stability
- Power, performance, and strength
- Brisance
- Density
- Volatility
- Toxicity
- Explosive train
- Oxygen balance (OB% or Ω)
- Chemical composition
    - ✓ Chemically pure compounds
    - ✓ Mixture of oxidizer and fuel

Availability and Cost:- These include availability of raw materials, its cost, complexity and its safety for manufacturing operations.

Sensitivity:- Sensitivity is the ease with which an explosive can be detonated or ignited. An explosive is sensitive to shock, friction or heat. Sensitivity should be considered in selecting an explosive suitable to its particular use.

Sensitivity to initiation:-Sensitivity to initiation is defined by the power of the detonator which is certain to prime the explosive to a sustained and continuous detonation.

Velocity of detonation:-It is that speed with which the reaction process spreads in the mass of the explosive, which is a significant feature of explosive and differs according to the kind of explosive.

Stability:- One of the main characteristic of explosive is its ability to be stored without detonation which is known as stability. The stability is affected by temperature of its storage, chemical constitution of explosive, exposure to sunlight and its electrical discharge.

Power, functioning, and potency:- The power or functioning of an explosive is its ability to do work which is determined by some tests to measure the substance for its proposed use.

Brisance: - Brisance is defined as the shattering effect (break) which is notable and separate from their total work capacity. Brisance regulates the efficacy of an explosion in

disintegrating shells, bomb casings, and grenades. The swiftness with which an explosive touches its peak power is a degree of its brisance. The brisance is tested by sand crush test.

Density: - Density is the mass of an explosive per unit volume.

Volatility:- Volatility of an explosive is the promptness with which it vaporizes. It influences the chemical composition of explosive followed by reduction of stability, which increases the hazard of handling.

Toxicity: - Some of the explosives are toxic to that extent which requires special handling due to hazards caused by them. Besides explosives some of their derivatives, decomposition products, residues, and released gases can also be toxic. The harmful product may be any heavy metal (such as lead, mercury etc), nitric oxides released from TNT and others.

Explosive Train: - Explosive material may be slotted in the explosive train of a device or system. For example pyrotechnic leads to the ignition of booster, this causes the main charge to detonate. Now let's understand what an Explosive Train is. It can be defined as a triggering chain of events that ultimately lead up to the detonation of explosives.

Chemically pure compounds:- Some chemical compounds are unstable. Every molecule of the compound separates into two or more new molecules (mostly gases) with the liberation of energy e.g. Nitroglycerin, Acetone peroxide, organic peroxide TNT, Nitrocellulose, RDX, PETN, HMX.

Oxygen Balance: - Oxygen balance is the degree to which an explosive can be oxidized. The sensitivity, strength, and brisance of an explosive depend on oxygen balance to some extent and approach to their maxima as oxygen balance approaches zero. If an explosive contains oxygen to convert all of its carbon to carbon dioxide, all of its hydrogen to water, and all of its metal to metal oxide with no excess molecules, the molecule is said to have a zero oxygen balance. The molecule is said to have a positive oxygen balance if it contains more oxygen than is needed and a negative oxygen balance if it contains less oxygen than is needed.

Chemical Composition: - An explosive can be characterized based on their Chemical composition which is either a chemically pure compound, such as nitroglycerin, or a mixture of a fuel and an oxidizer, such as black powder or grain dust and air.

- ✓ Chemically pure compounds:- Some chemical compounds are unstable. Every molecule of the compound separates into two or more new molecules (mostly gases) with the liberation of energy e.g. Nitroglycerin, Acetone peroxide, organic peroxide TNT, Nitrocellulose, RDX, PETN, HMX.
- ✓ Mixture of oxidizer and fuel:- An oxidizer is a pure substance (molecule) that in a chemical reaction can contribute some atoms of one or more oxidizing elements, in which the fuel component of the explosive burns. On the simplest level, the oxidizer may itself be an oxidizing element, such as gaseous or liquid oxygen. e.g. Black powder (Potassium nitrate, charcoal and sulfur), Flash powder, Ammonal, Armstrong's mixture, Sprengel explosives, ANFO, Cheddites. Oxyliquits, Panclastites.

METAL DETECTOR

It's the Nineteenth Century. Scientists realize that electricity can be used to pinpoint the location of metal, and what a boon that could be for mining operations! However, early machines were crude, battery hogs, and not particularly effective. Gustave Pierre Trouvé from Paris took a different approach. In 1874, he built a prototype of a handheld device. Its purpose was two-fold. It could be used to detect metal fragments inside injured patients as well as aid miners.

Jump forward to 1881. President James A. Garfield is shot in the back. Doctors cannot find the bullet in order to remove it. Alexander Graham Bell, who knew of Trouvé's invention and was trying to improve it, offers to locate the elusive bullet with a device of his own making. He tries his best but is unable to locate bullet with certainty. Garfield later dies from infection, not from the gunshot itself. Later, others speculate the metal bedsprings interfered with the signals.

In 1931, German immigrant Dr. Gerhard R. Fisher set up shop in his garage, founding Fisher Research Labs. Soon after came the Metalloscope. It's certainly a far cry from today's more lightweight and streamlined devices! But it jumpstarted the hobby worldwide.

Today's metal detectors incorporate the developments from many other individuals, resulting in a very different look. But Fisher is credited with the first portable device available for purchase. Fisher Research Labs is currently owned by First Texas Products, which also owns Bounty Hunter and Teknetics metal detector brands.

Working nature of metal detectors.

The overarching scientific principle at work is that metal, when energized, transmits an electromagnetic field. So, a metal detector creates electricity and sends it through a transmitter coil to create an electromagnetic field that is projected toward the ground. A buried metallic object then creates its own electromagnetic field in response. The receiver coil picks up that secondary field and turns it back into electrical responses. These responses are interpreted in different ways by a tone, and sometimes by a Target ID numerical value or some kind of visual display.

The frequency or frequencies emitted by a detector affect how well it finds certain targets. Generally speaking, low frequencies are better for large objects while high frequencies are better for small objects. There are other factors that can affect performance such as type of soil (and the minerals and salts dissolved within it), electrical interference from other sources, how deep things are buried and their orientation, and so on.

Objects that the metal detectors dectects

Many people think a metal detector can only detect ferrous or iron-based objects. But that's not true. It can detect all kinds of metal, magnetized or not. So, nickel, bronze, brass, copper, lead, tin, zinc, silver, gold, iron, and aluminum objects can be located.

For example, stainless steel and titanium are not good conductors of electricity nor are they magnetic, so they are difficult to locate. Same with pearls, bones, gemstones, stone, and paper. Aluminum, on the other hand, easily conducts electricity even though it is not magnetic. Pull tabs from aluminum cans are a common find.

Sometimes, certain metals require more specific settings or a specialized detector in order to be located more easily.

Found objects can include rings, jewelry, coins, and historical items (known as relics) like musket balls, buckles, old nails, Civil War weapons, and more.

As a result, common subgroups of detecting include:

- ✓ Coin shooting—looking for coins after major contemporary events or searching for coins in general, whether current or old
- ✓ Prospecting—looking for valuable metals
- ✓ Relic hunting—looking for items of historical value
- ✓ Treasure hunting—looking for hidden caches

Types of metal detectors

There are several types. Three common ones are:

- ✓ BFO or Beat Frequency Oscillator. Entry-level detectors typically contain a BFO. It has a large coil in the search head and a smaller one in the control box. Each has a pulse oscillator but on slightly different frequencies. The pulses generate radio waves to create audible tones. The tones change when a magnetic field interferes with them. They are also not as accurate or as controllable.
- ✓ VLF detectors. These are quite popular and tend to be the most common. These Very Low Frequency devices use a single frequency between 6 to 30 kHz and rely on phase shifting between the transmitted and received signals. VLF detectors are a strong muli-purpose option. They even work on dry sand. These devices are sometimes also called Induction Balance detectors.
- ✓ PI or Pulse Induction. This generally uses a single coil that's both transmitter and receiver. It pulses its signals and uses higher frequencies. This kind of detector is better for things deeper in the ground, soils with higher mineral content, and on saltwater beaches.

Features of metal detectors

- ✓ Operating Frequency: VLF detectors can come in a variety of single frequency models. 5 to 10 kHz range are just fine for all-around hunting, as are those up to 30 kHz.
- ✓ Weight. For children, seniors, and those just getting started, a too-heavy detector will make swinging it a chore and cut down on time spent in the field. Therefore, this can be an important consideration.
- ✓ Discrimination and Notch Discrimination. These settings help the detector to ignore certain conductivity levels. This may not be available on many multipurpose detectors.
- ✓ Depth Indicator. This can let a user know about how deep they need to dig into the ground to find the object. Minimal surface disturbance is good etiquette and requires a precise cut. There are accessories that can help with this too, which we'll touch on shortly.

- ✓ Ground Balance. When the soil has a lot of dissolved minerals, the effectiveness of a metal detector diminishes. Many starter detectors come with a preset ground balance for average ground conditions. More advanced ones have automatic ground balance, which adjusts to the actual soil conditions. Some models even feature a manual ground balance.
- ✓ Target ID. A metal detector can't identify what it's found. But many of them can give a hint. There might be a signal strength indicator or an assigned numerical value. Even tone-only ones utilize varying audio qualities, depending on the metal type. Experts suggest that beginners bury different types of things in the backyard and learn how their metal detector responds to each of them as a great way to train the ear.
- ✓ Search Coil. These come in all sizes and different technologies. Bigger ones are certainly going to cost more but will be able to search more deeply.

Composition of Bullets and detecting powder burns

A typical bullet is composed of a lead core (often with added antimony), a metal jacket usually made of brass (copper and zinc), and a primer containing chemicals like lead styphnate and barium nitrate, which when ignited by the firing pin, creates the explosive force to propel the bullet; powder burns are detected by analyzing gunshot residue (GSR) on a suspect's hands or clothing, primarily looking for elements like lead, antimony, and barium from the primer, which can be identified using techniques like scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS).

i. Bullet components:
   Core: Primarily lead, often with small amounts of antimony for added hardness.
   Jacket: Usually brass (copper and zinc alloy).
   Primer: Contains chemicals like lead styphnate and barium nitrate, which ignite when struck by the firing pin.
ii. Gunshot residue (GSR):
   The tiny particles left behind after a firearm is discharged, mainly originating from the primer.
iii. Key elements in GSR: Lead (Pb), antimony (Sb), and barium (Ba).

iv. Detection methods:

Chemical tests: Older methods used chemical reagents like sodium rhodizonate to visually identify lead on surfaces.

Scanning Electron Microscope (SEM) with EDS: The most reliable method for analyzing GSR, allowing for precise identification of elements like lead, antimony, and barium on a sample.

GUNSHOT RESIDUE– CLASSIFICATION AND COMPOSITION

Composition, classification, production and nature of gunshots residues is very complex and their composition depends on several factors like composition of propellants & primers, composition of projection, composition of barrel and barrel fouling.

Composition of Propellants and Primers

Black Powder

Black powder is the oldest recorded propellant invented by Chinese around the tenth century. It has the following composition

- ✓ Potassium nitrate (saltpeter)-75%
- ✓ Finely divided particles of charcoal -15%
- ✓ Sulphur -10%

Saltpeter furnishes the oxygen while the Charcoal and Sulphur are the fuels. Black powder produces lots of smoke that could easily reveal the position of the shooter.

Smokeless Powder

Smokeless powder was developed in the late 19^{th} century to replace black powder as a propellant in weapons as smokeless and is for more energetic propellant per unit weight.

There are two varieties: Single base, Double base

The basic components of the smokeless powder are Nitroglycerine and Nitrocellulose (gun cotton). Nitrocellulose is used alone or in combination with Nitroglycerine, to form smokeless powders. The former is called single base powder and the later double base powder. Cordite and modified cordite are double base powders. Some smokeless powder is an intimate mixture of Nitrocellulose, Potassium Nitrate, Charcoal and sulfur in the approximate ratio of 20: 60: 12: 8.

Primer

In the modern primer, mercury fulminate has been replaced and the composition be:

(a)	Leadstyphnate	32 – 42%
(b)	Antimonysulphide	13 – 17%
(c)	Bariumnitrate	27 – 37%
(d)	PETN	4 – 6%
(e)	Tetracene	3 – 5%
(f)	Aluminium	6 – 8%

Organic Components of Smokeless Powder- The inorganic materials in modern smokeless powders and primers giving rise to GSR can originate from several substances, which are:

- ✓ From primers: Lead, Barium antimony
- ✓ From propellants: Nitrites, Nitrates and carbon monoxide - a gas produced by propellant and gets absorbed by skin and flesh, turning them to bright red color or cherry red Colour.
- ✓ From Jackets Copper, Zinc and Nickel also in cases where shells are coated with Nickel.
- ✓ From barrels: Iron from barrels
- ✓ From bullet: Lead
- ✓ From carbon in propellants: Particles of carbon

All these GSR are produced from propellants primers bullets and jackets and are inorganic in nature.

Organic Components of GSR

i. Nitrocellulose, the unburnt or the semi-burnt part of the main component of the propellant.
ii. Lubricants used for lubricating bullets are organic in nature and appear as GSR.
iii. When double base propellants are used, the unburnt and semi-burnt parts of Nitroglycerine.
iv. Organic materials used as plasticizers are also detected as GSR.

Collection of GunShot Residue

Dry Methods of Collection of GSR

i. A cellophane sheet is impregnated with acetic acid, after impregnation the same is pressed against the site. It will pick up bad particles.
ii. Use of adhesive tapes: An inert adhesive tape (or an adhesive aluminum tape) is pressed against the site bearing the GSR many a times to pick up the desired GSR which can then be subsequently selected for examination.
iii. A solution of cellulose acetate is applied bearing the GSR. When it gets dried up it may be peeled off and the gunshot residues will be picked up by the cast.
iv. The site bearing the powder marks is sprayed with a colloidal solution. The film is reinforced with nylon fibers. The reformed film that picks up the GSR is peeled off on drying.
v. The residues in the barrel are collected by washing the same with hot distilled water. The washings are tested for constituents of the gun powder residues

<u>Collection of Organic Residues</u>

The evolution of the organic component of GSR is gaining importance day by day and especially in the recent times. Some of the techniques of collection are mentioned briefly:

i. Technique of Swabbing

   A clean piece of cloth or a filter paper is moistened with an organic solvent, which may by acetone, alcohol or ether and the site suspected of containing GSR is swabbed. The swabs are collected and extracted.

ii. Tape lifting technique

   An inert tape having 2-3 cms width is taken and the site is taped to pick up all GSR- of organic and inorganic origins. This technique is becoming very popular because of convenience in collection of both organic & inorganic GSR as well being economical and can be carried out quickly.

iii. Vacuum Lifting Technique

   This technique is especially suitable for collecting of GSR from clothes. The material deposited on the filter dust is extracted with a suitable solvent for further processing. Sometimes the lack of color contrast between the powder and the garment or presence of heavily encrusted deposits of blood can obscure the visual detection of gun powder. Often an infrared photograph of suspect area, on the garment, overcomes such the problem.

UNIT-III: Forgery and Counterfeiting

Forgery and counterfeiting are both crimes that involve making copies of something with the intent to deceive. Forgery usually involves documents, while counterfeiting usually involves physical items like money.

Forgery

- Involves altering genuine documents like checks, passports, or birth certificates
- Can be difficult to detect with the human eye
- Can require digital tampering detection software

Counterfeiting

- Involves making false money, securities, or consumer products
- Can be detected physically, such as by feeling the texture of the bill
- Can be detected by using iodine currency pens

Penalties

- The penalties for counterfeiting range from fines to imprisonment
- The severity of the punishment depends on the value of the forged goods

Related laws

- Counterfeiting is a federal crime in the United States
- Laws against counterfeiting are relatively uniform across countries
- Producing counterfeit goods, such as fake designer products or knock-off electronics, also falls under trademark infringement laws.

There are multiple types of signature forgery, including freehand simulation, trace-over fraud, blind forgery, and electronic forgery.

Types of forgery signature

- Freehand simulation: Forging a signature by imitating the signer's style by hand
- Trace-over fraud: Forging a signature by tracing over an existing signature
- Blind forgery: Forging a signature without seeing the original signature
- Electronic forgery: Forging a signature using electronic image-editing software
- Automatic pen machines: Forging a signature using a machine that mimics the signer's pressure and movements
- Signature forgery apps: Forging a signature using mobile apps and software

Auto forgeries

An auto forgery is when someone pretends to forge their own signature so that they can contest the validity of the check or document. This is a type of friendly fraud. The same strategies that can help you detect between skilled forgeries and legitimate signatures can often help you tell when someone has signed their own name in a different manner or using their non-dominant hand.

Blind forgery

A blind forgery doesn't attempt to mimic the real signature. Typically, the thief doesn't have access to the real signature. They just sign a cheque, credit card slip, or loan document and hope for the best. These are the easiest types of signatures to detect especially when dealing with cheques.

Electronic manipulation

Thieves use this strategy to alter signatures in digital or paper documents. They utilize Photoshop or other design programs to copy legitimate signatures and add them to documents. Spotting these types of forgeries requires advanced tools or forensic experts.

Free-hand simulation

A free-hand simulation is when a thief draws someone's signature. They study the shapes and lines in the signature, and then, they try to replicate them. An automated signature verification tool can spot this type of forgery more efficiently than a teller or bank employee.

Guided hand forgeries

This is when someone guides someone else's hand to help them sign their own name. This isn't necessarily a sign of fraud. Typically, guided forgeries happen when someone wants to sign a document but struggles to do so on their own due to age or health conditions. These types of signatures don't look natural, and they often miss legitimate details.

If system is regularly flagging a certain customer's signature as forgeries but they're working with a relative or a health care provider to produce a guided signature, it may be avoided by a power of attorney on their account rather than signing in this way.

Practiced simulation

This phrase refers to a free-hand simulation where the thief practices to emulate the target's signature. However, practicing someone's signature a few times produces a lot different result than when someone signs their own signature thousands of times during their lifetime.

Practiced forgeries often have the right shape, but they're written more slowly. This is why it's critical to use signature verification tools that look beyond static elements like the shape of the signature and analyze dynamic elements related to how the signature was written. For example, practiced simulations often use the same pressure throughout the signature. Real signatures, in contrast, vary their pressure at random points. This is a dynamic element of the signature.

Random signatures

This is another name for a blind forgery. It just means that the thief has presented a random signature instead of the real one. For example, this is the type of forgery that occurs when someone steals a box of checks from a stranger but has no signed checks to model their forgery on.

Simple forgery

A simple forgery is the same as a blind or random forgery. When someone forges a check with no reference signature, the result is nothing close to the legitimate signature. This often affects financial institutions when a merchant accepts a forged check and deposits it in their account at your bank.

Skilled forgeries

A skilled forgery uses free-hand simulation. The forger studies the target's actual signature or even just a writing sample. They learn the shapes and strokes used in the victim's real handwriting, and then, they emulate these elements when they copy the signature.

However, it's generally impossible for the forger to suppress their own patterns. They tend to bring in elements of their own signatures, and as a result, the forgery loses the victim's markers of authenticity.

Trace-over forgery

In this case, the thief has access to the real signature, and they trace over it to produce a close facsimile of the original. These forgeries are harder for the naked eye to detect than a simple or blind forgery, but their telltale give is heavy lines and a lack of fluidity. Spotting forgeries is nearly impossible without extensive training and even highly experienced forensic analysts can't necessarily spot skilled forgeries. To protect your bank from forgeries on checks or other documents, you need signature verification tools that can spot the differences between forgeries and real signatures.

At SQN Banking Systems, our **signature verification tools** scan transactions for signs of forgeries. Then, they display the potential forgery next to the reference signature so that your employee can easily review the issue. We also offer tools to help facilitate e-signature collection and storage as well as solutions to address a broad range of fraud and cyber risks. To learn more, contact us today.

Inherent signs of forgery methods

Inherent signs of forgery methods include: inconsistent pen pressure, unnatural letter formations, abrupt starts and stops, tremors or shaky lines, uneven spacing, visible tracing lines, obvious retouching, significant variations from a person's typical writing style, slow and deliberate strokes, and a lack of natural flow in the writing, especially when comparing to known genuine samples.

- **Pen pressure inconsistency:** A forged signature might have very even pressure throughout, lacking the natural variations in pressure seen in a genuine signature.
- **Unnatural letter formations:** Letters may appear overly perfect or have unusual shapes, indicating an attempt to mimic another person's writing style.
- **Abrupt starts and stops:** Sharp beginnings and endings of strokes can be a sign of a forgery, as someone trying to copy a signature might lift the pen more frequently than a natural writer.
- **Tremors or shaky lines:** Visible tremors or shaky lines in the writing can indicate hesitation or an attempt to carefully copy a signature.
- **Uneven spacing:** Inconsistent spacing between letters or words can be a giveaway for a forged document.

- **Visible tracing lines:** If a signature was traced, faint indentations or outlines from the original document might be visible.
- **Obvious retouching:** Areas where the writing appears to have been altered or "cleaned up" can be a sign of forgery.
- **Significant variation from normal writing:** Comparing the suspected forgery to a known sample of the person's writing should reveal significant differences in style, letter formation, and overall flow.
- **Slow and deliberate strokes:** Forgers often write slowly and carefully, resulting in visible hesitation and unnatural stroke patterns.
- How to detect forgery:
- **Compare to known samples:** Always compare the suspected forgery to a verified sample of the person's handwriting or signature.
- **Use a magnifying glass:** A magnifying glass can help identify subtle inconsistencies in pen pressure, stroke direction, and letter formations.
- **Consult a document examiner:** For complex cases, seeking professional expertise from a forensic document examiner is recommended.

Identification of forgery

A forged signature can be identified by looking for: Inconsistent pen pressure, Variations in pen lifts, and other warning signs.

Preventing forgery

Forgery can be prevented by:

- Verifying documents
- Using secure authentication methods for items of value
- Training personnel on how to recognize signs of forgery
- Using digital signature verification, which compares a presented signature to a reference signature

Preventing signature forgery involves implementing security measures and best practices to make it difficult for forgers to replicate signatures and commit fraud.

The following steps individuals and businesses can take to prevent signature forgery:

i. Document security: Implement secure document storage and access controls. Use locked cabinets or secure digital document management systems.
ii. Employee training: Educate employees about the risks of signature forgery and provide training on verifying signatures.
iii. Authentication procedures: Develop and follow robust authentication procedures, especially for financial transactions and important contracts.
iv. Use digital signatures: Consider using digital signatures for electronic documents, as they provide a higher level of security.
v. Secure access: Restrict access to sensitive documents and accounts. Only authorized personnel should have access.
vi. Regular auditing: Conduct regular audits of financial records and contracts to detect any irregularities or suspicious activity.
vii. Anti-fraud software: Consider using anti-fraud software and tools to detect suspicious activities and prevent unauthorized access.
viii. Background checks: Conduct background checks on employees who handle sensitive documents or have access to financial accounts.
ix. Tamper-evident seals: Use tamper-evident seals or security features on important documents to make any alterations immediately noticeable.
x. Regularly update security measures: Stay current with security technology and best practices, updating your measures as needed to address evolving threats.

Using advanced security technologies to prevent signature forgeries

In the ever-evolving landscape of technology, where challenges loom large, our greatest allies emerge from within – innovative technologies that stand as vigilant guardians, preventing and overcoming pitfalls such as signature forgery. Advanced security technologies are crucial in preventing signature forgery, providing robust authentication methods, enhancing document integrity, and deterring fraudulent activities.

1. Biometric signature verification

Biometric authentication provides an unparalleled level of security by analyzing unique traits like fingerprints or handwriting patterns to verify a person's identity and signature

authenticity. This advanced method ensures that only the authorized individual can sign a document, deterring potential forgeries and safeguarding against unauthorized access.

2. Digital signature technology

Digital signatures use encryption and cryptographic algorithms to secure electronically signed documents, guaranteeing their integrity, authenticity, and non-repudiation. These cryptographic techniques create a digital "fingerprint" of the document, making any alterations detectable, thus bolstering trust and confidence in digital transactions.

3. Blockchain-based authentication

Blockchain technology, renowned for its decentralized and immutable nature, offers a tamper-resistant storage system for signature data. As each signature is recorded in a chain of blocks, any attempt at altering or forging the signature becomes nearly impossible due to the distributed nature of the blockchain.

4. Secure signature pads and devices

Specialized signature pads and devices come equipped with security features that ensure the secure capture and storage of signatures. With encryption and authentication mechanisms, these devices prevent tampering, guaranteeing the authenticity of signatures and minimizing the risk of fraudulent activities.

5. Optical character recognition (OCR)

OCR technology analyzes the consistency and characteristics of signatures against known samples, allowing for signature verification. By detecting irregularities or discrepancies in the signature patterns, OCR assists in identifying potential forgeries, providing an extra layer of security in signature authentication processes.

Writing deliberately modified forgery methods

- Direct technique – forger works directly with ink
- Indirect techniques – forger work first with pencil and afterwards covers the pencil strokes with ink.

Simulated free hand forgery – Used by forgers who have a certain skill in writing. After some practice, the forger tries to write a copy of the model quickly. Simulated forgery is the act of copying a signature or writing by drawing it. It's also known as "free hand forgery".

Creation of simulated forgery

- Forgers may use a genuine signature as a model to create an artistic reproduction.
- Forgers may trace the signature using various methods.
- Forgers may use an electrostatic copier or computer to reproduce the signature.

The indicators of simulated forgery

- Tremors
- Blunt letter forms
- Lack of spontaneity
- Slow, hesitant, and tremulous line quality
- Pen lifts
- Blunt starts and stops
- Patching
- Static pressure

Identification of simulated forgery

A determination can be made that the writing was produced by simulation.

- If the writing contains enough normal characteristics of the writer's true hand, it may be possible to identify the writer.
- Under magnification, simulated signatures may reveal numerous pen stops and lifts or signs of correction.

Uses of UV rays

Ultraviolet (UV) rays are primarily used for disinfection, including killing bacteria and viruses, which make them valuable in medical settings for sterilizing surgical equipment, purifying water, and treating certain skin conditions like psoriasis; they are also used in industries to cure inks and resins, detect counterfeit currency, and contribute to vitamin D production in the body through sun exposure.

Key applications of UV rays:

- **Medical applications:** Sterilization of surgical tools, treating skin conditions like psoriasis with phototherapy, blood irradiation
- **Water purification:** Eliminating bacteria and other microorganisms in drinking water

- **Industrial applications:** Curing inks and resins, surface treatment, hardening dental fillings
- **Forensic applications:** Detecting fingerprints with fluorescent powders under UV light
- **Security applications:** Identifying counterfeit currency with UV markings
- **Tanning beds:** Stimulating melanin production in the skin for a tan (although excessive exposure can be harmful)

Types of written letter

When comparing types of written letters there are two types; Formal and Informal

- Formal letters, which are professional and follow a strict format
- Informal letters, which are more casual and personal, written to friends and family, with a relaxed tone and structure

Specific types of letters within these categories include business letters, cover letters, complaint letters, and friendly notes depending on their purpose and recipient.

Formal Letters:

i. Business Letter: Correspondence between companies or businesses and clients regarding official matters.
ii. Cover Letter: A letter accompanying a job application highlighting qualifications and interest in a position.
iii. Complaint Letter: A letter to address a grievance or issue with a company or service.
iv. Letter of Recommendation: A letter written by someone familiar with an individual to endorse them for a job or program.

Informal Letters:

i. Friendly Letter: A casual letter written to a close friend or family member sharing personal updates.
ii. Thank You Note: A short letter expressing gratitude for a gift or kind gesture.
iii. Invitation Letter: A letter requesting someone's attendance at an event.

Key Differences:

i. **Tone:** Formal letters use a serious, professional tone while informal letters are friendly and conversational.
ii. **Format:** Formal letters adhere to a set structure with specific salutations, closing phrases, and layout, whereas informal letters have more flexibility in formatting.
iii. **Recipient:** Formal letters are typically sent to authorities, companies, or unknown individuals, while informal letters go to close acquaintances.

Checking silver line water marrk

One of the easiest ways to check the authenticity of an Indian banknote is by examining Mahatma Gandhi's watermark. In genuine notes: The watermark is embedded into the paper during the manufacturing process and is visible when held against the light. The image appears clear, with no distortion or extra thickness.

Identification of a Fake Currency Note

1.Mahatma Gandhi's Watermark-One of the easiest ways to check the authenticity of an Indian banknote is by examining Mahatma Gandhi's watermark. In genuine notes:

- The watermark is embedded into the paper during the manufacturing process and is visible when held against the light.
- The image appears clear, with no distortion or extra thickness.
- Fake notes often have a blurry, greasy, or rough image due to poor reproduction methods.
- **Checking process:** Hold the note against a light source and ensure that the watermark is distinct and consistent with the denomination.

2. Security Thread-The security thread is a crucial feature that runs through the note. In real currency:

- The security thread is partially visible and appears as a broken line under normal light.
- When tilted, it appears continuous and shows inscriptions such as "भारत" (Bharat) and "RBI."

- Counterfeit notes often have a printed imitation of the security thread, which lacks depth and shifting effects.
- **Checking process:** Hold the note at an angle under a light source and observe the thread for embedded text and colour shifts.

3.Ink Quality and Printing Precision**-** Authentic notes have high-quality ink and precision printing. Signs of fake currency include:

- Smudged ink or broken lines.
- Discoloration or dull text that appears faded.
- Uneven printing where some letters or numbers are not properly aligned.
- **Checking process:** Closely examine the print clarity under good lighting. The edges of images and text should be sharp, not blurred.

4.Formatting and Serial Numbers**-** Every currency note has a unique serial number. Genuine notes maintain:

- Uniform font size, spacing, and alignment.
- Perfectly aligned numerals without uneven gaps.
- Counterfeit notes often have misaligned numbers or inconsistent fonts.
- **Checking process:** Compare the serial number with another genuine note of the same denomination to spot irregularities.

5.Typography and Micro-lettering**-** Micro-lettering is a special feature that appears in small font size, visible only under magnification. On real notes:

- The words “RBI” and the denomination appear between Mahatma Gandhi’s image and the security thread.
- The text is sharp and well-defined.
- Counterfeit notes often have blurred, missing, or misspelled micro-lettering.
- **Checking process:** Use a magnifying glass to examine the micro-lettering.

6.Devanagari and Regional Languages**-** Indian banknotes display the denomination in both English and Devanagari on the front, with the reverse side featuring 15 regional languages. Counterfeit notes may:

- Have inconsistent font styles.
- Show missing or poorly printed regional language scripts.

- **Checking process:** Compare the denomination script with an authentic note and look for printing inconsistencies.

7.Intaglio (Raised) Printing**-** Genuine currency notes feature raised printing that can be felt by touch. This includes:

- The Mahatma Gandhi portrait.
- The Ashoka Pillar emblem.
- Braille identification marks for visually impaired individuals.
- Counterfeit notes often have flat or indistinct embossing.
- **Checking process:** Run your fingers over the note. Authentic notes will have a textured feel, whereas fake notes may feel smooth.

Detection of gold purity in 22 carat ornaments

To detect the purity of gold in 22-carat ornaments, you can utilize methods like acid testing (nitric acid test), look for the BIS hallmark (916), or use an electronic gold tester.

Methods for Detecting Gold Purity in 22-Carat Ornaments:

i. Acid Testing (Nitric Acid Test):
   This method involves applying nitric acid to the gold alloy and observing the reaction to assess its purity.
   A professional jeweler or assaying lab will typically perform this test.
   The reaction of the acid with the gold will indicate the purity level.

ii. BIS Hallmark (916):
   22-carat gold is also known as 916 gold, meaning it contains 91.6% pure gold.
   Look for the "916" hallmark on the jewelry to verify its purity.
   The BIS (Bureau of Indian Standards) hallmark indicates that the gold content has been evaluated and adheres to international standards of purity.

iii. Electronic Gold Tester:
   These devices measure the gold content in jewelry using a non-destructive method.
   They can provide a quick and accurate assessment of the gold purity.

iv. Hydrostatic Weighing: This method involves measuring the weight and volume of the gold sample to determine its density, which can help determine its purity.

v. X-ray Fluorescence (XRF) Analysis: This technique uses X-rays to analyze the elemental composition of the gold, providing a precise measurement of its purity.
vi. Touchstone Test: This involves rubbing a gold sample against a dark, porous stone (touchstone) and then applying different acid strengths to determine the gold's purity.
vii. Mobile App Verification: The Bureau of Indian Standards (BIS) has created a smartphone application called the 'BIS Care App' to track all ISI and hallmark-certified gold and silver jewellery

Detection gold-plated jewelry,

Methods employed to detect gold-plated jewelry like acid testing, examining for hallmarks, and checking for a magnet, as a magnet will not stick to gold.

i. Acid Testing: A small scratch is made on the piece, and a drop of acid solution is applied to the mark. Different acid solutions correspond to specific gold purity levels. If the jewelry reacts differently or dissolves in the acid, it may not be genuine gold.
ii. Examining for Hallmarks: Look for stamps or markings on the jewelry that indicate the gold content or type of plating (e.g., "RG" or "RGP" for rolled gold or rolled gold plate). Gold, white gold, and rose gold all use the same hallmark as they start as fine gold and are mixed with alloys.
iii. Magnet Test: Gold is not magnetic, so if a magnet sticks to the jewelry, it's likely not solid gold. A magnet will not stick to genuine gold.
iv. Ultrasonic Testing: This method can be used to detect fake gold bars or coins, but it may be less reliable for jewelry with complex shapes or thin materials.
v. XRF and SEM: These methods can be used to analyze the composition of the jewelry and determine the presence of gold.
vi. Tapping Test: For gold bars or coins, tapping with a hammer and listening for the sound can help distinguish between solid gold and fake gold.
vii. Visual Inspection: Look for signs of wear or discoloration, as gold plating can wear off over time.

Authenticity of a diamond

the authenticity of a diamond can be verified by reputable diamond grading reports from organizations like the Gemological Institute of America (GIA) or the International Gemological Institute (IGI), which provide detailed assessments of the 4Cs (cut, color, clarity, and carat weight).

Reputable Grading Reports:

i. GIA (Gemological Institute of America): GIA reports are known for their thoroughness and unbiased assessments, providing a detailed analysis of the diamond's characteristics, including its 4Cs, and any known treatments. It also provide a full description of the diamond, including color, weight, measurements, and cutting style, and will disclose any known treatments.
ii. IGI (International Gemological Institute): It also offers grading reports that can help verify the authenticity and quality of a diamond.
iii. Look for a Certificate: When purchasing a diamond, always ask for a certificate from a reputable grading lab. This certificate should include details like the diamond's shape, dimensions, carat weight, color grade, clarity grade, and any treatments performed.

Concept of 4Cs:

- Cut: Refers to the diamond's shape and the angles and facets that determine its brilliance and sparkle.
- Color: Measures the absence of color in a diamond, with colorless diamonds being the most valuable.
- Clarity: Refers to the absence of inclusions and blemishes within the diamond.
- Carat Weight: Measures the diamond's weight, with one carat equal to 200 milligrams.

Beware of Imitations:

- ✓ Lab-Grown Diamonds: These diamonds are created in a lab and are chemically identical to natural diamonds, but they can be identified through specialized testing.
- ✓ Cubic Zirconia: A common imitation of diamonds, cubic zirconia is a synthetic gemstone that is much softer and has a different refractive index than real diamonds.

UNIT-IV: Tracks and Traces

Tracking is one of the oldest sciences known to man. Before the development of agriculture, hunting was major occupation of the primitive man and was the main source of supplying him food and clothing. The men of these ages learnt to distinguish the track made by the dangerous animals from the track made by other animals, which were likely to call an easy prey to his crude weapons and provide him with food. His existence depended on the ability to master the science of tracking. This science of tracking has been kept alive by 'Shikaris' and professional trackers in remote regions of various countries of the world. The Khojis, a group of untrained and illiterate tribal people is known for their skill in tracking down criminals. Though they may have difficulty in explaining their methods, but have a high degree of skill in observing, tracking and comparing the criminals even from the partial footprints by observing the presence of an additional toe, absence of any toe, scars or wrinkle pattern and other peculiarities such as tissue growth on foot; each of these taken as an extra advantage for the identification of an individual. The police in tracking down the criminals employ a few of these professional trackers. There are numerous stories of the incredible feats performed by these professional trackers. Despite advancements in the scientific aids in the investigation of crime, the older techniques of tracking by Khojis are still capable enough to produce good results.

Nature:

Track marks are varied in nature; naked footprints, footwear marks, paw marks, tyre marks, dragline of a load; impression of a stick or pugmarks of a beast are also included in track evidence. Individual marks and their collective patterns are both useful in the identification of individuals.

A mark may be a print or an impression. A mark having two dimensions like length and breadth is called *print,* while a mark with three dimensions length, breadth and height or depth, is an *impression.* The terms 'print' which is usually found on hard surface and impression which is mostly found in comparatively soft surface. So the term 'marks' includes both prints and impressions.

Objects smeared with powders and liquids leave prints on various surfaces. Thus, a foot or footwear smeared with either dust, ink, oil or blood etc. leaves print. Prints can also be found on oiled, waxed or dusty surfaces without being smeared.

Foot and footwear impressions can also be found on surfaces like soft clay, mud and snow etc.

Footprints

The footprints are generally found almost at every crime scene as none can tread on the ground without leaving foot or footwear prints/impressions (collectively termed as marks). These marks are mostly found at the following points:

- At the point of entry,
- At the scene where crime took place, where the struggle or fight has taken place.
- The route through the crime scene. This may or may not be apparent.
- At the point of exit. It can sometimes be harder to find than at the point of entry.

Footprints are particularly helpful in personal identification of the suspect because each footprint is unique. Careful scientific examination of these footprints yields information, which aids in linking the suspect with the crime scene or the suspect was present at the scene of the crime.

Footprints also give indications about the number of individuals present at the scene of crime. They may also indicate whether struggle has taken place or not, about the routes taken by the culprit, their assembly points, their conference site, their hiding places etc.

The investigator overlooks these marks and valuable information is lost, this might have happened due to number of reasons like:

- Incomplete searching
- Entry and Exit points of crime scene are not known
- Arrived at the scene after the area has been walked all over, or
- Weather may not be conducive to record permanently.

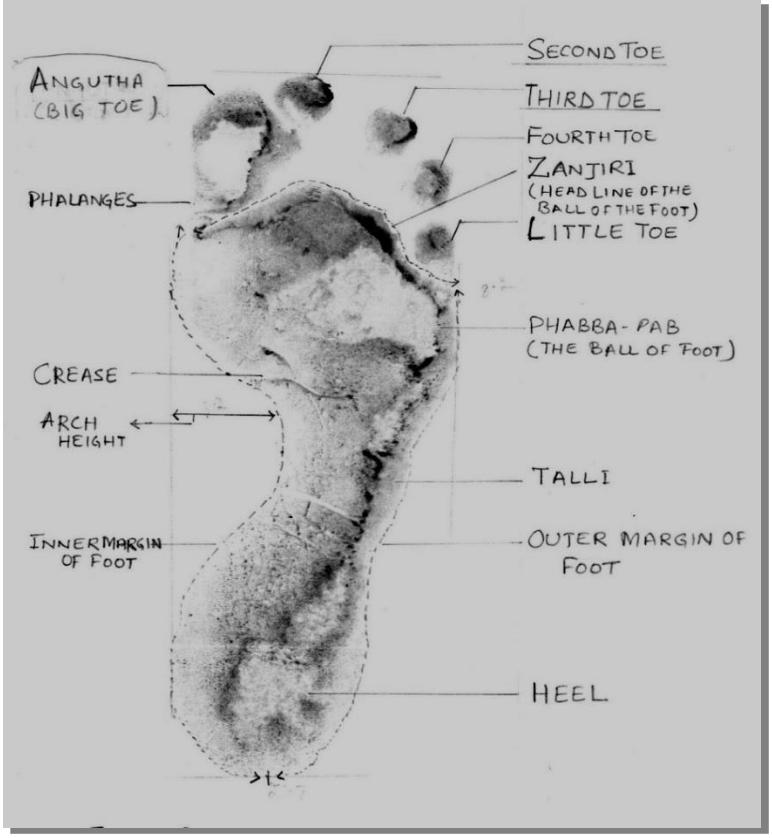
It is well established that everybody part including feet are in proportion to the total body height. Thus, the foot measurements can be useful to find approximate height of the person.

Footwear Marks

Footwear marks include the marks of shoes, sandals and chappals. The footwear can be factory-made or handmade. It is made up of leather, rubber (natural or synthetic) or plastics. Cloth is used in canvas shoes.

In some parts of India shoes are also made from strings alone. The persons especially in rural areas wear hand-made leather shoes.

The soles of a pair of shoes may be stitched, nailed or pasted with the upper leather. Ordinarily this stitching and nails are used in combination. The adhesive are increasingly used.



The footwear evidence suffers from one great drawback. If the culprit is not taken in custody soon after the commission of crime and continues to wear the shoes, the additional wear and tear will change the original surface pattern and identification of the marks may not be possible with respect to shoes. The time after which the marks become unidentifiable cannot be given. It varies or deteriorates with the extent of use or misuse, nature of the sole material and the territory in which it is used.

It is always advisable to get the footwear marks compared even when it is recovered after a considerable interval of time.

On the other hand, footwear marks are identified with respect to the footwear in about eighty percent cases. The belief of the judiciary, the bar and the investigating officer that the naked footmarks are more valuable than the footwear marks is, therefore, not correct.

In case of footwear marks, it is necessary to establish that the culprit owned and wore the particular shoe at the material time as the footwear mark identifies the footwear and not the wearer. Other evidence must establish the latter.

Tyre Marks

In crime cases motor vehicles are very frequently involved for coming at and going away from the crime scene after commission of crime. The tyre marks left by the vehicles used can be valuable evidence in narrowing down the type of vehicle involved and the route adopted before and after the commission of crime. The tyre marks are also like footprints, either two-dimensional prints or three-dimensional impressions depending upon the surface on which they are present.

Skid Marks

Skid marks are the marks left by wheels of motor vehicles, which are no longer rotating. These marks are characteristic in appearance and caused due to the wheels sliding across the surface of the road. Skid marks are short-lived type of evidences, which are left at the scene and play an important role in the successful reconstruction of a road traffic incident. They help in the estimation of speed of the vehicle which is an important consideration in a 'hit and run' crime scene or in case of vehicle clashes.

Pug-Marks

The term pugmark refers to the footprints of almost all the animals. Every individual animal species has a distinct pugmark and it is used as a means for identification. Wildlife conservationists are often engaged in collecting different sort of data regarding the pugmarks in the areas specifically assigned to them. Pugmarks are also used for tracking

rogue animals which maybe a danger to mankind or even to themselves because of injuries etc. Trained wildlife investigators make an accurate identification of species, sex, age and physical condition of an animal by analyzing their specific pugmarks.

Extraneous Matter

Footwear sometime also picks up secondary evidences like dust, dirt, paint and other materials from the places through which the wearer passes. The study of these traces or secondary evidences proves useful in cases where the places visited have characteristic soil or dust. For example, the shoe will pick up flour in a flourmill, coal from a colliery, dye from a dye factory, and fibers from a cloth mill and so on. Even the soils from different places give significant variations when chemically analyzed in the forensic science laboratory.

Collection and Preservation of Track Marks

After carefully observing the track marks at most probable locations (mostly at the point of entry, crime scene and at the point of exit or away from the scene), it is most important to collect and preserve the track marks (Which include foot print, footwear marks and tyre marks). Depending upon the marks whether they are two or three-dimensional, proper technique is required to be adopted.

Foot prints on Floors

Footprints are often present at the inner location of the crime scene, especially on hard surfaces such as floors, glass, counter tops, desktops, and chair seats etc. A simple procedure to locate these indoor prints is by means of a high-intensity light at a low angle. Often these prints (two dimensions) are dust prints and very easily destroyed. Once detected, every care must be taken to preserve it.

Footwear and Tyre marks

Although great emphasis has been given to the footprints, follows concerning collecting and preservation, this type of evidence applies equally well to tyre marks evidence.

Foot impressions (three dimensional) are generally found outside the crime scene i.e. at the point of entry or exit; the first precautionary measure is therefore to protect the impression from alteration or destruction, preferably by covering it with a box or cordoning off the whole area. Impressions in thawing snow are especially difficult, so a box covered with snow to prevent thawing should protect them. If a foot impression is in such a A capable crime scene investigator on reaching the crime scene try to recognise, collect

various types of evidences to solve the crime by identifying the person who have committed the crime. These evidences in the form of foot/footwear and tyre impressions have to be preserved properly to be used in the court of law as follows:

Preservation of Footwear Evidence

Footwear evidence could be preserved either by taking photographs or by preparing casts (three dimensional) depending upon the surface on which they are present or, by lifting, in case of two dimensional dust prints.

Footwear Impression

Photographing Track Impressions

In all the cases, before attempting to collect the track marks, it is mandatory to record them first with the help of notes, sketches and then with photography. Photographs need to be taken both at a distance from the track marks and close to it.

In a photograph taken from distance, the location of the number of track marks should be fixed with respect to some fixed objects or landmarks. Then to record every detail of the track marks, close-up photographs should be taken by putting either one or preferably two scales (one horizontal and other vertical) along with the track marks. Close-up photos should indicate size, shape, and any irregularities (in the form of wear marks). While taking photographs or to avoid distortion, the following precautions should be taken:

- The lens of the camera should be kept parallel to the track marks.
- Proper arrangement should be made to get greater depth of field and all the important points should be in sharp focus.
- Identification marks should be put along with the track marks.
- Proper lighting arrangement should be made.
- A tripod is suggested for most close-up photography.

Although large format cameras, e.g., 4 x 5 or 2-inch formats, allow for larger negatives, but 35 mm cameras are more widely used for crime scene work and produce good acceptable results. The quality of photographic films should be very good. Footwear and tyre impressions require film that can capture finer details; therefore, fine-grained films are best suited for this purpose. Prints can be clicked either with Black-and-white or color films. High-resolution digital cameras can provide good results for track mark impression examination.

Before taking photographs, any extraneous matter that may have fallen into the impression after it was formed should be cleaned away with the help of tweezers. If it is not possible to carry out this cleaning without disturbing the details of the impression, it should be omitted.

Materials trampled into the impression, such as leaves or grass, should not be removed because they form part of the impression and no details will be found under them. Careless removal of a trampled blade of grass can destroy parts of the impression. If a foot impression has been found in snow, it may be difficult to get a clear picture of it. Hard snow may be dusted with aluminum powder, which gives a clearer picture.

Cast of footwear impressions is generally made with dental stone powder. Other materials include paraffin, sulfur, and silicone rubber, can be utilized, but are less frequently used.

Casting Procedure for Track Marks

When three dimensional track marks such as a footprint or tyre track is encountered, a positive cast of it should be made. Several types of casting materials are commercially available like plaster of paris and dental stone (which are a type of gypsum or calcium sulfate) etc. But plaster of paris is one of the most commonly preferred casting materials at the crime scene because it is inexpensive; easy to use and best to record the details of the marks exactly the way they were in reality. Another advantage of plaster of paris is that it solidifies very quickly.

Detailed steps involved in the procedure for making cast with the most common casting material plaster of paris (Fig. 2-6) are as follows:

After photography of the track marks with and without a scale, examine the area containing track marks carefully. Any precautions thought necessary to protect the integrity of the track marks must be taken.

Foreign matters or loose pieces or leaves (if any) should be vigilantly removed without disturbing the surface of the mark. Any accumulated water or liquid if available should be removed with a pipette or plastic syringe.

The impression is prepared for casting, if necessary. Particularly, when three-dimensional impression is in loose, dry sand or soil, the surface must be prepared by spraying shellac or lacquer solution onto a cardboard deflector held above the mark at a 450 angle so the sprayed liquid falls onto the pattern surface by gravity, rather than being propelled by a potentially disruptive jet of gas.

The shellac or lacquer will harden the surface of the mark by binding the loose particles of soil, once dried, make it suitable for casting. If the pattern is in very dry, firm dirt, it should be sprayed with light oil.

A physical barrier to restrict the flow of the plaster must be set up around the impression i.e. with aluminum frame as shown in fig-4, 5&6. Commercially manufactured metal frames are available for this purpose, but any material (cardboard, wood strips, metal frame) that will retain plaster and confine it to the immediate area of the mark will suffice. A little ingenuity with commonly available materials will solve most containment problems.

Showing Containers and Frame Used for Preparation of Cast

Showing Sunken Foot Print

Showing Frame Placed around the Foot Print

Showing Casting Procedure

Showing Completion of Foot Print Cast

Showing various stages in the preparation of caste of foot or footwear impression

The recent methods for lifting wet footprint impressions by making use of dental stone or gypsum and liquid silicone commonly known as 'microsil'.

Preservation of Two Dimensional Footprints

Photography is always one of the best means to preserve the footprints particularly the two dimensional dust prints. After this, one of the following methods should be applied to preserve it by making caste.

Recovering and preserving the object on which the footprint is made.

Footprints are often found on objects stepped on by the criminal while entering in the dark through a window. If the window is broken, then all fragments of glass should be examined. This type of print is usually best detected by allowing illumination from one side at low-angle. Rubber heels and soles leave good prints on glass. Detailed prints are also found on paper or cardboard that may be scattered about the room during a safe burglary. All such loose objects bearing prints should be carefully preserved and sent to the laboratory for examination.

Electro-static lifting

Readymade kits are available to lift dust print with electrostatic lifters, which pick up dust prints onto Mylar-coated foil by means of static electricity. This procedure has applications in certain situations in which suspects had walked on tile/hard floors.

A special lifter is preferred whenever dust or a dust-like substance holds the print from the shoe (smeared foot/footwear marks). The lifter is a sheet of black rubber with a slightly sticky surface that is pressed against the print, picking up a replica of the whole print. Oblique light photography under laboratory conditions brings out this dust print to a contrast often better than that observed in the original print. If a sufficiently large fingerprint lifter is available, it may be used instead of the special lifter. Care must be taken not to stretch the rubber lifter because the dust image may become distorted.

Lifting with photographic paper

This technique may be employed when special lifters are not available. Black (exposed, developed, fixed, and washed) or white (fixed and washed) photography paper can be used, as determined by the color of the material in the print. The paper is dampened with water or dilute ammonia, laid emulsion side down over the print, and beaten against the print with a stiff brush or clapped with the palm. When the whole surface has been thoroughly beaten, the paper is removed and laid out to dry.

Enhancement of prints present on any transparent or colored substrate

Various types of enhancers may often be employed to develop the prints if present on different substrates or any type of intervening medium or if they are almost latent. For e.g. conventional and fluorescent fingerprint developers can also be used as a Mechanical Enhancers when the footmarks or footwear marks or tyre marks are found on transparent

substrates like glass doors or windows and white colored background materials like tiles, floors, etc. Similarly there is another set of enhancers called Chemical Enhancers, which include the blood enhancement chemicals and residue material enhancers. The former class of enhancers comprises of patent blue, fushcin acid, luminal, amido black and leuco crystal violet that can be used to improve the quality of prints stained with blood; and the later one consists of chemicals like bromophenol blue, safranin, potassium thiocyanate, diazoflouren and 8-hydroxyquinalone. All these can be employed for enhancing the prints which been generated by any extraneous material

Obtaining Standards Footprints for comparison from a Suspect

When the original prints are from footwear, the examiner has to obtain the shoe print. Subject is requested to carefully step onto a sheet of tracing paper or acetate sheet after inking. While, taking prints of bare foot, the foot is blackened by pressing it against a thin layer of printing ink. In order to get a true picture of the sole, the foot prints can be taken in the following four positions:

- Normal standing position,
- Standing position with pressure outside of the foot
- With pressure inside, and
- Finally when walking.

This can also be applied to stocking feet.

Another method for obtaining known foot/footwear exemplars can be obtained by using talcum powder and black carbon paper. A thin coating of talc is spread on a sheet of newspaper placed with talc side up on top of about 10 sheets of newspaper that act as a cushion. Then the suspect is made to walk over the newspaper containing talc with shoes. The talc-covered shoe is then impressed onto the carbon paper. The carbon paper is similarly cushioned with about 10 sheets of newspaper. The resulting print is photographed using high-contrast copy film. The developed negative will show a positive reproduction of the impression that can be superimposed over a negative from the crime scene.

Forensic Investigation of Track Marks

The whole investigation of track marks follows two major laws which the forensic science relies upon i.e. Law of Individuality and Principle of Exchange or Locard's exchange Principle

Whenever an item of footwear or a tyre touches a substrate, it results in direct transfer of both class and individual characteristics. The suspected footwear or tyre can be compared with them in order to substantiate any linkage to or elimination from an alleged crime.

Class Characteristics

Those characteristics which are common to a particular group and which differentiate the members of that particular group from those of another group are termed as Class Characteristics. These comprise of type of footwear like sneaker, loafer, fleet, chappal, etc., physical size and shape, design or model of the footwear and the brand name tag or logo of manufacturer.

In case of tyre marks tread width or Tyre stance, depth of pattern when present deep-set in mud, design and logo of manufacturing company are considered as class characters.

In case of bare or naked footmarks length of feet, width of feet and curvature of heel constitute the class characters.

Individual characteristics

The characteristics that specifically belong to one particular type and are not present in any other are termed as Individual characteristics. These include wear and tear marks present on insole as well as outsole of footwear, various features like scratches, cuts, holes, etc. retained by the shoe's outsole, any materials adhered to the outsole for a long time that includes gum, nails, pins, threads used while stitching/repairing a torn sole and most importantly the maker's art like any patchwork if the footwear is handmade.

Individual characters in case of tyre marks are almost similar to those found in case of footwear marks. Wear and tear marks, random cuts, holes made by sharp embedded pebbles or nails, etc. are the important individual marks.

In both the cases, any extraneous material like sand, hair, fiber, paint chip, etc found embedded over the pattern should never be overlooked as they may act as important corroboratory evidence.

Ridge pattern present either on the tarsals of feet or on the tali, shape of the bulf line or Zanziri and arch of feet are considerable individual features in case of naked or bare footmark.

A side by side match (also called point-by-point analysis) of the questioned and standard track marks is performed by making use of either the photographs or tracings of the plaster of Paris casts of the same. Composite matching by using a comparison microscope is another way of comparing the questioned and standard samples.

Presence of sufficient identifying characteristics ends up with a positive identification. As such there is no fixed number as per the characteristics that should be looked for. Comparison is based upon the class and individual characteristics as discussed earlier.

Showing a Footwear Impression and the Stud Alleged to have made the Print

Analysis of walking pattern or Gait Pattern is an important aspect of track mark, which has great application in crime investigation. It consists of a series of footprints or footwear impressions made by a person while walking or running and is highly individualistic and results obtained are reproducible, thereby qualify as one of the important forensic evidence.

It includes the direction line, the walking line, the foot line, the foot angle, the principal angle, the step length and the step width etc.

Direction line: an imaginary straight line indicating the direction of walk or run.

Walking line: A straight or zig- zag line produced as a result of placing one's feet or footwear along the direction line.

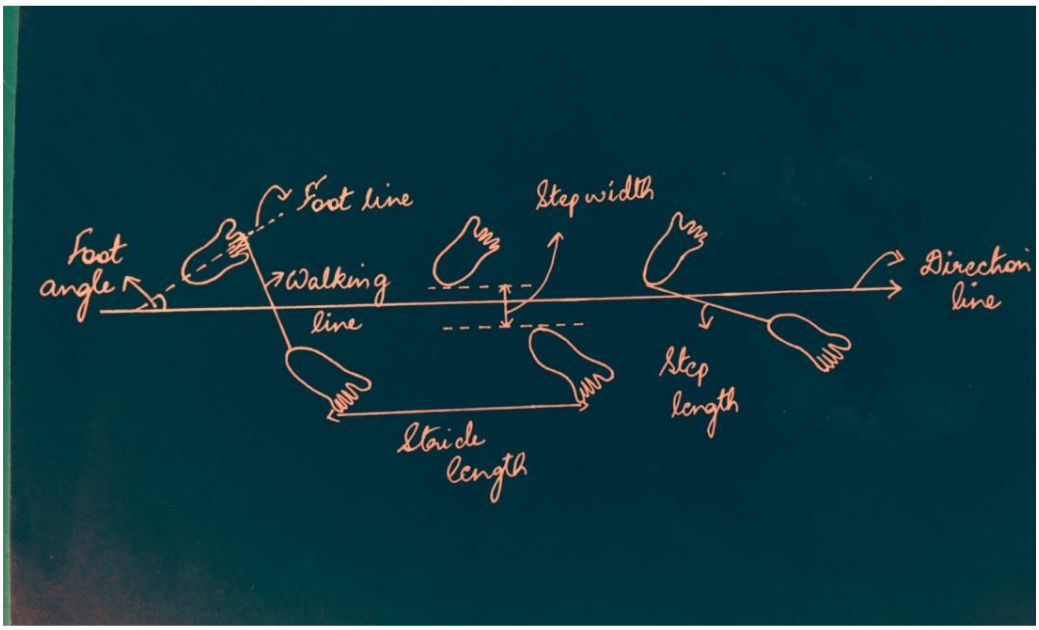
Foot line: A tangent indicating the inclination of foot with respect to the direction line.

Foot angle: An angle between the direction line and the foot line.

Principal angle: It is the sum of two feet angles i.e. angle between foot lines of two feet.

Step length: A straight line joining the heels of two successive feet.

Step width: The distance between parallels drawn to inner sides of both feet.



Showing Outline of Gait Pattern

Determination of height, age and sex of the depositor can be very well performed by analyzing gait pattern of the same.

Summary

i. A capable crime scene investigator on reaching the crime scene try to recognise, collects various types of evidences to solve the crime by identifying the person who have committed the crime. These evidences in the form of foot/footwear and tyre impressions have to be preserved properly to be used in the court of law.

ii. In all the cases, before attempting to collect the track marks, it is mandatory to record them first with the help of notes, sketches and then with photography. Photographs need to be taken both at a distance from the track marks and close to it.
iii. When three dimensional track marks such as a footprint or tyre track is encountered, a positive cast of it should be made. Several types of casting materials are commercially available like plaster of paris and dental stone (which are a type of gypsum or calcium sulfate) etc.
iv. Individual characters in case of tyre marks are almost similar to those found in case of footwear marks. Wear and tear marks, random cuts, holes made by sharp embedded pebbles or nails, etc. are the important individual marks.
v. Analysis of walking pattern or Gait Pattern is an important aspect of track mark, which has great application in crime investigation. It consists of a series of footprints or footwear impressions made by a person while walking or running and is highly individualistic and results obtained are reproducible, thereby qualify as one of the important forensic evidence..

Analysis of biological substances

Review of Traditional Genetic Markers

There are five major classes of traditional genetic markers (individualizing genetic characteristics):

(1) Blood group antigens;
(2) Red cell isoenzymes;
(3) Serum or plasma proteins;
(4) Certain hemoglobin variants; and
(5) The HLA system antigens.

Each of the first three classes has a number of different "systems," and many of these markers have proved useful in bloodstain analysis. A "system" refers to a protein, enzyme, or antigen that shows multiple types among individuals attributable to multiple genes at a single genetic locus (location within the entire DNA). The traditional genetic-marker systems used in forensic biological evidence analysis are summarized below.

Table 4.1 Summary of Traditional Genetic-Marker Systems Discrimination

System	Number of Types*	Discrimination Index	
		Caucasian	African-American
Blood Groups			
ABO	4	0.62	0.64
Rh	7	0.79	0.69
MNSs	9	0.83	0.78
Kell	2	0.15	0.04
Duffy	3 or 4	0.62	0.56
Kidd	3	0.61	0.55
Isoenzymes			
PGM	3 (or 10)	0.52 (0.75)	0.47 (or 0.73)
ACP	5	0.66	0.54
AK	2	0.13	0.04
ADA	2	0.18	0.10
ESD	3	0.35	0.27
GLO	3	0.61	0.62
CA II	1 or 3	- -	0.33
PGD	2	0.09	0.13
GPT	3	0.63	0.48
PEPA	1 or 3	- -	0.21
Serum Groups			
Hp	3	0.62	0.72
Gc	3 (or 6)	0.57 (or 0.75)	0.33 (or 0.67)
Tf	2	0.04	0.15
Gm / Km	many	- -	- -
Hemoglobin Variants	3	- -	0.04

The traditional systems for typing biological evidence are called "genetic markers" because they are inherited in a consistent, predictable way. As a result, the types can be used to distinguish between individuals in populations.

When genetic-marker types are found in evidence items, they are compared with the types of one or more people to determine whether they match. If a person's genetic-marker types do not match the types found in the evidence, the person is excluded. Exclusions are absolute proof that the person did not deposit the evidence. A finding that the types do match does not conclusively indicate that the evidence came from that person. Rather, such a result means that the person is included in a segment of the total population of persons who might have deposited the bloodstain because everyone in that segment of the population has that same set of types. In other words, traditional genetic markers can partially, but not completely, individualize biological evidence.

Traditional genetic markers for the individualization of biological evidence have been entirely displaced by DNA typing. Not only are some kinds of DNA typing far more individualizing than any one or combination of traditional markers, DNA is significantly more stable in biological evidence than were the traditional genetic markers.

There is still occasional interest in the traditional marker systems, usually because older cases sometimes resurface in which there insufficient material for DNA is typing. Traditional genetic-marker systems have been extensively reviewed elsewhere and thus are described only briefly below.

A. Blood Groups

ii] Bloodstains

The major blood group systems are ABO; Rh, MNSs, Kell, Duffy, and Kidd. Each system is controlled by its own 'genetic locus. A person's blood group in any system is determined by the presence or absence of blood group antigens on the surface of the red cell. Specific antibodies are used to test a person's red blood cells for the presence of any one of these antigens. A series of specific antibodies can be used to determine a person's red cell antigen types in the different blood group systems. When blood dries, the red cells rupture, and thus a bloodstain do not have any intact red cells. For this reason, bloodstains cannot be typed like whole blood because there are no red cells to work with, and indirect methods, described briefly below, must be employed.

Blood groups were the first category of human genetic marker. The ABO blood group system, first described in 1901 by Landsteiner, is by far the most commonly typed system in bloodstain analysis. The ABO system consists of four basic types: A; B; AB; and O. A person's ABO type is determined by which antigens are present on the red cells.

The cells are typed with anti-A, anti-B, and a third reagent called anti-H (which reacts with type O red cells). The ABO system has another property that makes it peculiar among the blood group systems-an individual's serum contains antibodies corresponding to the antigens that he or she lacks. Thus, type A people have anti-B, type B people have anti-A, type O people have both, and type AB people have neither. As a result, blood can be typed for ABO using either red cells or serum. ABO is the only blood group system in which people have "naturally occurring" blood group antibodies of this kind.

In his original description of the ABO blood group system, Landsteiner noted that ABO antibodies were still detectable in a two-week-old bloodstain on linen. People interested in typing bloodstains subsequently tried to develop typing methods based on the detection of the serum antibodies. Lattes were the first, beginning in1913, and he did considerable research and casework in this area. Bloodstain ABO typing by detection of the serum antibodies is called the "Lattes procedure."

Over time, forensic workers developed ABO typing methods based on detecting the blood group antigens. The first method used was absorptioninhibition,57 but another more sensitive method, called "absorption-elution,"58 eventually became the standard procedure.

Because the ABO antigens are considerably more stable than the antibodies in dried stains, many laboratories did not use the Lattes procedure in routine work. For various reasons, there was general agreement that a bloodstain could not be conclusively typed for ABO using either the Lattes method or the elution method. Conclusive typing would require that both tests be done. Many laboratories did not use the Lattes test because it only gave reliable results in fresh bloodstains, and many of the bloodstains being examined in forensic laboratories were already too old to expect Lattes results. As a consequence, laboratories reported the ABO antigens they detected in bloodstains, but would not conclusively assign blood types.

The absorption-elution technique can also be used to type other blood group system antigens. For a time, quite a few laboratories typed MN in addition to ABO. Biochemical studies in the 1970s showed that there was an intrinsic problem with the reliability of MN typing in bloodstains, however, and the system was dropped. Very few laboratories in the United States typed the other blood group antigens in bloodstains, but such typing was somewhat more common in Europe and elsewhere.

[ii] Body Fluid Evidence

The ABO antigens were typed routinely in forensic body fluid specimens for many years, and the system is expressed somewhat differently in body fluids. Most of the genetic-marker systems found in blood are not expressed in body fluids, although ABO blood group antigens, a few isoenzymes, and perhaps immunoglobulin allotypes are. Thus, until DNA typing emerged, there were few useful genetic markers for semen in sexual assault cases.

In the 1930s, it was found that ABO blood group substances could be present in large quantity in body fluids, and that this characteristic was genetically controlled. About 75% of most population groups were found to have ABO in body fluids and were called "secretors." The remainder, who had little or no such ABO substances in body fluids, was called "nonsecretors." The ABO substances found in secretor body fluids corresponded to the individual's blood group, except that secretors of all the blood groups were found to have substance H

Table 4.2 ABO Group Substances in Body Fluids of Secretors

Blood Group	**ABO Blood Group Substances in Body Fluids**
O	H
A	A + H
B	B + H
AB	A + B + H

Forensic scientists quickly took advantage of this finding62 because it provided a method for including or excluding possible semen depositors in sexual assault cases. The method, primarily used to detect A, B, and H in body fluids was absorption-inhibition, and there are several variations of that test. Typically, a person's saliva was tested to determine secretor

status. Sexual assault evidence-almost always a mixture of fluids from the woman and the offender could be tested to determine the ABO antigens present. To interpret the findings from the evidence, the blood group and secretor status of the two people had to be determined. A suspect could then ordinarily be included or excluded as a possible depositor.

B. Isoenzymes

Enzymes are the body's catalysts; they speed up chemical reactions, which would otherwise be too slow to maintain life. Red cells, tissues, and body fluids contain many enzymes. Some of the enzymes in human red cells and tissues have been found to be controlled by polymorphic gene loci, so that different individuals will have different forms of the enzyme. The different forms can be detected using appropriate methods, thereby giving genetic information about the person. Enzymes controlled by polymorphic genetic loci, and thereby exhibiting multiple genetically controlled forms, are called "isoenzymes." The most important red cell isoenzyme systems used in forensic serology were as follows: phosphoglucomutase (PGM); acid phosphatase (ACP or EAP); adenylate kinase (AK); adenosine deaminase (ADA); esterase D (ESD); glyoxalase I (GLO); carbonic anhydrase II (CA II); glucose-6-phosphate dehydrogenase (Gd or G6PD); 6phosphogluconate dehydrogenase (PGD); glutamic-pyruvic transaminase (GPT); and peptidase A (PEPA). Not all of them were equally useful. Their characteristics as genetic markers are summarized in Table 4.1.

Isoenzyme typing is done by a procedure called electrophoresis, a process for separating different protein molecules (which the isoenzymes are) in an electric field because of differences in their net charge. In practice, electrophoresis is carried out on different types of gels (made of starch, agarose, polyacrylamide, etc.). These different gels are prepared on glass or plastic carriers, which can be placed into electrophoresis chambers. The specimens to be analyzed are applied to the gel, and the electrophoresis chamber allows an electric current to be applied throughout the gel. Positively charged proteins will migrate toward the negative electrical pole, while negatively charged proteins will migrate toward the positive. If the isoenzymes of interest are differently charged under the test conditions, they can be separated in this way, and detected later, after the electrophoresis has finished. A related protein separation procedure, which works on a

different principle, is called isoelectric focusing, and it has also been used to separate some of the proteins and enzymes that are important in bloodstain analysis.

C. Serum Groups

Some of the proteins in serum have several forms, like the isoenzymes described above. They are not enzymes, however, and have to be detected differently. The most important proteins used in forensic serology were the immunoglobulin markers (Gm and Km), haptoglobin (Hp), group specific component (Gc), transferrin (Tf) and protease inhibitor (Pi). Except for Gm and Km, which were typed serologically (somewhat like red cell antigens), the other systems were all typed by electrophoresis or isoelectric focusing techniques. The genetic properties of individual systems are summarized in Table 4.1 above.

D. Hemoglobin Variants

Hemoglobin can show inherited variations, and a few of the variant hemoglobins occur frequently enough in populations to have been useful bloodstain genetic markers. Hemoglobin variants were determined by electrophoresis or isoelectric focusing.

E. HLA System

The HLA system was the most complex antigen system discovered. HLA antigens constitute the histocompatibility complex, and mismatches in HLA types are the reason for tissue transplant rejection. HLA antigens occur in tissues and on the white blood cells, so that lymphocytes were commonly used for HLA typing. The typing was done by serological procedures somewhat similar to those used to type red cell antigens, but HLA typing procedures were more complex and more difficult. Good methods for typing HLA in dried blood were never developed, but the system was widely used in-disputed parentage and disputed paternity testing until it was displaced by DNA typing methods.

Principles of Biological Evidence Individualization

Individualization of a biological evidence specimen involves comparison of the genetic-marker types or, under modern methods, DNA types in the specimen with those of people who might have been depositors. A person whose types do not match the evidence types is excluded. In inclusion cases in which the specimen types do match the types found in some identified person, genetic-marker type frequencies in populations are used to calculate the fraction of the population that can be included as possible depositors of the evidence (along

with the person in the case). Thousands of population studies done over many decades provided the data used for this purpose with the traditional marker systems.

Population data for systems in populations are subjected to statistical tests for Hardy-Weinberg equilibrium (HWE) and for independence. HWE allows the calculation of expected type frequencies in a population within reasonable confidence intervals from the frequencies of a population sample (e.g., a few hundred unrelated individuals). Independence must be shown to allow use of the so-called product rule -- multiplying together the individual system (locus) type frequencies to get the overall genetic profile frequency.

Profile frequencies decrease as more systems are included in a profile. With traditional genetic-marker systems, no one system was highly polymorphic. As a result, laboratories tried to add more and more systems to their routine profiling to better individualize evidence. Even under the best circumstances, however, evidence could never be individualized to a degree even approaching that obtained by DNA typing methods.

It is clear that genetic-marker type frequencies vary in different human populations, such as Caucasians, African-Americans, and Chinese. In the United States, data has generally been collected for Caucasians, African-Americans, and separately for "Hispanic" populations, and sometimes for Chinese, Japanese, or Native American people. As a rule, laboratories provide genetic profile frequencies for all the populations for which data are available, since the ethnic or racial origin of the actual evidence depositor is not known.

A parameter referred to as the Discrimination Index (DI), which can be calculated from population genetic data for genetic-marker systems, is actually the probability that two randomly selected, unrelated individuals in a population will have different types, i.e., will be discriminated.65 The DI, shown in Table 29-4 above, provides a measure of the relative usefulness of a system for individualization.

Characteristics of Blood-Sex of Origin, Presence of Antibodies, and Presence of Drugs

Before DNA typing methods were available, there was some research on the possibility of using other detectable characteristics-including sex of origin, presence of various antibodies, and presence of drugs-as tools for bloodstain individualization.66 Bloodstains could, in theory, be tested for any, of three characteristics to determine whether they were of male or female origin: Barn bodies; F bodies; or sex hormone levels. Barr bodies, which

were originally described by Barr and Bertram,67 are characteristic of the nuclei of mammalian female cells. For bloodstains, the fluorescent Y chromosome (F body) technique was the most promising. Sex hormone quantitation by radioimmunoassay techniques was also successfully applied to the problem. Although these techniques appeared to be reliable in skilled and experienced hands, they were never in widespread use in the United States. The commonly used modern DNA typing techniques routinely provide sex of origin results. The determination of syphilis antibody, anti-parasitic antibodies, antibodies present as the result of infection or allergy, hepatitis B antigen, and various drugs in bloodstains were all investigated as other potential means of comparing bloodstains with possible depositors prior to the availability of DNA typing.

Evidence Collection and Preservation

A. Blood Evidence,

No single prescription for handling evidence can be given that would apply to every case. Evidence collection requires judgment and training, and the techniques to be used should be decided in consultation with laboratory personnel. Few considerations are as important as, preserving the integrity of a scene. Every feature of a scene should be recorded by photography and by sketches that include good measurements. More cases are made difficult by activities at the scene than by any analytical procedure in the laboratory. Evidence collected at the scene must, of course, be carefully labeled to preserve the chain of custody.

Dried blood specimens are best packaged in paper containers, and never in airtight containers where bacterial or mildew contamination might develop. Bloodstains should be thoroughly dry before packaging. Bloodstain patterns are often critical to reconstructing events, and careful records should be made of patterns before they are destroyed by collection of the blood. If any field testing is to be done, it should be carried out by specially trained investigators or supervised by someone from the laboratory.

B. Sexual Assault Case Evidence

Sexual assault case evidence can, but does not always, consist of three separate groups of items: evidence from the victim and the victim's person; evidence from the scene; and

evidence from the suspect. Like blood evidence, fluid stains and swabs collected in sexual assault cases should be thoroughly dry before packaging.

Evidence from the victim and the victim's person is generally collected in a clinical setting by physicians or nurses: Clothing is usually collected, and in many jurisdictions, a sexual assault evidence collection kit is used to collect evidence from the victim's person. The evidence collection kits vary from place to place, although there has been a significant effort to standardize them. In some states, there is a standard kit, and a legislatively mandated coordinating committee is responsible for specifying the kit's components. Where a kit is used, provision is generally made for collecting articles of clothing and debris and other material that may be adhering to the clothing. In addition, dried stains on the victim's body and vaginal, anal, and oral swabs and slides are collected. Some kits make provision for collecting "foreign" and known hairs, and fingernail clippings. A known blood specimen (or a buccal scraping) is also collected. The slides are used to look for sperm, and the swabs are generally used for semen identification tests and deoxyribonucleic acid (DNA) typing. The "best evidence" in a given case depends on what happened and how long the victim waited to come forward. The more time that elapses between the sexual assault and the physical examination, the less likelihood that good semen evidence on vaginal or other swabs will be found. Panties that were worn following the assault can provide good semen evidence. In some cases, the best semen evidence might be found in stains on clothing.

The evidence collected from the scene should include any items in which biological evidence might be found. Scenes should also be processed for other physical evidence.

Some jurisdictions provide "suspect" evidence collection kits. These make provision for collection of clothing, a known blood specimen or stain or buccal scraping, and penile swabs. Some kits have been designed to be used for victims or suspects by following separate instructions and using the kit's contents for different purposes.

Condoms are sometimes collected as evidence in sexual assault cases. A condom can provide very good evidence because there is semen on the inside and vaginal epithelial cells on the outside.

The critical feature in handling sexual assault cases is cooperation by all the parties involved: investigators; examining clinicians; and laboratory personnel. Errors made in

evidence collection in connection with the physical examination are often irreversible. As noted above, some jurisdictions have spontaneously, or following legislative mandate, established coordinating committees to set guidelines for medical examinations and specify the makeup of evidence collection kits. These committees usually include representation from laboratory personnel, law enforcement; clinicians, prosecutors, and victim services agency personnel. The development of forensic nursing as a specialty has helped in the process of sexual assault evidence collection in many jurisdictions. Some jurisdictions also have Sexual Assault Response Teams (SARTs) that swing into action when there is a victim to be seen. Besides evidence collection, there are medical and health matters that must be properly handled, and follow-up is generally indicated.

Drug-assisted sexual assault (i.e., sexual assault involving "date-rape drugs") is a growing problem as of this writing. The full extent of the problem is not completely known and is not easy to establish by normal scientific or epidemiological methods. From a forensic science viewpoint, toxicological analysis is indicated in such a case along with the usual biological evidence identification and DNA typing, and specimens must be separately collected for that purpose. Blood and urine are the typical toxicological specimens, but if too much time has elapsed between the assault and the examination, they may no longer contain detectable quantities, of the drug. To deal with those situations, there is active, ongoing research into the possibility of using hair to detect the drug even weeks or months after administration.

One of the problems with some "date rape drug" cases is that some of the drugs employed for the purpose of the assault are also abused in recreational use, thus providing a suspect with an "innocent" explanation for the toxicological findings. In addition, victims may have little or no recollection of the events and may not be able to provide much information about what happened.

Sexual assault evidence collection, except for the possible collection of specimens for toxicological analysis, is focused on gathering the best evidence for DNA typing. Not only is DNA typing a powerful tool for individualizing such evidence, but DNA profiles can also be compared with those in offender data banks in many states and nationally.

The literature on sexual assault and evidence collection is vast. However, there are no summaries or reviews readily available.

C. Saliva Traces from Bite Marks

In the pre-DNA era, saliva was collected from people for routine secretor status determination, but this is no longer necessary. It may be necessary on occasion to collect saliva from a body around the area of a bite mark. This should be done in cooperation with a qualified forensic odontologist, so that the bite mark characteristics are not affected.68 The area can generally be swabbed to collect saliva traces, but very small amounts of swabbing material should be used, since the amount of saliva is likely to be small. It is also necessary in these situations to collect "control" swabs from areas of the body near the bite mark to show that the DNA profile assumed to be from the saliva is not a contaminant.

Continuing Importance of Forensic Serology Activities in Era of DNA Typing

In 1904, Dr. Florence, inventor of the "Florence test" for semen identification, sarcastically commented on the possibility of "individualizing" a bloodstain specimen: "It is no longer a matter of distinguishing rabbit blood from human blood, but rather of saying that this stain was made by the blood of Pierre, and not by that of Paul or Francois. A quarter century later, Dr. Landsteiner, who was awarded the Nobel Prize for Physiology or Medicine in 1930 for the discovery of human blood groups, said in his laureate address: "These findings justify the assertion that very numerous individual blood differences exist in man : . . and that there are certainly other differences which could not yet be detected. Whether each individual blood really has a character of its own, or how often there is complete correspondence, we cannot yet say.

On the twentieth century, bloodstain and biological evidence individualization is essentially a reality through DNA typing techniques and technologies. Traditional genetic-marker testing has been abandoned and takes its place as a chapter in the history of forensic biological evidence analysis. Notwithstanding the DNA typing revolution, some activities long associated with "forensic serology" remain important and continue to be a vital part of forensic biological evidence analysis. Blood and physiological fluid stains and traces still require identification. More importantly, those aspects of "forensic serology" most characteristic of its association with criminalistics remain critical if biological evidence analysis is going to help unravel a case. Recognizing the crucial physical evidence in a given case, using experience and judgment to select the most important and informative

specimens for typing in terms of the case, and interpreting stain patterns are essential criminalistics skills that cannot be replaced by any DNA typing technique.

Detecting steroid consumption in athletes and racehorses

Dope is generally administered at or proximate the therapeutic dose, which results in relatively low concentrations in biological fluids. Consequently, screening procedures must be both sensitive and comprehensive. Generally, the screening procedures depend upon the detection of either the unchanged drug or its metabolites. The identification of the corresponding metabolites is often advantageous supplementary evidence to support the identification of the parent drug.

Instrumental methods Gas Chromatography using Nitrogen–Phosphorus Detection (GCNPD), High Performance Liquid Chromatography using Ultraviolet Detection (HPLCUV), Gas Chromatography- Mass Spectroscopy (GC- MS) and Liquid Chromatography-Mass Spectroscopy (LC-MS) are the predominant analytical methods in most human sports drug-testing laboratories. Even if not routinely used for screening, some kind of TLC technology is sporadically used by many laboratories to isolate or purify a compound of interest followed by the analysis of the scrape from the TLC plate by GCMS, LC-MS, etc.

UNIT V- MEDICAL ASPECTS

AIDS

AIDS (acquired immune deficiency syndrome) is a chronic condition caused by HIV (human immunodeficiency virus). HIV is a virus that attacks the body's immune system, specifically destroying and impairing the immune cells (different types of white blood cells). This can hamper your ability to fight off infection and disease, causing symptoms such as fatigue, fever, weight loss, and swollen lymph nodes.

HIV, and subsequently AIDS, continue to be major global health issues, however thanks to advancements it is now a manageable chronic health condition. It is estimated that 38 million people worldwide are affected by HIV and approximately two-thirds have access to treatment to prevent HIV from progressing; antiretroviral therapy.

Causes AIDS

There are **three stages** of HIV: **acute HIV infection**, **chronic HIV infection**, and **AIDS**, which is the **most advanced** and **severe** form of HIV. If HIV is left untreated or undetected, AIDS will develop **eight to ten years** after the initial infection. At this stage, the immune system is badly damaged.

Causes of HIV/AIDS:

- HIV (Human Immunodeficiency Virus): HIV is the virus that causes AIDS.
- Transmission: HIV is transmitted through contact with infected bodily fluids, including:
- Unprotected sexual contact: Vaginal, anal, and oral sex without a condom.
- Sharing needles or syringes: For injecting drugs.
- Mother to child: During pregnancy, childbirth, or breastfeeding.
- Blood transfusions or organ transplants: From an infected donor.
- AIDS (Acquired Immunodeficiency Syndrome): AIDS is the most advanced stage of HIV infection, occurring when the immune system is severely weakened.

Prevention of HIV/AIDS:

- Safe Sex Practices:
- Condom use: Use condoms consistently and correctly during all sexual activity.
- Limit sexual partners: Reduce the number of sexual partners.

- Get tested: Know your HIV status and your partner's status.
- Preventing Needle Sharing:
- Never share needles or syringes: If you inject drugs, never share needles or syringes with others.
- Use sterile equipment: If you inject drugs, always use sterile equipment and water.

Medications:

- PrEP (Pre-Exposure Prophylaxis): A daily medication for people who are HIV-negative to prevent infection.
- PEP (Post-Exposure Prophylaxis): A course of medication taken after potential exposure to HIV to prevent infection.
- ART (Antiretroviral Therapy): Medication for people living with HIV to suppress the virus and prevent transmission.

Other preventative measures:

- Avoid unsafe injections, blood transfusions, or tissue transplantation:
- Get tested for HIV and other STIs:
- Seek medical care for STIs:
- Avoid contact with another person's blood:
- If HIV positive, do not donate blood, plasma, body organs, or sperm:
- HIV-positive women who might become pregnant should talk to their provider about the risk
- to their unborn child and discuss methods to prevent their baby from becoming infected:
- Breastfeeding should be avoided to prevent passing HIV to infants through breast milk

Drug

DRUG According to "WHO"can be defined as "A Drug is any substance that is used or proposed to be used to modify or explore physiological structures or pathological states for the benefit of the recipient." Eg: paracetamol, ciprofloxacin, sal-butamol, or it can be said that

A drug is a stuff which may have medicinal, intoxicating, performance augmenting or other effects, when taken or inserted into a human / animal body and which is not

considered a food or a food supplement. Drugs are defined differently by various drug control laws, government regulations, as medicine or on the basis of their usage.

The definition of drug in pharmacology, can be stated as "a chemical substance used in the treatment, cure, prevention or diagnosis of disease or otherwise used to enhance physical or mental well-being." For chronic disorders, Drugs can be prescribed for a limited duration or on a regular basis.

Drugs of Hallucinogens and Opioids are the examples of Recreational drugs, which are chemical substances that affect the CNS. These type of drugs are abused for distinguished beneficial effects on consciousness, perception, behavior and personality. Addiction and habituation is the beginning drugs abuse.

Drugs which are taken from outside the organism this usually distinguished from endogenous biochemical. For example, when hormone insulin is synthesized in the body; it is called a hormone when it is synthesized by the pancreas inside the body, but it is called a drug when it is introduced into the body from outside.

Classification of Drugs

On the basis of the purpose of their use, different drugs can be classified into following two heads:

- Therapeutic Drugs
- Psychoactive Drugs

Although both of these categories; often overlap. Due to the specific usage and wide range, psychoactive drugs are treated as a distinct class.

Therapeutic Drugs

A Therapeutic drug is a substance that has healing or preventive properties in relation to certain diseases, or is administered to enable a medical diagnosis. The drugs in common therapeutic use that may be classified chiefly into following four categories:

i. **Analgesics and Antipyretics**. An analgesic is a type of drug that relives pain. On the other part, an antipyretic is a type of drug that is used to reduce the temperature of the body. Aspirin and Paracetamol are the commonly used drugs in this category. **Aspirin** (Acetylsalicylic Acid) is a white crystalline powder having an acidic taste and is used commonly in houses for pains, aches, etc. Even small doses of this drug

may prove to be fatal due to idiosyncrasy. However, minimum fatal dose is about 5-10 grams.

Paracetamol (Acetaminophen) is a metabolite of phenacetin, and is widely in use these days in place aspirin. Ingestion of 20 tablets of 500 milligram each within three to five days is proved to be fatal.

ii. **Antihistaminics**. These are the drugs which antagonize the action of histamine. These are commonly used in allergic disorders and other conditions like common cold. The common preparations include: Promethazine hydrochloride (Phenergan), Diphenhydramine (Benadryl), Chlorcyclizine (Histantin), Antazoline (Antistine), etc. Its fatal dose is about one gram.

iii. **Antidepressants**. These are the drugs which are generally used in psychiatric disorders to treat the endogenous depression. These drugs have an initial sedative effect which is followed by an antidepressant effect within a week or more. Commonly used antidepressant drugs are: Imipramine, Amitriptyline, etc.

iv. **Tranquilizers.** These are the drugs that produce a general tranquility without the impairment of high- thinking facilities or the inducement of a sleep. To reduce tension and anxiety of mental patients Tranquilizers like reserpine and chlorpromazine are useful.

Drug Schedules

Drugs are classified into 5 categories or schedules depending on the medical uses or the risk of dependency and misuse. The risk of misuse of a drug is a determining factor in a drug's classified schedule. Schedule I drugs have high potential for misuse and schedule V drugs have the least risk of being misused. The Controlled Substances Act (CSA) identifies and lists drugs and their schedule. Each schedule is determined based on the risks of using the drug.

i. **Schedule I** drugs are drugs that have a high potential for misuse and typically have no medical uses. One drug that has been highly discussed and legalized in some states that is still considered schedule I is marijuana.

ii. **Schedule II** drugs have high potential for misuse and a high risk of physical and psychological dependence. Hydrocodone and Adderall are two drugs that fall into this schedule.

iii. **Schedule III** drugs have moderate to low potential risk of physical and psychological dependence. Tylenol with codeine and anabolic steroids are in this schedule.

iv. **Schedule IV** drugs have low potential for misuse and dependence. Xanax and Valium are two drugs that fall into this schedule.

v. **Schedule V** drugs have low potential for misuse. Quantities of these drugs are often monitored. Cough medicine with codeine and Lyrica are two drugs that fall into this schedule.

Examples of Drugs in Each Drug Schedule

Schedule I	**Schedule II**	**Schedule III**	**Schedule IV**	**Schedule V**
Heroin	Cocaine	Ketamine	Diazepam (Valium)	Cough medicine with Codeine
LSD	Methampheta mine	Anabolic Steroids	Alprazolam (Xanax)	Narcotics (unless in another schedule)
Marijuana	Oxycodone	Codeine, Hydrocodone products mixed with aspirin and acetaminophen	Lorazepam (Ativan)	Stimulants (unless in another schedule)
Ecstasy	Morphine			Depressants(unless in another schedule)
Fentanyl	Methadone			
Metha-qualone	Adderall			

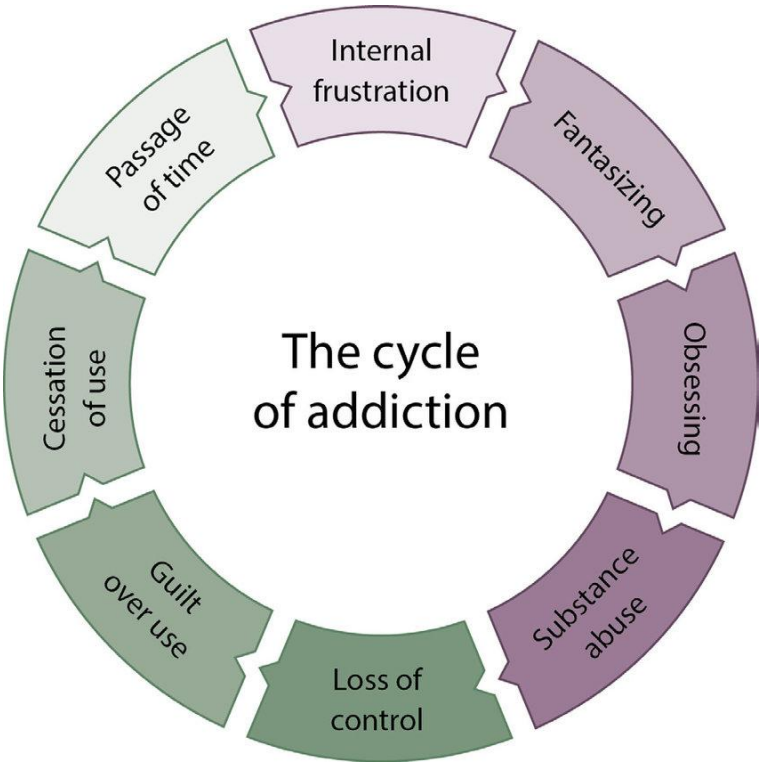
Drug Misuse Risks and Concerns

The Cycle of Addiction:

A substance-use disorder is defined as a medical illness in which the person is unable to stop using a drug even though it causes health and social problems in their life. Severe substance-use disorders are also known as addiction.

The infographic above helps explain how drug users can progress from drug use to addiction. This progression can happen over a short period of time or it can take many

years. Misuse is defined as drug use that is illegal or not aligned with medical use guidelines. Most drug use happens in the experimental and social recreational drug-taking patterns. The hope is that drug use does not lead to misuse because the user recognizes the need to break their use patterns and or seek help. Misuse begins with recurrent drug use. Often individuals fail to follow through on obligations at work, home and school. They may use substances when they know the use can be physically hazardous. They often have legal problems associated with the drug use and continued social and interpersonal problems despite knowing their drug use is a concern. It is really hard to define what misuse is because it isn't always nicely wrapped into one package.



Substance addiction behaviors often include one or more of the following:

- loss of control over drug use
- continuation of use despite harm to oneself and others
- compulsive use and cravings that are often the sole focus of the user

The 4 C's of addiction and the examples provided below will help you better understand addiction and addiction risks.

i. ***Control,*** often looked at as loss of control by the user. The user might say this about themselves: "I try to drink only one day a week, but I end up drinking everyday."

ii. ***Continued use*** when the user keeps on using even though they know there are harmful consequences. The user might say this about themselves: "I know my alcohol use caused me to lose my job, but I cannot stop drinking alcohol."

iii. ***Compulsion*** when the user can do nothing but think about using. The user might say this about themselves: "No matter what I do, I cannot get alcohol out of my mind. I think about it all the time."

iv. ***Cravings*** which cause the physical drive to use and keep using. The user might say this about their cravings: "No matter how much alcohol I drink, I still crave it all the time."

Plastic surgery

Plastic surgery plays a crucial role in treating burns, focusing on improving both function and appearance by addressing scarring and restoring damaged tissues through techniques like debridement, skin grafting, and scar revision.

Goals of Reconstructive Burn Surgery:

- **Improve Function:**
  Burn scars can restrict movement, especially around joints. Reconstructive surgery aims to release tight scar tissue (contractures) to restore range of motion.
- **Enhance Aesthetics:**
  Large burns often leave extensive scars that can be disfiguring. Reconstructive surgery aims to improve the appearance of these scars and restore a more natural look to the affected area.
- **Address Psychological Impact:**
  Burn scars can have a significant psychological impact on patients. Reconstructive surgery can help improve self-esteem and confidence by improving the appearance of the affected area.

Common Surgical Procedures:

- **Debridement:** This involves removing dead or infected tissue from the burn wound to promote healing and prevent infection.

- **Skin Grafts:**

  Temporary Grafts: These are used to cover the burn area temporarily, protecting it from infection and pain. Sterilized pigskin (xenograft) is a common material for temporary grafts.

  Permanent Grafts (Autografts): These involve taking skin from a healthy part of the patient's body and transplanting it to the burned area. This is a permanent solution for covering the wound.
- **Scar Release:** This procedure involves releasing tight scar tissue to improve range of motion and reduce the appearance of scars.
- **Z-plasty and W-plasty:** These techniques are used to reshape scars and improve their appearance, particularly around joints.
- **Skin Flaps:** These involve taking a piece of skin, along with underlying tissue, from a nearby area and moving it to the burn site to cover the wound and restore function.
- **Tissue Expansion:** This technique involves using a balloon-like device to expand skin tissue, allowing for a larger area of skin to be used for reconstruction.
- **Surgical Skin Planing (Dermabrasion):** This technique uses a tool to physically remove the outer layer of the skin to minimize the appearance of raised scars.
- **Microsurgery:** This technique allows for tissue transfer with microscopic precision, which can be helpful in cases of severe burns.
- **Laser Therapy:** Laser skin resurfacing can be used to minimize the appearance of scars.

Need for Plastic Surgery:

- ✓ **Severe Burns:** If burns are extensive, deep, or cause significant functional limitations, plastic surgery may be necessary.
- ✓ **Scarring:** Even relatively minor burns can leave scars. Plastic surgery can help minimize the appearance of scars and improve their functionality.
- ✓ **Contractures:** If burns cause tight scar tissue that restricts movement, plastic surgery can help release these contractures.

- ✓ **Loss of Sensation:** Burns can cause a loss of sensation in the affected area. Plastic surgery can help restore some sensation and improve function.
- ✓ **Cosmetic Concerns**: If burns cause disfiguring scars, plastic surgery can help improve the appearance of the affected area.

Benefits of Plastic Surgery for Burns

The benefits of plastic surgery for burns are:

- ✓ Plastic surgery can improve the confidence and self-esteem of burn patients. Severe burns can damage the face, mouth, ears or even eyes. This can cause disfigurement and subsequent frustration. As a result, when those parts are restored through plastic surgery, it can boost the patient's self-confidence.
- ✓ Plastic surgery can provide better sleep, in patients whose nose or nasal cavity has been damaged by burns. Plastic surgery helps restore the nose, thereby aiding in better breathing and sleep.
- ✓ Sometimes severe burns can lead to vision loss in patients because of drooping eyelids or collection of excess skin and muscle around the eyes. Blepharoplasty is a cosmetic surgery that helps restore vision by correcting the eyes.

Risks of Plastic Surgery for Burns

- ✓ Undesirable scarring
- ✓ Pain at the site of surgery might not be relieved by painkillers.
- ✓ Infection at the site of plastic surgery might show symptoms like blisters, redness, swelling or tenderness at the surgical site. You might also develop high temperatures in case of an infection.
- ✓ Rejection of skin grafting by the body
- ✓ Loss of sensation at the site of **plastic surgery**
- ✓ There might be yellow-colored drainage from the surgical site that must be reported to the doctor immediately.

Metabolite analysis using Mass Spectrum:

MS can typically detect in the femtomolar to attomolar range. Coupled to either gas chromatography (GC), ion chromatography (IC) or liquid chromatography (LC), MS can routinely analyze hundreds of compounds in a single sample and run, making it a very powerful and high-throughput process. With the advancement of high resolution accurate

mass (HRAM) MS systems, as well as enhanced metabolite databases/libraries, metabolite identification has improved significantly.

- ✓ Innovations in MS have also enabled metabolomics to emerge as its own field of study, and to complement genomics and proteomics (multiomics) as core technologies in academic and industrial research labs.
- ✓ This overview outlines the role of mass spectrometry in the field of metabolomics and reviews MS methodology and instrumentation.

Introduction to mass spectrometry

Mass spectrometry (MS) measures the mass-to-charge ratio (*m/z*) of ions to identify and quantify molecules in simple and complex mixtures. The development of high resolution accurate mass (HRAM) MS workflows with high throughput and quantitative capabilities has expanded the scope of what we know about the metabolites involved in different cellular and biological pathways; it has also enabled putative biomarker discovery in several related research areas.

Mass spectrometer function

A mass spectrometer contains an ion source, a mass analyzer and an ion detector. The nature of these components varies based on the type of mass spectrometer, the type of data required, and the physical properties of the sample. Samples are introduced into the mass spectrometer in liquid or gas form and then vaporized and ionized by the ion source. Once ionized, the ions can be accelerated through the remainder of the system. Electric and/or magnetic fields from mass analyzers deflect the paths of individual ions based on their mass and charge ratio (*m/z*). Commonly used mass analyzers include time-of-flight [TOF], orbitraps, quadrupoles and ion traps, and each type has specific characteristics. Mass analyzers can be used to separate all analytes in a sample during global (or full scan) analysis, or they can be used like a filter (e.g., quadrupole, ion trap) to deflect only specific ions towards the detector.

Ions then hit the detector. Most often, these detectors are electron multipliers or microchannel plates, and they emit a cascade of electrons when hit. This cascade is amplified or multiplied for improved sensitivity. The entire process occurs under extreme vacuum (10-6 to 10-8 torr) so that contaminating gases, neutral atoms and molecules, and

non-sample ions are removed. Such contaminants can collide with sample ions and alter their paths, they can also result in non-specific reaction products.

Newer orbitrap analyzer technology captures ions around a central spindle electrode and analyzes their *m/z* values as they move across the spindle with different harmonic oscillation frequencies. Orbitrap technology can achieve extremely high sensitivity and high resolution accurate mass (HRAM) of obtained mass spectra. Orbitrap HRAM has several advantages for metabolomics studies. Mass spectrometers are connected to computers with integrated software that analyzes the ion detector data and produces spectra that organize the detected ions by their individual *m/z* values and relative abundance. These ions can then be compared with available databases and libraries to predict their molecular identities based on their *m/z* values.

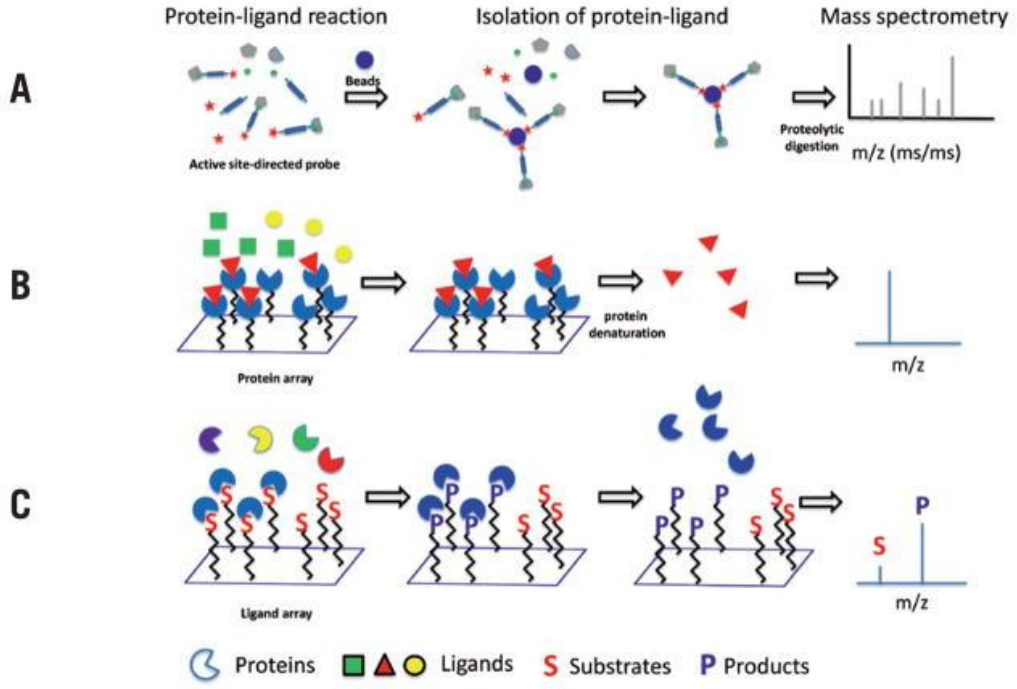
Tandem mass spectrometry

In metabolomics, single MS or full scan data is used for relative quantitation (profiling) as well as for searching through MS databases such as METLIN for metabolite identities. However, when additional data are required for specific ions, tandem mass spectrometry is used. During these approaches, a sample is injected into the mass spectrometer, after which it is ionized, accelerated through and analyzed by mass spectrometry (MS^1). Ions derived from the MS spectra are then selectively fragmented and analyzed through a second stage of mass spectrometry (MS) to generate the spectra of the ion fragments.

This fragmentation occurs by a number of dissociation techniques. One method involves hitting the ions with a stream of inert gas, which is known as collision-induced dissociation (CID) or higher energy collision dissociation (HCD). Other methods of ion fragmentation include electron-transfer dissociation (ETD) and electron-capture dissociation (ECD). These fragments are then separated based on their individual *m/z* ratios. In metabolomics, MS/MS is commonly used to increase confidence during metabolite identification when searching through MS/MS mass spectral libraries. With more advanced MS systems, multiple sequential rounds of mass spectrometry (e.g., MS^3) can be achieved, and these data can be analyzed with ion fragment tree data to achieve further structural elucidation.

MS analysis of metabolite-protein interaction

MS is being used for annotation of putative enzyme functions, suggesting potential metabolic reactions, and validating the existence of metabolic pathways using in vitro enzymatic assays. Such studies can be broken down into three groups,

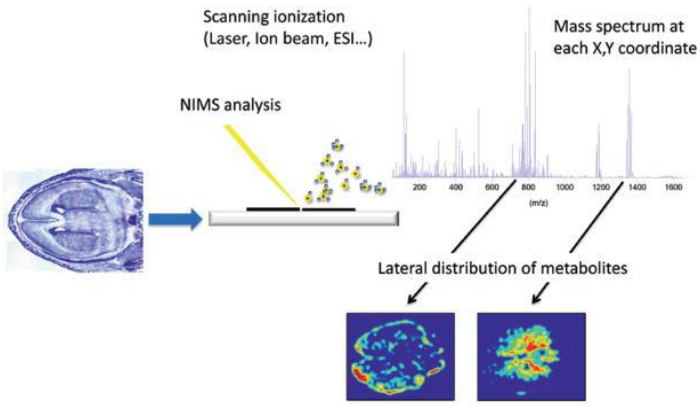


MS analysis of protein-metabolite interaction.

ABPP utilizes chemical probes and beads to selectively profile actively bound proteins through specific crosslinking reactions and proteomic analysis of tagged peptides. (B) Protein arrays are used to bind ligands that can subsequently be released for MS-based identification. (C) Surface-immobilized metabolites can bind proteins (proteomic analysis) or detect specific enzymatic transformations of the immobilized substrate.

MS-based metabolite imaging

A limitation of LC/MS, CE/MS, or GC/MS methods is the loss of spatial information that results upon metabolite extraction from homogenized samples. Metabolomic imaging technologies, therefore, can be an important alternative and provide information on the spatial distribution of metabolites within tissues. MALDI imaging is the most widely used MS-based tissue imaging approach. MALDI matrix is typically applied to the sample (i.e., tissue) either by spotting or spraying, and images are generated by raster scanning the laser over the sample, providing a mass spectrum at each x,y coordinate. Composite images are constructed by mapping the distribution and abundance of ions within the sample.



MS imaging approaches are used to study the spatial distribution of metabolites within biological samples.

Metabolites are desorbed and ionized, and mass spectra are collected. The resulting data enables image reconstruction that can be used to define metabolite localization patterns.

Another widely used approach for imaging is SIMS. In SIMS, the sample is sputtered with ions (i.e., gold, gallium, bismuth) to generate secondary ions. The resultant ions are analyzed typically using time-of-flight mass analyzers (TOF-SIMS). This matrix-free technique does not have the background matrix ions and also has the advantage that ion beams can be focused to ~100 nm. However, the energetic SIMS ionization process results in extensive molecular fragmentation that significantly complicates metabolite identification and data interpretation. Such limitations in imaging analysis are now being addressed using new soft techniques, such as desorption electrospray ionization (DESI).

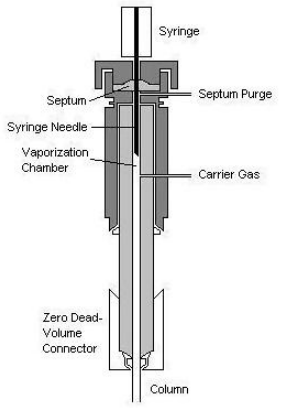
DESI is based on scanning the surface with the electrospray cone (62). NIMS is another matrix-free approach that uses a scanning laser system'to generate ions from the liquid-filled nanostructured surface (18)

Gas chromatography

Gas chromatography is a term used to describe the group of analytical separation techniques used to analyze volatile substances in the gas phase. In gas chromatography, the components of a sample are dissolved in a solvent and vaporized in order to separate the analytes by distributing the sample between two phases: a stationary phase and a mobile phase. The mobile phase is a chemically inert gas that serves to carry the molecules of the analyte through the heated column. Gas chromatography is one of the sole forms of chromatography that does not utilize the mobile phase for interacting with the analyte. The stationary phase is either a solid adsorbant, termed gas-solid chromatography (GSC), or a liquid on an inert support, termed gas-liquid chromatography (GLC).

Instrumentation

Sample Injection



A sample port is necessary for introducing the sample at the head of the column. Modern injection techniques often employ the use of heated sample ports through which the sample can be injected and vaporized in a near simultaneous fashion. A calibrated microsyringe is used to deliver a sample volume in the range of a few microliters through a rubber septum and into the vaporization chamber. Most separations require only a small fraction of the initial sample volume and a sample splitter is used to direct excess sample to waste. Commercial gas chromatographs often allow for both split and splitless injections when alternating between packed columns and capillary columns. The vaporization

chamber is typically heated 50 °C above the lowest boiling point of the sample and subsequently mixed with the carrier gas to transport the sample into the column.

Carrier Gas

- Carrier gas in a high-pressure cylinder with attendant pressure regulators and flow meters
- Helium, N_2, H, Argon are used as carrier gases.
- Helium is preferred for thermal conductivity detectors because of its high thermal conductivity relative to that of most organic vapors.
- N_2 is preferable when a large consumption of carrier gas is employed.
- Carrier gas from the tank passes through a toggle valve, a flow meter, (1-1000 ml/min), capillary restrictors, and a pressure gauge (1-4 atm).
- Flow rate is adjusted by means of a needle valve mounted on the base of the flow meter and controlled by capillary restrictors.
- The operating efficiency of the gas chromatograph is directly dependant on the maintenance of constant gas flow.

Column Oven

The thermostatted oven serves to control the temperature of the column within a few tenths of a degree to conduct precise work. The oven can be operated in two manners: isothermal programming or temperature programming.

- In isothermal programming, the temperature of the column is held constant throughout the entire separation. The optimum column temperature for isothermal operation is about the middle point of the boiling range of the sample. Isothermal programming works best only if the boiling point range of the sample is narrow.
- In the temperature programming method, the column temperature is either increased continuously or in steps as the separation progresses. This method is well suited to separating a mixture with a broad boiling point range. The analysis begins at a low temperature to resolve the low boiling components and increases during the separation to resolve the less volatile, high boiling components of the sample. Rates of 5-7 °C/minute are typical for temperature programming separations.

Open Tubular Columns and Packed Columns

Open tubular columns, which are also known as capillary columns, come in two basic forms. The first is a wall-coated open tubular (WCOT) column and the second type is a support-coated open tubular (SCOT) column. WCOT columns are capillary tubes that have a thin later of the stationary phase coated along the column walls. In SCOT columns, the column walls are first coated with a thin layer (about 30 micrometers thick) of adsorbant solid, such as diatomaceous earth, a material which consists of single-celled, sea-plant skeletons. The adsorbant solid is then treated with the liquid stationary phase. While SCOT columns are capable of holding a greater volume of stationary phase than a WCOT column due to its greater sample capacity, WCOT columns still have greater column efficiencies.

Detection Systems

- Detectors sense the arrival of the separated components and provide a signal.
- These are either concentration-dependent or mass dependant.
- The detector should be close to the column exit and the correct temperature to prevent decomposition.

Recorder

- The recorder should be generally 10 mv (full scale) fitted with a fast response pen (1 sec or less). The recorder should be connected with a series of good quality resistances connected across the input to attenuate the large signals.
- An integrator may be a good addition.

The procedure of Gas Chromatography

<u>Step 1: Sample Injection and Vapourization</u>

- ✓ A small amount of liquid sample to be analyzed is drawn up into a syringe.
- ✓ The syringe needle is positioned in the hot injection port of the gas chromatograph and the sample is injected quickly.
- ✓ The injection of the sample is considered to be a “point” in time, that is, it is assumed that the entire sample enters the gas chromatograph at the same time, so the sample must be injected quickly.
- ✓ The temperature is set to be higher than the boiling points of the components of the mixture so that the components will vaporize.

- ✓ The vaporized components then mix with the inert gas mobile phase to be carried to the gas chromatography column to be separated.

Step 2: Separation in the Column

- ✓ Components in the mixture are separated based on their abilities to adsorb on or bind to, the stationary phase.
- ✓ A component that adsorbs most strongly to the stationary phase will spend the most time in the column (will be retained in the column for the longest time) and will, therefore, have the longest retention time (Rt). It will emerge from the gas chromatograph last.
- ✓ A component that adsorbs the least strongly to the stationary phase will spend the least time in the column (will be retained in the column for the shortest time) and will, therefore, have the shortest retention time (Rt). It will emerge from the gas chromatograph first.
- ✓ If we consider a 2 component mixture in which component A is more polar than component B then:
- ✓ component A will have a longer retention time in a polar column than component B
- ✓ component A will have a shorter retention time in a non-polar column than component B

Step 3: Detecting and Recording Results

- ✓ The components of the mixture reach the detector at different times due to differences in the time they are retained in the column.
- ✓ The component that is retained the shortest time in the column is detected first. The component that is retained the longest time in the column is detected last.
- ✓ The detector sends a signal to the chart recorder which results in a peak on the chart paper. The component that is detected first is recorded first. The component that is detected last is recorded last.

Applications

GC analysis is used to calculate the content of a chemical product, for example in assuring the quality of products in the chemical industry; or measuring toxic substances in soil, air or water.

Advantages

- ✓ The use of longer columns and higher velocity of carrier gas permits the fast separation in a matter of a few minutes.
- ✓ Higher working temperatures up to 5000C and the possibility of converting any material into a volatile component make gas chromatography one of the most versatile techniques.
- ✓ GC is popular for environmental monitoring and industrial applications because it is very reliable and can be run nearly continuously.
- ✓ GC is typically used in applications where small, volatile molecules are detected and with non-aqueous solutions.
- ✓ GC is favored for non-polar molecules.

Limitations

- ✓ Compound to be analyzed should be stable under GC operation conditions.
- ✓ They should have a vapor pressure significantly greater than zero.
- ✓ Typically, the compounds analyzed are less than 1,000 Da, because it is difficult to vaporize larger compounds.
- ✓ The samples are also required to be salt-free; they should not contain ions.
- ✓ Very minute amounts of a substance can be measured, but it is often required that the sample must be measured in comparison to a sample containing the pure, suspected substance known as a reference standard.

Mass Spectrometry Detectors

Mass Spectrometer (MS) detectors are most powerful of all gas chromatography detectors. In a GC/MS system, the mass spectrometer scans the masses continuously throughout the separation. When the sample exits the chromatography column, it is passed through a transfer line into the inlet of the mass spectrometer. The sample is then ionized and fragmented, typically by an electron-impact ion source. During this process, the sample is bombarded by energetic electrons which ionize the molecule by causing them to lose an electron due to electrostatic repulsion. Further bombardment causes the ions to fragment. The ions are then passed into a mass analyzer where the ions are sorted according to their m/z value, or mass-to-charge ratio. Most ions are only singly charged.

The Chromatogram will point out the retention times and the mass spectrometer will use the peaks to determine what kind of molecules is existing in the mixture. The figure below represents a typical mass spectrum of water with the absorption peaks at the appropriate m/z ratios.

Arson

Arson is the act of willfully and deliberately setting fire to or charring property. Although the act of arson typically involves buildings, the term can also refer to the intentional burning of other things, such as motor vehicles, watercraft, or forests. The crime is typically classified as a felony, with instances involving risk to human life or property carrying a stricter penalty. Arson that results in death can be further prosecuted as manslaughter or murder. A common motive for arson is to commit insurance fraud. In such cases, a person destroys their own property by burning it and then lies about the cause in order to collect against their insurance policy. Arson is also often committed to conceal another crime, such as murder or burglary.

A person who commits arson is referred to as an arsonist, or a serial arsonist if the person has committed arson several times. Arsonists normally use an accelerant (such as gasoline or kerosene) to ignite, propel, and direct fires, and the detection and identification of ignitable liquid residues is an important part of fire investigations.[Pyromania is an impulse control disorder characterized by the pathological setting of fires. Most acts of arson are not

Degrees

Many U.S. state legal systems and the legal systems of several other countries divide arson into degrees, depending sometimes on the value of the property but more commonly on its use and whether the crime was committed in the day or night.

- ✓ **First-degree arson** – Burning an occupied structure such as a school or a place where people are normally present
- ✓ **Second-degree arson** – Burning an unoccupied building such as an empty barn or an unoccupied house or other structure in order to claim insurance on such property

- ✓ **Third-degree arson** – Burning an abandoned building or an abandoned area, such as a field, forest or woods.

Many statutes vary the degree of the crime according to the criminal intent of the accused. Some US states use other degrees of arson, such as "fourth" and "fifth" degree, while some states do not categorize arson by any degree. For example, in the state of Tennessee, arson is categorized as "arson" and "aggravated arson.

Burning characteristics

Burning characteristics encompass various aspects of how materials behave when ignited, including flame behavior, smoke production, odor, and residue, which can be used to identify materials or assess their flammability.

i. **Flame Behavior:**

Ignition: How easily a material ignites and the type of flame it produces (e.g., bright, yellow, or smoky).

Burning Rate: How quickly the material burns, whether it melts, shrinks away from the flame, or burns slowly.

Flame Height and Spread: The height and speed at which flames spread across a material.

ii. **Smoke and Odor**:

Smoke Color and Density: The color and amount of smoke produced during burning.

Odor: The type of odor emitted during burning (e.g., burning hair, paper, or plastic).

iii. Residue:

Ash and Residue Type: The type of residue left behind after burning, such as ash, char, or beads.

iv. Material Identification:

Natural vs. Synthetic Fibers:

Burning tests can help distinguish between natural fibers (like cotton, wool, or linen) and synthetic fibers (like nylon or polyester) based on their burning characteristics.

Examples: Cotton burns rapidly with a yellow flame, leaving soft gray ash and smelling like burning paper. Wool burns slowly and produces a dark ash with a

smell of burning hair. Nylon melts and produces a hard, grey bead with a celery smell.

v. **Fire Safety and Building Codes**:

Surface Burning Characteristics:

Building codes often regulate the surface burning characteristics of interior finish materials to ensure fire safety.

Note 1

- ASTM E84 Test: The ASTM E84 test method is used to measure flame spread and smoke development of building materials.
- Fire-Retardant Materials: Fire-retardant materials or treatments are designed to reduce the flammability of materials.

Chemistry of Combustible materials

Combustible materials are substances that can burn in the presence of oxygen, undergoing a chemical reaction (combustion) that produces heat and light. They are characterized by containing elements like carbon, hydrogen, and sulfur, and their flammability depends on factors like volatility and temperature.

Combustion

Combustion is a chemical process where a substance (fuel) reacts rapidly with an oxidant (like oxygen) to produce heat and light.

- ✓ It's an example of an exothermic reaction, meaning it releases energy in the form of heat and light.
- ✓ The products of combustion are often gases like carbon dioxide and water vapor.

Combustible Materials

Combustible materials are substances that can undergo combustion.

- ✓ They are often solids, liquids, or gases that contain elements like carbon, hydrogen, and sulfur.
- ✓ Examples include wood, paper, plastics, fabrics, cooking gas, kerosene, and various fuels.
- ✓ The ease with which a material ignites and burns is known as its flammability.

- ✓ A flammable material ignites easily at ambient temperatures, while a combustible material requires more effort to ignite.

Factors Affecting Flammability:

- ✓ **Chemical Composition:** The presence of elements like carbon, hydrogen, and sulfur contributes to a material's ability to burn.
- ✓ **Physical State:** Solids, liquids, and gases can be combustible, but their flammability can vary.
- ✓ **Volatility:** Materials that easily vaporize (like gasoline) are more flammable than those that don't.
- ✓ **Temperature:** Higher temperatures increase the rate of vaporization and can lead to ignition.
- ✓ **Oxygen Availability:** A sufficient supply of oxygen is necessary for combustion to occur.
- ✓ **Surface Area:** Increased surface area (like finely divided dust) can enhance flammability.
- ✓ **Combustible vs. Flammable:**
- ✓ *Combustible***:** Refers to any substance that can burn. Combustible materials typically have flash points above 37.8°C (100°F) but below 93.3°C (200°F). Examples **Solids:** Wood, paper, plastics, fabrics, coal, charcoal. **Liquids:** Kerosene, gasoline, diesel, oil. **Gases:** Cooking gas (LPG), compressed natural gas (CNG), methane, hydrogen.
- ✓ *Flammable:* Refers to a substance that ignites and burns easily at ambient temperatures. Flammability is often determined by the flash point, the lowest temperature at which a liquid can form an ignitable mixture in air. Flammable materials have flash points below 37.8°C (100°F).

Nature of combustion

Combustion is a rapid, exothermic (heat-releasing) chemical reaction involving a fuel and an oxidant (usually oxygen), producing heat and light, often as a flame, and oxidized products.

Definition: Combustion is a chemical process where a substance (the fuel) reacts with an oxidant (like oxygen) to produce heat and light.

Exothermic Reaction: Combustion reactions release energy in the form of heat, making them exothermic.

Redox Reaction: Combustion is also a redox reaction, meaning it involves both oxidation (loss of electrons) and reduction (gain of electrons).

Examples: Common combustion reactions include burning wood, coal, gasoline, and natural gas. The products of combustion typically include heat, light, and compounds like CO_2 and H_2O.

Conditions: Combustion requires a fuel, an oxidant (oxygen), and an ignition source (like a spark or flame) to start the reaction.

Self-Sustaining: Once initiated, a combustion reaction can often sustain itself if the reaction produces enough heat to maintain the temperature required for the reaction to continue.

Importance:

Combustion is a fundamental process used for heating, cooking, powering vehicles, generating electricity, and more.

Incomplete Combustion:

If there isn't enough oxygen, combustion can be incomplete, producing less energy and potentially harmful byproducts like carbon monoxide and soot.

Complex Chemical Process:

Combustion is a complex process involving many chemical reactions and the formation of various chemical species.

BALLISTICS

Ballistics, in the context of small arms, is the study of projectiles and firearms, encompassing internal, external, and terminal aspects, which are crucial for understanding the behavior of bullets and their effects.

- ✓ Ballistics is the science of projectiles and firearms, encompassing their motion and effects.
- ✓ It can be divided into three main categories: internal, external, and terminal ballistics.

Types of Ballistics:

- ✓ **Internal Ballistics:**
  This focuses on the events that occur within the firearm's barrel, from the moment the propellant is ignited to the projectile leaving the muzzle.
- ✓ **External Ballistics:**
  This deals with the projectile's trajectory after it leaves the barrel, considering factors like gravity, air resistance, and wind.
- ✓ **Terminal Ballistics:**
  This examines the projectile's impact and effects on a target, including wound ballistics (the study of effects on living tissue).

Small Arms:

- ✓ Small arms are weapons designed for individual use, typically with calibers ranging from 4.6 to 40 or 66 mm.
- ✓ Examples include handguns (pistols and revolvers) and shoulder arms (rifles, carbines, submachine guns, and light machine guns).

Key Concepts in Small Arms Ballistics:

- ✓ **Ammunition:** A typical cartridge consists of a cartridge case, primer, propellant, and projectile.
- ✓ **Trajectory:** The path a projectile follows through the air, influenced by external factors.
- ✓ **Muzzle Velocity:** The speed of the projectile as it leaves the barrel.
- ✓ **Effective Range:** The distance at which a projectile can be fired with a reasonable degree of accuracy.

- ✓ **Ballistic Coefficient:** A measure of a projectile's aerodynamic efficiency, which affects its trajectory and range.
- ✓ **Drag:** The resistance of the air to the projectile's motion.
- ✓ **Gravity:** The force that causes the projectile to drop from its line of sight.
- ✓ **Wind:** A factor that can cause the projectile to deviate from its trajectory.

Examples of Small Arms Ammunition:

- ✓ 5.56mm x 30mm JVPC ammunition (under development at Ammunition Factory Khadki, Pune).
- ✓ 5.7mm x 28mm P90 ammunition.
- ✓ 4.6mm x 30mm MP7 ammunition.
- ✓ 7.62mm x 39mm ammunition.
- ✓ 6.8mm x 43mm ammunition.

Laboratory examination of barrel washing and detection of powder residue by chemical tests.

- ✓ Laboratory examination of barrel washing, or more precisely, a "barrel wash examination," is a forensic ballistics procedure to identify and analyze gunshot residue (GSR) and other trace evidence collected from a firearm's barrel after firing.
- ✓ Purpose:
- ✓ The primary goal is to determine if a firearm has been recently fired and to analyze the types and quantities of GSR present, which can help link a firearm to a crime scene or a suspect.
- ✓ Procedure:
    - Collection: After firing, the barrel is washed with a specific solvent to collect GSR and other trace evidence.
    - Analysis: The collected washings are then examined in a laboratory using various techniques, such as:
        - Microscopy: To identify and count GSR particles.
        - Spectroscopy: To determine the chemical composition of GSR.
        - Gas Chromatography-Mass Spectrometry (GC-MS): To identify and quantify organic compounds in the washings.

Significance:

- ✓ **Linking Firearms to Crimes:** GSR analysis can help establish a link between a firearm and a crime scene or a suspect.
- ✓ **Reconstructing Events:** GSR patterns and distribution can provide insights into the distance between the shooter and the target, as well as the sequence of events.
- ✓ **Excluding Suspects:** If a firearm is found to not contain GSR after a barrel wash, it can help exclude a suspect from being involved in a shooting.
- ✓ **Other Forensic Ballistics Examinations:**

  Forensic ballistics also involves:
- ✓ **Examination of Firearms:** Identifying the type, make, and caliber of a firearm.
- ✓ **Examination of Ammunition:** Identifying the type and caliber of ammunition.
- ✓ **Comparison of Bullets and Cartridge Cases:** Determining if a bullet or cartridge case was fired from a specific firearm.

<u>Chemical tests</u>

Chemical tests, such as the Sodium Rhodizonate test and the Greiss test, are used to detect powder residue, specifically gunshot residue (GSR), by identifying characteristic compounds like lead, barium, and nitrates.

- ✓ **Sodium Rhodizonate Test:**

  This test is used to detect the presence of lead and barium, which are components of the primer in ammunition. It involves reacting the sample with sodium rhodizonate, resulting in a color change that indicates the presence of these metals.
- ✓ **Greiss Test:**

  This test is used to detect the presence of nitrites, which are a byproduct of gunpowder combustion. It involves reacting the sample with a solution containing sulfanilic acid and alpha-naphthylethylenediamine, resulting in a color change that indicates the presence of nitrites.

Importance of GSR Analysis:

Gunshot residue analysis is crucial in forensic investigations to determine if someone recently fired a gun, was in close proximity to a firearm when it was fired, or came into contact with someone who fired a gun.

Modern Techniques:

Modern GSR analysis often involves scanning electron microscopy (SEM) with energy-dispersive X-ray spectroscopy (EDS) to identify the elemental composition of GSR particles.

Limitations:

While chemical tests are useful for screening, they may not be definitive and can sometimes produce false positives. More sophisticated methods, such as SEM-EDS, are often used for confirmation and detailed analysis.