CHAPTER 36
CARDIAC POISONS

NICOTIANA TABACUM : All parts are poisonous except the ripe seeds. The dried leaves (*tobacco, tambaku*) contain one to eight percent of nicotine and are used in the form of smoke or snuff or chewed. The leaves contain active principles, which are the toxic alkaloids nicotine and anabasine (which are equally toxic); nornicotine (less toxic). Nicotine is a colourless, volatile, bitter, hygroscopic liquid alkaloid. It is used extensively in agricultural and horticultural work, for fumigating and spraying, as insecticides, worm powders, etc.

ABSORPTION AND EXCRETION : Each cigarette contains about 15 to 20 mg. of nicotine of which 1 to 2 mg. is absorbed by smoking; each cigar contains 15 to 40 mg. Nicotine is rapidly absorbed from all mucous membranes, lungs and the skin. 80 to 90 percent is metabolised by the liver, but some may be metabolised in the kidneys and the lungs. It is excreted by the kidneys.

ACTION : It acts on the autonomic ganglia which are stimulated initially, but are depressed and blocked at later stage. It also acts on the somatic neuromuscular junction, and afferent fibres from sensory receptors.

ACUTE POISONING : G.I.T. Burning acid sensation, nausea, vomiting, abdominal pain, hypersalivation. Cardiopulmonary: Tachycardia, hypertension, tachyapnoea (early); bradycardia, hypotension, respiratory depression (late). Cardiac arrhythmias may occur. C.N.S.: Miosis, confusion, headache, sweating, ataxia, agitation, restlessness, hyperthermia (early); mydriasis, lethargy, convulsions, coma (late). Death may occur from respiratory failure.

CHRONIC POISONING : Symptoms are cough, wheezing, dyspnoea, anorexia, vomiting, diarrhoea, anaemia, faintness, tremors, impaired memory, amblyopia, blindness, irregularity of the heart with extrasystoles and occasionally attacks of pain suggesting angina pectoris.

WITHDRAWAL SYMPTOMS: Intense urge to smoke, anxiety, impaired concentration and memory, depression or hostility, headache, muscle cramps, sleep disturbances, increased appetite and weight gain, diaphoresis and rapid respirations. A short period (6 to 12 weeks) of maintenance often followed by a gradual reduction in 6 to 12 weeks is adopted.

Nicotine replacement therapy (NRT) includes use of nicotine products including gum, transdermal patch, nasal spray, lozenge and inhaler.

FATAL DOSE: 50 to 100 mg. of nicotine. It rivals cyanide as a poison capable of producing rapid death; 15 to 30 g. of crude tobacco.

FATAL PERIOD: Five to 15 minutes.

TREATMENT: (1) Wash the stomach with warm water containing charcoal, tannin or potassium permanganate. (2) A purge and colonic wash-out. (3) Mecamylamine (Inversine) is a specific antidote given orally (4) Protect airway. (5) Oxygen. (6) Symptomatic.

POST-MORTEM APPEARANCES: They are those of asphyxia. Brownish froth at mouth and nostrils, haemorrhagic congestion of GI tract, and pulmonary oedema are seen. Stomach may contain fragments of leaves or may smell of tobacco.

THE CIRCUMSTANCES OF POISONING: (1) Accidental poisoning results due to ingestion, excessive smoking and application of leaves or juice to wound or skin. (2) For malingering tobacco leaves are soaked in water for some hours and placed in axillae at bed time, which is held in position by a bandage. Poisonous symptoms are seen the next morning. (3) Suicidal and homicidal poisoning is rare.

DIGITALIS PURPUREA: Entire plant is toxic, containing over thirty cardiac and steroidal glucosides. The root, leaves and seeds of digitalis contain digitoxin, digoxin, digitalin, digitalin and digitonin and digoxin (glycosides).

SIGNS AND SYMPTOMS: GIT: Anorexia, nausea, vomiting, diarrhoea. CARDIAC: Arrhythmias: extrasystoles, ventricular tachycardia and fibrillation, atrial flutter and fibrillation, SA block, AV block. ENDOCRINE: Gynaecomastia. VISUAL: Transient amblyopia, photophobia, diplopia, blurring, scotomata, colour aberration, halos. SKIN: Urticaria. CNS: Headache, fatigue, muscle weakness, neuro-psychiatric disorders, confusion, anxiety, depression, disorientation, drowsiness, delirium, hallucinations, trigeminal neuralgia. Death occurs from cardiovascular collapse.

FATAL DOSE: 15 to 30 mg. of digitalin: four mg. of digitoxin; digoxin 10 mg; leaf : 2 g.

FATAL PERIOD: One to twenty-four hours.

TREATMENT: (1) Stomach wash with a solution of tannic acid. (2) The bowels should be evacuated. (3) Activated charcoal in repeated doses. (4) Digoxin-specific antibody fragments (Fab) one vial i.v. in 30 minutes for each vial, which contains 38 mg Fab fragments. Total 10-20 vials. (5) In the absence of Fab

fragments, ventricular irritability can be treated with phenytoin 50 mg/min. i.v. up to one gram, followed by 300 to 400 mg. daily. Specific antidote for digitalis induced cardiac arrhythmias are: 100 mg. lignocaine i.v. or dilantin or propranolol. (6) Trisodium EDTA may help to lower the serum calcium. (7) Potassium salts to reduce extrasystoles and tachyarrhythmias. (8) Bradycardia should be treated with atropine sulphate 0.6 mg. i.v. repeated as necessary up to four days. (9) Symptomatic.

POST-MORTEM APPEARANCES: They are not characteristic. There may be slight inflammation of the gastric mucosa and fragments of the leaves may be found in the alimentary canal.

Poisoning is accidental, due to therapeutic overdose.

NERIUM ODORUM: Nerium odorum *(white oleander, kaner)* grows wild in India. Flowers usually fragrant, are borne in terminal clusters. They are white, pink, dark red or rarely pale-yellow. They are two-and-half to five cm. wide and have five petals or in double blooms, many petals. The leaves are narrow, lanceolate, leathery, dark green on upper surface, lighter beneath, and 10 to 25 cm. long. Seed pod is slim, cylindrical, ribbed, up to 15 cm. long, turns brown, dries and splits, releasing small seeds tipped with brown hairs. All parts of the plant including nectar are poisonous, containing several cardiac glycosides, primarily oleandroside (oleandrin), and nerioside (nerin), which resemble digitalis in action and folinerin and rosagenin. The nector yields poisonous honey.

Signs and Symptoms: The plant is occasionally a source of contact dermatitis. Emanations from flowers, especially when fading cause headache, dizziness, respiratory difficulty and nausea. Ingestion causes difficulty in swallowing and articulation, abdominal pain, vomiting, profuse frothy salivation and diarrhoea. Pulse is first slow and later rapid and weak, blood pressure falls, fibrillation, AV block, respirations are increased, pupils are dilated, muscular twitchings, tetanic spasms, lock-jaw, drowsiness, coma, respiratory paralysis and death occurs. Death usually results from cardiac failure.

Fig. (36–1). Digitalis purpurea.

Fatal Dose: 15 to 20 g. of the root; 5 to 15 leaves.

Fatal Period: 20 to 36 hours.

Treatment: (1) Stomach wash. (2) Symptomatic.

Post-mortem Appearances: They are not characteristic. Congestion of organs is seen. It can be detected long after death.

The Circumstances of Poisoning: (1) The root, leaves or fruit are often used as a paste or decoction for suicidal purposes. (2) Homicide is rare. (3) As an abortifacient, root is used either locally or taken internally. (4) Root is taken internally for treating venereal diseases. (5) Root is used for treating cancers and ulcers in the form of paste. (6) The decoction of leaves is applied externally to reduce swelling. (7) As a cattle poison, the juice of root is applied on piece of cloth and inserted into the anus of the animal. (8) Smoke from the burning plant is toxic. When plant material is used to roast food over a fire, the poisonous sap transferred to the food may be lethal.

CERBERA THEVETIA: All parts of cerbera thevetia (yellow oleander; *pila kaner)* are poisonous. The flowers are large, bell-shaped and yellow, 5 to 7 cm. long and five cm. wide, the five lobes spirally twisted and spreading, and the leaves are lanceolate. The fruit is globular, light-green, about 4 to 5 cm. in diameter and contains a single nut which is triangular with a deep groove along the edge. Each nut contains five pale yellow seeds. The seeds contain four percent of the cardiac glycoside thevetin, which is one-eighth as potent as ouabain and similar to digitalis in action; thevetoxin is similar to but less toxic than thevetin; nerifolin (more potent than thevetin); peruvoside, and ruvoside, cerberin and also a bitter principle that acts on the CNS, and produces tetanoid convulsions. All active principles are glycosides. Milky juice exudes from all parts of the plant.

Signs and Symptoms: The sap of the plant may cause inflammation in sensitive individuals. Chewing the bark or seed kernel causes a slight numbing sensation and feeling of heat in the mouth and purging. Ingestion causes burning pain in the mouth, dryness of throat, tingling and numbness of tongue, vomiting, diarrhoea, headache, giddiness, dilated pupils, loss of muscular power and fainting. Pulse is rapid, weak and irregular, blood pressure low. Heart block, collapse and death from peripheral circulatory failure occurs.

Fatal Dose: 8 to 10 seeds; 15 to 20 g. of root; 5 to 10 leaves.

Fatal Period: 2 to 3 hours.

Treatment: (1) Wash out the stomach. (2) Sodium molar lactate transfusion with glucose and one mg. atropine, 2 ml. adrenaline and 2 mg. noradrenaline is beneficial. (3) Symptomatic.

Post-mortem Appearances: They are not specific. Stomach and duodenum may be congested and may show fragments of seeds.

The Circumstances of Poisoning: (1) The root and seeds are used sometimes for suicide or homicide. (2) Root and seeds are taken for criminal abortion. (3) For cattle poisoning, the seeds are crushed and fed to the animal with corn or bread.

CERBERA ODALLAM *(Pilikirbir):* This plant is closely allied botanically to cerbera thevetia. It is a small plant or a shrub that grows wild all over India. The leaves are dark green, fleshy and lanceolate, 20 to 30 cm. long, and 4 to 6 cm. broad. The flowers are white, like those of jasmine. The fruit resembles a mango, is globular and dark green and has a thick fibrous mesocarp which encloses usually a single seed. The seed is flattened and ovoid and contains two kernels which are pearly-white but when dry it may have a bluish tinge or it may become gelatinous. Milky acrid juice (toxic) exudes from all parts of the plant. The active principles are cerberin, cerberoside, odollin, odolotoxin, thevetin and cerapain (glycosides).

Signs and Symptoms: They appear within one hour. The initial symptoms are gastrointestinal. Cardiac toxicity may occur within three hours of ingestion. There is bitter taste, nausea, severe retching, vomiting, abdominal pain and in few cases diarrhoea, general weakness, blurring of vision, sinus bradycardia, irregular respiration, collapse and death from heart failure. ECG may show sinus

Fig. (36–2). Cerbera odallam.

bradycardia, S-A block, atrial fibrillation and other arrhythmias. Hyperkalaemia and depression of transaminase activity are chief biochemical changes.

Fatal Dose : Kernel of one fruit.

Fatal Period : One to two days or more.

Post-mortem Appearances: They are those of asphyxia. Eyes are congested. Lungs are congested and oedematous. Subepicardial, subendocardial and subpleural petechial haemorrhages are found. Stomach mucosa is congested with submucous haemorrhages and gastritis. The internal organs are congested.

Treatment : (1) Stomach wash. (2) Atropine 0.5 mg. i.v. and repeated every 15 to 30 minutes to keep heart rate above 50 per minute. (3) Correct hyperkalaemia.

Circumstances of Poisoning : (1) For suicide, the kernels are taken as such, or after grinding it with jaggery or molasses or by preparing a curry with it. (2) For homicide, the powdered kernel is added to alcohol. (3) Bark, leaves and milky juice are used as emetic and as purgative.

CLEISTANTHUS COLLINUS: The vernacular names in India are; oduvan, karlajuri, karada, garari. It belongs to family euphorbiaceae and grows on dry hills in various parts of India. All parts of the plant are poisonous. Oduvin (glucoside) is the toxic principle. The leaves or root are ground and mixed with jaggery or sugar to mask its bitter taste. The toxin blocks neuromuscular transmission and also acts on the cardiac conductive system.

FATAL DOSE: 200 to 400 gm. of leaves.

FATAL PERIOD: One to three days.

Signs and Symptoms: Nausea, vomiting, diarrhoea, abdominal pain, dilated pupils, feeble pulse, tachycardia, tachypnoea with stertorous breathing, hyperpyrexia,

muscle cramps and cardiac conductive defects.

TREATMENT: Symptomatic.

AUTOPSY: Signs of asphyxia.

QUININE: The bark of the various species of cinchona plants contain quinine, cinchonidine and other alkaloids. Quinine occurs as white needle-shaped, odourless crystals and has a bitter taste.

ACTION: It is a strong protoplasmic poison with anaesthetic and sclerosing action. It stimulates and then depresses central nervous system.

SIGNS AND SYMPTOMS : In fifteen to thirty minutes there is headache, giddiness, ringing in the ears, partial deafness, disorders of vision, pupils are fixed and dilated. There is mental confusion, pain in the abdomen, vomiting, diarrhoea, confusion of thought, muscular weakness, itching, erythematous or urticarial rash on the skin, methaemoglobinaemia, tachycardia, hypotension, cyanosis, delirium and coma. Death occurs from respiratory failure. Large doses cause haemolysis and the renal tubules may be blocked by haemoglobin leading to death from uraemia.

CINCHONISM is caused by repeated therapeutic doses or overdose. Symptoms are: tinnitus, vertigo, deafness, diplopia, scotomata, blindness, skin rash, hypoglycaemia, and cardiac arrhythmias.

FATAL DOSE : 8 to 15 g.

FATAL PERIOD : 6 hours. Quinidine 4 to 6 g.

TREATMENT : (1) Gastric lavage should be performed and a concentrated solution of magnesium sulphate left in the stomach for rapid elimination of poison. (2) Activated charcoal. 50 g. every 2 to 4 hours for 24 hours. With each dose of charcoal give 30 g. of sodium or magnesium sulphate until stools look black. (3) Forced acid diuresis. (4) Bilateral stellate ganglion block causes immediate return of the vision. (5) Symptomatic.

POST-MORTEM APPEARANCES : There may be congestion of the organs and haemolysis of red cells. Renal tubules may be blocked by haemoglobin.

THE CIRCUMSTANCES OF POISONING : Poisoning is usually accidental due to overdose. Suicide is rare. It is used as an abortifacient.

ACONITE

There are several varieties of aconite (monk's hood, blue rocket, *mitha zaher, bish, bikh*), but the roots of Aconitum napellus and Aconitum ferox are commonly used. It grows in the Himalayas. All varieties and all parts of the plant are poisonous; least when young, more so when seeds ripen and most when bloom. The root is most potent; contains aconitine and ten or more other alkaloids, such as pseudo-aconitine, indaconitine, bikhaconitine, picraconitine, aconine, mesaconitine, jesaconitine, etc. Aconitine stimulates and then depresses CNS.

The dry root is conical or tapering, and shows scars or bases of broken rootlets, and is arched or shrivelled with longitudinal wrinkles. It is usually five to ten cm. long, and one-and-half to two cm. thick at the upper end. The external colour is dark-brown, and when freshly cut the internal colour is white, which becomes pink on exposure to air. It is odourless but the taste is sweet, then acrid. When dried and soaked in oil the root is black, heavy, hard and brittle with a strong offensive odour. The root is mistaken for horse-radish root which is long, cylindrical, yellowish-white externally and whitish internally, does not change on exposure to air and the taste is pungent.

Signs and Symptoms : Leaves handled or rubbed on the skin, produce tingling and numbness; so also the root if held for a long time in the hand. The odour of the plant has a narcotic effect. The pollen causes pain and swelling in the eyes. The symptoms occur immediately or within a few minutes. There is a burning sensation from the mouth to the stomach and tingling and numbness in the mouth, tongue and pharynx. This is followed by salivation, nausea, vomiting and diarrhoea. Later the mouth is dry and patient suffers from thirst and is unable to swallow. Tingling and numbness are then felt all over the body. There is headache, giddiness, pallor, profuse sweating, subnormal temperature, the limbs become weak and the patient is unable to walk or stand. There may be twitching of the muscles with darting pains, and cramps and convulsions may occur. The pupils alternately contract and dilate (**hippus**), but remain dilated in the later stages. The vision becomes dim and there may be diplopia. Hypotension, cardiac arrhythmia

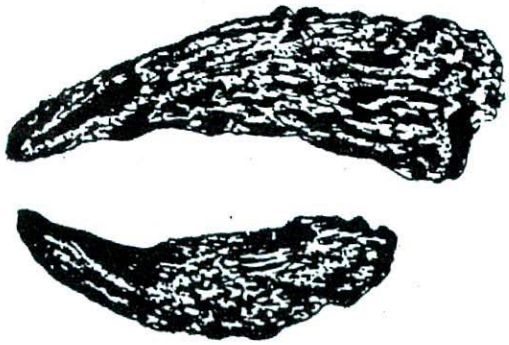

Fig. (36–3). Dried roots of Aconitum napellus.

with AV block occurs. At first there is tachycardia, but in later stages bradycardia occurs due to AV block. The mind usually remains clear, although there may be hallucinations. There is marked general muscular weakness, oppression in the chest, and death occurs from paralysis of heart or respiratory centres or both.

Fatal Dose : One g. root; 2 to 5 mg. of aconitine; 250 mg. extract; 2 to 30 ml. tincture.

Fatal Period : Two to six hours.

Treatment : (1) Gastric lavage with warm water, and weak solution of iodine in potassium iodide or tannic acid to precipitate alkaloid, or animal charcoal. (2) Atropine half to one mg. is useful. (3) Symptomatic.

It is eliminated by all routes but mainly in the urine.

Post-mortem Appearances : They are not characteristic, but are those of asphyxia. The mucosa of the stomach and duodenum show congestion and occasionally ecchymosis. The lungs, kidneys and brain are congested. Excretion is mainly in the urine and traces in saliva, sweat and bile. Aconitine is extremely unstable and is destroyed by putrefaction.

The Circumstances of Poisoning : (1) Accidental poisoning is due to eating the roots in mistake for horseradish root, by the use of quack remedies containing it, or from taking liquor to which aconite is added to increase intoxication. (2) Suicidal cases often occur. (3) It is given with betel leaf to conceal its taste for homicide. (4) Root is used as an abortifacient. (5) Cattle poison. (6) Arrow poison.

CHAPTER 37
ASPHYXIANTS

Henderson and Haggard divided noxious gases into five groups.

(1) IRRITANTS : The gases injure the air passages or lungs or both, and produce inflammatory changes. They are smoke, tear gases, ammonia, formaldehyde, chlorine, phosgene, nitrogen dioxide, sulphur dioxide.

(2) CHEMICAL ASPHYXIANTS : These are gases which by combining with haemoglobin, or by acting on some tissue constituent prevent oxygen from reaching tissue or the tissues from using it. The examples are carbon monoxide, hydrogen sulphide, arsine, carbon disulphide, and cyanide.

(3) SIMPLE ASPHYXIANTS : These are inert gases, which when breathed in high concentration act mechanically by excluding oxygen. They are carbon dioxide, methane, helium, nitrogen and nitrous oxide. Symptoms appear when these gases exceed 20 to 30% of inspired air. When the inspired air contains less than 10% oxygen death may result from slight exertion.

(4) VOLATILE DRUGS : These are gases with little or no irritant effect upon the air-passages, which act after absorption into the blood, either as an anaesthetic, or as agents toxic to the liver, kidneys or other organs including the nervous system. They are aliphatic hydrocarbons, halogenated hydrocarbons and aromatic hydrocarbons.

(5) SYSTEMIC POISONS : These are insecticides, arsine, stibine.

CARBON MONOXIDE

It is a colourless, tasteless, non-irritative gas which is produced due to incomplete combustion of carbon. It is insoluble in water. It burns with a blue flame. It is lighter than air and significant quantities are present only in the upper reaches in the vicinity of a fire.

Action : CO is readily absorbed across the alveolus and combines with haemoglobin. Normal blood contains 20% of oxygen, with 18% bound to haemoglobin and 2% dissolved in plasma. About 10 to 20% CO is present in extracellular tissues combined with myoglobin and haemoproteins. CO affinity to myoglobin is about 40 times greater than oxygen, which may cause direct myocardial depression. CO has 200 to 300 times greater affinity for haemoglobin than that of oxygen. It displaces oxygen from its combination with haemoglobin and forms a relatively stable compound known as carboxyhaemoglobin. It thus reduces the oxygen content of the blood, and hence that of the tissues. It acts as a chemical asphyxiant and produces death due to anaemic anoxia. CO is a potent cellular toxin. It effectively and firmly binds to haemoglobin and myoglobin. It inhibits the electron transport by blocking cytochrome A_3 oxidase and cytochrome P–450, and therefore intracellular respiration. It interferes with other ferroproteins such as myoglobin and various enzymes. The presence of COHb in the circulation interferes with the release of the oxygen from what little oxyhaemoglobin remains. Normally, after somatic death, the cells near the capillaries continue to function, extract oxygen from oxyhaemoglobin and cause blue staining. In CO poisoning this cannot occur, because the cells cannot break the COHb compound. Potent cellular poisons, e.g. cyanide, fluoroacetate and freezing, block the metabolism of the cells so fast and completely that they cannot extract oxygen from oxyhaemoglobin. In these cases, the blood under the skin and in the tissues will be cherry-red due to oxyhaemoglobin.

Elimination: It is eliminated through lungs; about 1% is metabolised to CO_2. Half-life of CO in a healthy adult breathing 21% oxygen (room air) is 4 to 5 hours. Breathing 100% O_2, it is reduced to 80 to 90 minutes. Hyperbaric oxygen (3 atmospheres pressure) reduces half-life to less than 30 minutes. It is not metabolised and is not lost through the skin, bile, perspiration, urine or faeces. CO is not absorbed by a body after death.

Sources : The common sources of CO include coal gas, smoke from fires and the fumes from defective heating appliances, e.g., furnace, stove, water heater, fire places, burning oil lamps. It is also found as a component of the fumes of coke kilns, lime kilns, explosion in mines (after damp), choke damp (improperly ventilated collieries at the dead ends) detonation of explosives, and the exhaust fumes of internal combustion engines. Industry accounts for about 20%. In a person smoking one pack of cigarettes per day, CO levels are about 5 to 6% and in a heavy smoker 15 to 20%. The exhaust gas of motor cars contain one to seven percent of CO, which causes the air of a small garage poisonous in 5 to 10 minutes. Diesel engines produce far less CO than petrol engines.

Table (36–1). Symptoms of CO poisoning

COHb%	Symptoms
0 to 10%	No appreciable symptoms.
10 to 20%	Breathlessness on moderate exertion, mild headache.
20 to 30%	Throbbing headache, irritability, emotional instability, disturbed judgement, defective memory and rapid fatigue.
30 to 40%	Severe headache, nausea, vomiting, dizziness, dimness of vision, confusion. cherry-red colour.
40 to 50%	Increasing confusion, sometimes hallucinations, severe ataxia, rapid respirations and collapse with attempts at exertion. Symptoms resemble alcoholic intoxication.
50 to 60%	Syncope or coma with intermittent convulsions, rapid respirations, tachycardia with a weak pulse and pink or red discolouration of the skin.
60 to 70%	Increasing depth of coma with incontinence of urine and faeces.
70 to80%	Profound coma with depressed or absent reflexes, a weak thready pulse, shallow and irregular respirations and death.
Above 80%	Rapid death from respiratory arrest.

During haemoglobin catabolism 0.4 to 0.7% COHb is produced in the body endogeneously. In haemolytic anaemia, COHb levels may reach 8%.

Signs and Symptoms : The symptoms of poisoning are often mistaken for symptoms of influenza or illness caused by eating contaminated food. The development of symptoms has a progression, roughly parallel to the rise in the saturation of the blood by CO. Similarly, regression of symptoms corresponds with the clearance of CO from the blood. Victims may not notice anything, except a headache, until they lapse into coma and die. The effects of CO are simply those of suboxia. Damage to the CNS may produce monoplegia or hemiplegia. Impairment of higher intellectual functions, personality changes, cerebellar damage, and severe Parkinsonism may occur and may be delayed by several weeks after apparent recovery. As most deaths are relatively rapid, blisters are rare. Bullae tend to be separate and isolated lesions. The bullous fluid is usually thick and cellular and there is often an inflammatory reaction in the surrounding skin. These bullae are localised by external pressure and are seen in the regions of the calves, buttocks, wrists and knees. They are caused due to skin hypoxia. They rarely involve fingers and toes. There is a tendency of the dying victim to wild, erratic swinging movements inside the room, disturbing clothing and furniture which gives an impression of violent struggle (automatism). The saturation required to cause death varies with the age and health of the person. Death usually occurs when eighty percent of haemoglobin is saturated with CO. Senility, any disease or the co-existence of any respiratory or circulatory deficiency, or of anaemia or in association with depressive drugs like barbiturates, and alcohol result in a significant reduction of maximum lethal saturation, and death can occur from as little as thirty percent saturation. CO can pass from the maternal to the foetal blood, and can produce intrauterine death, even though the mother survives. The rate of CO combining with haemoglobin depends on the atmospheric concentration and rate of respiratory exchange. Physical activity during exposure increases rate of saturation of blood. Children saturate their blood more rapidly than adults because of their relatively high rates of respiratory exchange. Patients recovering from CO poisoning may suffer neurological sequelae including tremors, personality changes, memory impairment, visual loss, inability to concentrate and Parkinsonism within 2 to 4 weeks. These effects may be temporary or permanent. Complete recovery after serious poisoning may take many weeks. Sometimes, people become ill again up to 4 weeks after recovery.

Chronic Poisoning: Symptoms include headache, confusion, weakness, paraesthesias, visual disturbances, hypertension, hyperthermia, palpitations, atrial fibrillation, bundle branch blocks, AV block, abnormal left ventricular function, decreased cognitive ability, mental retardation, psychosis, Parkinsonism and incontinence.

Delayed Deaths: Coma is accompanied by degenerative changes in brain and capillaries. Individuals with long term survival following

significant exposure may have a Parkinsonian syndrome or may develop even neurological states.

The Effect of Different Air Concentrations of CO : Humidity, high environmental temperature, and physical activity increase the respiratory rate and thus, the absorption of CO. The upper limit of safety is 0.01% CO in air. If a person breathes CO in low concentration for a considerable length of time, especially during sleep, he will be poisoned just as effectively as though he were exposed to a high concentration for a shorter period. When low concentrations of gas are inhaled, coma does not occur immediately, but a state of complete helplessness may develop, and the victim may not be able to save himself. A concentration of 0.5 to 1% of CO in the atmosphere can produce carboxyhaemoglobin saturation levels of 75% in 2 to 15 minutes. Exposure to atmosphere containing 0.2% of gas will cause death in about four hours, 0.4% in one hour, and 10% in 20 to 30 minutes.

Treatment : (1) Remove the patient to fresh air immediately. If he is conscious and breathing, no treatment is required. (2) Any patient with COHb level greater than 25% should be treated. (3) The most widely accepted treatment is 100% oxygen provided by a tight-fitting mask preferably with rubber seals and endotracheal intubation for patients with a depressed mental status, until CoHb falls to 15 to 20%. (4) CO_2 should not be given. (5) Hyperbaric oxygen (HBO) therapy has several disadvantages, such as vomiting, convulsions, agitation, rupture of tympanic membranes, blocked sinuses, etc. (6) Gastric lavage early in the course of treatment may prevent aspiration pneumonitis. (7) A whole blood transfusion is useful. (8) The patient should be kept at complete rest for at least 48 hours. (9) Avoid stimulant drugs. (10) Give antibiotics as a prophylaxis against lung infection. (11) Cerebral oedema should be treated with fluid restriction, steroids, and mannitol.

Post-mortem Appearances : A cherry-red colouration of the skin, mucous membranes, conjunctivae, nail-beds, areas of hypostasis, blood, tissues and internal organs is seen in 15 to 20% of cases only. It is associated with 30 to 40% CO Hb. Cyanide poisoning and exposure of the dead body to the cold may cause redness similar to that due to CO. The cherry-red discolouration changes to dark-green, then to brown with the onset of decomposition. The blood is fluid, hyperaemia is general and serous effusions are common. There may be blistering of the skin of dependent areas, such as buttocks, calves, wrists and knees, due to cutaneous oedema. Congestion of the lungs with pink fluid blood, and if the victim survived for some time, pulmonary oedema with congestion are found. The lungs may show bronchopneumonic consolidation. In delayed deaths, tiny focal necroses occur in the myocardium. Frank myocardial infarction has been reported after severe exposure and relative hypoxia, usually in the presence of pre-existing coronary disease. Within five days histological changes occur here. Pleural and pericardial anoxial haemorrhages are common. In persons surviving after severe CO exposure and in delayed deaths bilateral, symmetrical necrosis and cavitation of the basal ganglia in the brain, especially the putamen and globus pallidus is the most characteristic lesion, though the cerebral cortex, hipppocampus, cerebellum and substantia nigra of brainstem may be affected. Punctiform and ring-shaped haemorrhages in the white matter of the brain with widespread oedema are common. Haemorrhages in the meninges and cortex, and selective cellular necrobiosis of ganglion cells in the cortex may be seen.

The Circumstances of Poisoning : (1) In India, suicide by CO is very rare. The person may be seated in his car with a tube leading from the exhaust into the passenger compartment or he may lie on the floor of the garage near the exhaust pipe, with doors and windows closed. (2) Accidental deaths may be caused by use of flueless braziers, exposure to exhaust gas of petrol engines, exposure to gas in mines following underground fires or explosions, and exposure to gas during fires. Accidents may occur in connection with incomplete combustion of wood, charcoal or coal in ill-ventilated room. (3) Homicide is uncommon, unless the victims are adults incapacitated by drink, drugs, disease or infirmity, or they are children.

TESTS : (1) In 15 ml. of water in a test tube, place two drops of blood suspected to contain CO and mix. Water turns pink due to COHb. With normal blood, colour is not pink. (2) Kunkel's test or tannic acid test: If tannic acid is added to blood it remains cherry-red in CO poisoning, while oxyhaemoglobin turns deep brown. (3) Hoppe-Seyler's test: Few drops of blood are added to a solution of ten% sodium hydroxide. Normal blood turns brownish-green, but if CO is present, the colour will remain pink. (4) Spectroscopic examination of blood shows characteristic

bands of carboxyhaemoglobin.

If only tissue is available, water is used to extract blood from liver, spleen, kidneys, lungs or other organs. Heavy cigarette smokers may have a CO blood level up to 10 to 12%. CO persists for many weeks after death, and may be detected even after putrefaction or embalming and prolonged burial. The cherry red colour of viscera will persist even if tissue is removed and placed in formaldehyde. Embalming will also not change the colour of viscera. It is preferable to use anticoagulants in specimens for examination. In some cases of fatal CO poisoning, blood analysis may not disclose COHb. This occurs in cases where the victim is shifted to CO free atmosphere, and sufficient breathing had occurred to clear the blood of COHb. But, the poisoned victim may die because of irreversible brain damage sustained while high CO concentration persisted. It is not a product of putrefaction. The gas cannot be absorbed by body after death.

If vapour or gas intoxication is suspected as the cause of death, ten ml. of heart blood should be collected prior to autopsy. CO-blood has very little tendency to clot. The cells tend to separate from the plasma in the blood vessels and organs of the body. Since CO is contained in the cells, care should be taken in removing the sample of blood. If the blood is taken from the heart, this may be done by filling the syringe and flushing it back into the heart then refilling to take the sample. Fluoride should be added as preservative. It should be placed in a tightly sealed gas-tight container. The blood need not be kept under a layer (2 to 3 mm thick) of liquid paraffin because the carboxyhaemoglobin molecule is extremely stable. If sufficient blood cannot be obtained from the heart or major vessels, the spleen or muscle should be sent for analysis. Pieces of lungs should also be placed in suitable container tightly sealed and refrigerated. In a badly burnt body CO can be detected in any sanguineous body fluid or bone marrow.

Non-dispersive infrared spectrophotometry and gas chromatography are analytical methods.

CARBON DIOXIDE: It is a heavy, colourless gas with a faintly sweet odour. Atmospheric air contains 0.033% CO_2, 21% oxygen and 70 to 80% nitrogen. Carbon dioxide is heavier than air, and therefore it settles when it accumulates in the absence of air movement. Common places which may contain CO_2 in excess include manholes, ship holds, old wells, silos and occasionally cellars.

Action : The gas is not toxic, but acts as a simple asphyxiant by preventing the tissue from obtaining oxygen.

Signs and Symptoms : The symptoms vary with concentration of the gas. 5% concentration of CO_2 in air (i.e. above the concentration in alveolar air) causes laboured breathing and mental confusion. Above 10% produce ataxia and unconsciousness. Air containing 30 %of pure CO_2 dose not produce any effects for some time. With 40% there is dyspnoea, discomfort, and muscular weakness. With 50% there is dyspnoea, a feeling of tightness in the chest, fullness in the head, ringing in the ears and loss of muscular power followed by drowsiness, unconsciousness, coma and death. 60 to 80% of CO_2 causes immediate unconsciousness with or without convulsive movements and rapid death due to some vasovagal reflex causing cardiac arrest, triggered by a chemoreceptor stimulus.

CO_2 from a well can be collected by using a bottle filled with soda-lime water and putting it inside a well.

Treatment : Artificial respiration and oxygen should be given freely. Cardiac stimulants are useful.

Post-mortem Appearances : There is marked cyanosis, congestion, suffusion of the eyes, dilation of the pupils and petechial haemorrhages.

Poisoning is usually accidental.

HYDROGEN SULPHIDE (H_2S): It is colourless, heavy, flammable gas with a smell of rotten eggs. It is formed during decomposition of organic substances containing sulphur. It is often found in large quantities in sewers, cess pools, privy vaults and tannery vats. It may also occur in glue factories and gas works, in the distillation of petroleum oil, in the manufacture of artificial silk and in other industries where sulphur compounds are used. Hydrogen sulphide in combination with CO_2 and methane formed in sewers, is known as **sewer gas**. Poisoning by this gas is almost always accidental, especially in sewer workers. It does not combine with haemoglobin but does so with methaemoglobin to form sulphmethaemoglobin. H_2S interferes with cellular respiration by inhibiting the action of cytochrome oxidase.

Signs and Symptoms : In great dilution, there is feeling of dullness and sleepiness, and death may occur during sleep without the victim regaining

consciousness. In weak concentration, there is cough, giddiness, nausea and feeling of oppression. The breathing is laboured and heart irregular, cyanosis of the face, inflammation of conjunctivae, lachrymation and photophobia, muscular weakness and prostration. In moderate concentration, metabolic acidosis secondary to anaerobic metabolism occurs. This results in CNS, respiratory and myocardial depression. There may be delirium, convulsions or coma, and death occurs from asphyxia. If breathed in a concentration of 0.1 to 0.2%, death occurs immediately from paralysis of respiratory centre. Its toxicity and rapidity of action are comparable to hydrocyanic acid.

Treatment : (1) The patient must be removed into the fresh air. (2) Artificial respiration and 100% oxygen given. (3) Excretion of sulphide can be accelerated by the formation of sulphmethaemoglobin, which allows for the non-toxic sulphate and thiosulphates to be filtered by the kidney. (4) Amyl nitrite inhalation and sodium nitrite infusion in the same dose as for cyanide, will hasten the formation of sulphmethaemoglobin.

Post-mortem Appearances : Rotten egg odour is given off. The general signs of asphyxia are present. The colour of the blood and viscera and bronchial secretions is greenish-purple.

Sulphur Dioxide (SO_2) : It is a direct respiratory irritant causing severe bronchospasm and inhibition of mucociliary transport.

Nitrous oxide is known as laughing gas.

Methane : The decomposition of organic matter in the well during summer produces methane or marsh gas. In diffused daylight, a series of reactions take place with chlorine successively replacing four hydrogen atoms in methane to form such vapours as chloroform and carbon tetrachloride. In the presence of air and light, the chloroform derived from marsh gas is slowly transformed into carbonyl chloride, an extremely poisonous gas.

METHYL ISOCYANATE (MIC): MIC is fairly stable liquid below 27°C, but becomes gaseous at 31°C. It has a pungent, sweetish smell. It boils at 37°C. It is highly volatile and inflammable. Its vapours are denser than air. It reacts vigorously with water, alkaloids and many solvents. It is used in the manufacture of pesticides, adhesives and plastic. It is one of the deadliest chemicals and can kill in very small doses when ingested, inhaled or when absorbed through the skin. It has two actions: (1) the irritant action of the vapour at the biophysical level, and (2) the carbamylation action at the biochemical level. The vapour causes intense irritation of the skin, eyes and mucous membranes.

SYMPTOMS : Acute irritation of the eyes, lachrymation, blurring of vision, severe buming in the throat, chest pain and laboured breathing. Pulmonary oedema causes death. Victims who survive for five to six days experience the above symptoms and also fever, cough with expectoration often bloody, oedema leading to death. About ten percent of the victims have psychiatric symptoms, such as anxiety, depression, sleep disturbances, gas phobia, and a feeling of helplessness. The systemic effects are: liver damage, kidney damage, methaemoglobinaemia and neurological deficits. The isocyanates affect the nucleic acids and thus may be potential teratogenic or mutagenic agents. In females, excessive vaginal discharge, anaemia, stillbirth and foetal abnormalities are seen.

AUTOPSY : Marked pulmonary oedema, increased weight of lungs to two to three times of normal, congestion of organs and effects of severe irritation of the eyes (whitening), nose, trachea and bronchi is seen in deaths occurring within two days. Victims dying between two to four days have pink blood, and those who die 5 days after the accident have dark-red blood, markedly congested organs and toxic necrosis of the gastrointestinal mucosa. Later deaths show parenchymatous degeneration of brain, heart, lung, liver and kidneys.

TREATMENT is purely symptomatic. Sodium thiosulphate is beneficial.

WAR GASES

The term "war gases" includes any chemical (gaseous, liquid or solid) which is used to produce destruction or damage mostly in times of war.

(1) Vesicant or Blistering Gases : These are mainly sulphur, mustard, phosgene oximes and lewisite (arsenic), which are volatile liquids. They are discharged in artillery shells so as to saturate the area of attack. Mustard gas causes irritation of the eyes, nose, throat and respiratory passages, nausea, vomiting and abdominal pain. It passes through the clothes into the skin and produces intense itching, redness, vesication, and ulceration especially of the moist areas.

Treatment : (1) Wash the affected parts thoroughly. (2) Eye wash with sodium bicarbonate solution. (3) B.A.L.

(2) Asphyxiants or Lung Irritants : These are chlorine and phosgene which are gases, and can be released from tanks, and gas shells. Chloropicrin and diphosgene are liquids which are used in gas

shells. Phosgene is ten times and chloropicrin four times more toxic than chlorine. Their action is mainly on the pulmonary alveoli. When inhaled, they cause watering of the eyes, coughing, dyspnoea, tightness of chest, headache, vomiting, restlessness, stertorous breathing, cyanosis and collapse. Death occurs in 24 to 48 hours due to acute pulmonary oedema.

Treatment : (1) Eye wash with boric acid. (2) Oxygen and adrenaline. (3) Anti-tussives. (4) Antibiotics.

(3) Lachrymators or Tear Gases : These are mainly chloracetophenone (C.A.P.) which is solid and ethyliodoacetate (K.S.K.), and bromobenzyl cyanide (B.B.C.) which are liquids. They are fired in artillery shells or pen guns. The vapours cause intense irritation of the eyes with a copious flow of tears, spasm of the eyelids and temporary blindness. They also cause irritation of air-passages. In long continued exposure there may be nausea, vomiting and blistering of skin. The effects are transitory.

The patient should be removed to the fresh air, and the eyes washed with warm normal saline or boric acid solution. Weak sodium bicarbonate solution is applied to the affected parts of the skin. I.V. aminophylline or salbutamol inhalation.

(4) Sternutators or Nasal Irritants : These are solid, organic compounds of arsenic and are fired in artillery shells. They are diphenyl chlorarsine (D.A), diphenylamine chlorarsine (D.M), and diphenylcyanarsine (C.D). Diphenylamine chlorarsine (sickening gas) is about six times as heavy as air. It has a specific action upon the vomiting centre in the brain. The vapours cause intense pain and irritation in the nose and sinuses, sneezing, headache, salivation, nausea, vomiting, tightness in the chest and prostration.

The above are used to control riots. Only two are of concern today: Ortho-chlorobenzylidene malanonitrite (CS), used by law-enforcement agencies and the military and CN (Mace) available in devices used for self-protection. They are solids dispersed in an aerosol of either powder or liquid. Effects begin within seconds after exposure and usually lost in 10 to 15 minutes. Improvement is usually rapid, and people rarely seek medical attention. Death has been reported after use of CN in enclosed spaces, but not from use in the open air.

The patient should be removed to fresh air, and nose irrigated with 5% sodium bicarbonate.

(5) **Paralysants** : These are hydrocyanic acid, sulphuretted hydrogen and carbon monoxide.

(6) **Nerve Gases** : The term nerve gases is incorrect. The nerve agents are esters of phosphoric acid (liquid) and are identical in their biological activity to organophosphates. The major agents are GA (Tabun), GB (Sarin), GD (Soman) and VX. The vapours are heavier than air, so they tend to sink into valleys, trenches and basements. These are colourless and odourless volatile liquids. They are absorbed from the lungs, gastrointestinal canal, skin or conjunctivae. They inhibit accetylcholine esterase. Exposure to a large amount of vapour will cause loss of consciousness within seconds, followed several minutes later by convulsions. Muscles become flaccid and breathing stops. Treatment is similar to organophosphates.

Biological Warfare: Bilogical weapons (B.W.) are defined as microorganisms or their products of metabolism that infect and grow in the target host producing a clinical disease that kills or incapacitates the victim. These include biological toxins and substances that interfere with normal behaviour, such as hormones, neuropeptides and cytokines. Bacillus anthracis, small pox virus, botulinum toxin and ricin are commonly used. Dissemination of BW agents occur by aerosol spray, explosives or food or water contamination. Remote control devices can be used.

HYDROCYANIC ACID

Hydrocyanic acid (prussic acid or cyanogen) is a solution of HCN in water either 2% or 4%, the latter being called "Scheele's acid". It is a vegetable acid found in nature in many fruits and leaves, such as almond, apricot, apple, cherry, peach, plum, pear, bamboo shoots, and in certain oil seeds and beans, where it exists in the form of a glucoside amygdalin, which is harmless, but usually co-exists with the enzyme emulsin, which hydrolyses it and liberates hydrocyanic acid. Amygdalin is converted to cyanide in the small intestine by bacteria in the presence of the enzyme emulsin. All parts of cassava plant contain cyanide. Hydrocyanic acid is usually obtained from distilling of cyanide by an acid. The pure acid is a colourless, transparent volatile liquid with an odour like bitter almonds and is rapidly decomposed by exposure to light. About 20 to 40% persons cannot smell the gas, and the ability to detect it is a sex-linked recessive trait. HCN is the normal

constituent of the body (15 to 30 micrograms). Cyanides are white powders and are in common use in many trades, in metallurgy, photography, electroplating, fumigation of ships and aircraft, in agriculture for spraying to destroy blight. Potassium ferrocyanide and ferricyanide are not poisonous.

Action : Cyanide inhibits the action of cytochrome oxidase, carbonic anhydrase and probably of other enzyme systems. It blocks the final step of oxidative phosphorylation and prevents the formation of ATP and its use as energy source. Cyanide acts by reducing the oxygen carrying capacity of the blood, and by combining with the ferric iron atom of intracellular cytochrome oxidase, preventing the uptake of oxygen for cellular respiration. There is an interference with the intracellular oxidative processes in the tissues and it kills by creating histotoxic or cytotoxic anoxia, although the blood may contain a normal oxygen content.

Absorption and Excretion : Cyanide gas is absorbed rapidly from the respiratory system, and the acid and cyanide salts from the stomach. The acid is also absorbed through the skin. Absorption is delayed when cyanide is taken on a full stomach or with much wine. Alkaline cyanides when ingested are converted by hydrochloric acid in the gastric juice into chlorides, and hydrocyanic acid is liberated. It has been suggested that those who are achlorhydric cannot therefore be poisoned by cyanides. This is doubtful, if not incorrect, because water in the gastric juice and the tissues of the stomach can hydrolyse cyanide, and liberate hydrocyanic acid. The greater part is converted by an enzyme rhodanase (present in liver and kidney) into thiocyanate. A small amount is excreted unchanged in the breath. It is mainly excreted in the urine.

Signs and Symptoms : This is the most rapid of all poisons. When inhaled as a gas, its action is instantaneous. With small doses, the person first experiences headache, confusion, giddiness, nausea and some loss of muscular power. Massive doses may produce sudden loss of consciousness and prompt death from respiratory arrest. If a large dose is taken, symptoms usually occur at once, but in some cases symptoms appear after about one minute, during which the victim may perform certain voluntary acts, such as corking, or throwing away the bottle, or walking a little distance. All symptoms ultimately reflect cellular hypoxia, and the symptoms shift rapidly, depending on the extent of the cyanide exposure. **C.N.S.:** Headache, vertigo, faintness, perspiration, anxiety, excitement, confusion, drowsiness, prostration, opisthotonus and trismus, cramps, twitchings, hyperthermia, convulsions epileptiform or tonic, which are sometimes localised but usually generalised, paralysis, stupor, coma, and death. **G.I.T.:** Bitter, acid, burning taste, constriction or numbness of throat, salivation, nausea, rarely vomiting. **R.S.:** Odour of bitter almonds in breath. Initially tachyapnoea and dyspnoea due to cyanide stimulation of chemoreceptors and the respiratory centre. Later rapid slowing of respiratory rate with severe respiratory depression and cyanosis. **C.V.S.:** Initially hypertension with reflex bradycardia, sinus arrhythmia. Later tachycardia with hypotension and cardiovascular collapse. The heart continues to beat for several minutes after stoppage of respiration. **Skin:** Perspiration, bullae. **Eyes:** Glassy and prominent, pupils dilated, unreactive. **Renal:** Acidosis. Death occurs from respiratory failure. In fatal cases more than one mg. of cyanide is found in blood.

Inhalation of vapour produces a sense of constriction about the throat and chest, dizziness, vertigo, insensibility, and death from respiratory failure. Inhalation of air containing one part in 2000 of cyanide is fatal almost immediately, 1 part in 1000 within few minutes, and 1 part in 50000 within few hours.

In poisoning by cyanides, the symptoms may not occur for 10 to 20 minutes, because of the delay in the decomposition of the salt by gastric juice, and the liberation and absorption of hydrocyanic acid. Potassium and sodium cyanide have a corrosive effect on the mouth, throat and stomach, and cause epigastric pain, vomiting and alkaline burns of the mucosa. Other symptoms are similar to hydrocyanic acid.

Survivors of serious acute poisoning may develop delayed neurologic sequelae, especially in the form of Parkinsonian symptoms.

Fatal Dose : 50 to 60 mg. of pure acid; 200 to 300 mg. of sodium or potassium cyanide. A concentration of 1:500 in air causes immediate death.

Fatal Period : 2 to 10 minutes; sometimes immediate. Potassium or sodium cyanide: half an hour. The patient may survive for several hours due to delayed absorption.

JUDICIAL EXECUTION : In some countries, hydrocyanic acid gas is used for legal execution.

The condemned person is strapped in a chair, and several cyanide "eggs" are dropped into a pan of strong acid, which produce large quantities of the poison gas immediately. Unconsciousness takes place very rapidly, although the heart continues to beat for 10 to 20 minutes. Death occurs after a few minutes.

Treatment : Treatment should be started immediately. The principle of the treatment is to reverse the cyanide-cytochrome combination. This is achieved by converting haemoglobin to methaemoglobin by giving nitrites. Methaemoglobin has a higher binding affinity for cyanide than the cytochrome oxidase complex, and removes cyanide from the cytochrome oxidase. Cyanides combine with methaemoglobin and form non-toxic cyanmethaemoglobin which in the presence of rhodanase and sulphate donors, such as thiosulphate, converts cyanide to thiocyanate which is excreted in the urine. Cyanide is directly converted to thiocyanate by the complexing of cyanide with thiosulphate under the influence of the enzyme rhodanase. Cyanide is also converted to cyanocobalamin (Vit B12) by complexing with hydroxocobalamin (Vit B12 A).

Cytochrome oxides + NaCN ----> Cytochrome oxidase cyanide.

Sodium nitrite + Hb ------>methaemoglobin.

Methaemoglobin + Na CN ----> Cyan-methaemoglobin.

(1) Break 0.2 ml. ampoule of amyl nitrite in a handkerchief and hold over the patient's nose for 15 to 30 seconds of every minute until sodium nitrite infusion is started. (2) 0.3 g. of sodium nitrite in 10 ml. of sterile water is given i.v. slowly, over a period of five minutes. Sodium nitrite forms methaemoglobin (Hb-Fe2+), then competes with cytochrome oxidase for the cyanide ion, thus protecting cytochrome oxidase. Do not remove the needle. (3) Through the same needle infuse 25 g. of sodium thiosulphate in 15% solution i.v. over a period of ten minutes. It converts cyanide to non-toxic thiocyanate, which is excreted in urine. Repeat the nitrite-thiosulphate injection after an hour if recovery has not occurred. (4) Both sodium nitrate and sodium thiosulphate can be repeated at half the initial dose at the end of one hour if symptoms persist or reappear. (5) Other antidotes are: Hydroxocobalamine (Vit B_{12}) 4 g. i.v. as infusion is given. It detoxifies cyanide by giving a hydroxyl group and then binding a cyanyl group from the cyanide, forming non-toxic cyanocobalamine which is excreted in the urine. It may be used with sodium thiosulphate which reacts with cyanocobalamine in the presence of the enzyme rhodanase, to produce thiocyanate. (6) Dicobalt EDTA acts by chelating cyanide to form a harmless product that is excreted in the urine. 600 mg. is given i.v. slowly. It is followed by 300 mg. if recovery does not occur. Cobalt EDTA and aminophenols are more rapid in action, efficacious, and less toxic than nitrites. (7) 4-dimethylaminophenol (4-DMAP) 3 mg/kg. i.v. (8) Gastric lavage is then performed on those who have ingested cyanide using activated charcoal, a mixture of 6% sodium carbonate, 15% ferrous sulphate and 3% citric acid, or 3% hydrogen peroxide, or preferably 5 to 10% sodium thiosulphate, or 1:5000 potassium permanganate, and 200 ml. is left in the stomach. Alternatively stomach wash can be done with a mixture of sodium bicarbonate and ferrous and ferric chloride. (9) Methylene blue is not effective. (10) Ventilate with hundred percent oxygen. (11) Methaemoglobin of more than fifty percent is an indication for exchange transfusion or administration of blood. (12) If death is delayed, a mixture of ferrous and ferric sulphate with potassium carbonate may be given as a chemical antidote to form Prussian blue. (13) Keep the airway clear. (14) Patient should be kept under observation for 24 to 48 hours, as cyanide toxicity may recur. (15) In poisoning by inhalation, remove the patient at once to fresh air and start artificial respiration and oxygen.

Post-mortem Appearances : Care should be taken to reduce the exposure of individuals in the mortuary to a minimum. The eyes may be bright, glistening and prominent with dilated pupils. The jaws are firmly closed and there is froth at the mouth. The colour of the cheeks and postmortem staining may be cherry-red in about half the cases, because oxygen remains in the cells as oxyhaemoglobin, and due to the formation of cyanmethaemoglobin. The odour of hydrocyanic acid may be noticed on opening the body. In cases of suspected cyanide poisoning, the cranial cavity should be opened first, as the odour is usually well-marked in the brain tissues. All the vessels of the body including the veins contain oxygenated blood. Bloodstained froth may be found in the trachea and bronchi. There is congestion of viscera and oedema of the lungs. The serous cavities are ecchymosed. The mucosa of the stomach and intestine is often red and congested. Degenerative changes may occur in the nervous system.

Potassium or sodium cyanide produce slight corrosion of mouth. The mucosa of the stomach may be eroded and blackened due to the formation of alkaline haematin. The stomach may contain frank or altered blood from the erosions and haemorrhages in the walls. Other findings are same as that of hydrocyanic acid. The blood concentration of persons dead of cyanide poisoning are usually in excess of one mg percent.

Specimen of blood must be covered with a layer of liquid paraffin to avoid evaporation.

Chronic Poisoning : It may be produced by the continued inhalation over long periods of very low concentrations of hydrocyanic acid vapour. The symptoms are headache, vertigo, nausea, vomiting, diarrhoea, chronic cachexia, mental disturbances, visual defects, such as scotomata, optic atrophy, and psychosis.

LEE-JONES TEST: To 5 ml of stomach contents add few crystals of ferrous sulphate and 5 drops of 2% sodium hydroxide. Boil and cool and add 10 drops of 10% hydrochloric acid. Greenish-blue colour indicates cyanide, and purplish colour salicylates.

The Circumstances of Poisoning : (1) Hydrocyanic acid and cyanides are usually used for suicide. It can be concealed in "suicidal pills", in rings or hollow teeth. (2) Occasionally, they are taken by accident or the fumes of the acid may be inhaled by those working with it. (3) It is rarely used for homicide and as cattle poison. Cattle poisoning can occur from eating linseed plant due to the natural development of a cyanogenetic glycoside.

Hydrocyanic acid is an extremely volatile substance. The blood and viscera should be preserved by adding an alkali and stored in well-stoppered bottles for analysis. Up to 70% may be lost after some weeks of storage from reaction with tissue components and conversion to thiocyanate. HCN is not produced after death by putrefactive changes. HCN retards decomposition like carbon monoxide, and to some extent acts as preservative, because of oxygen binding affinity they possesss. Formaldehyde rapidly destroys cyanide and as such embalming should be avoided before autopsy. Cyanide may be formed in stored blood samples at room temperature. By contrast in some positive samples cyanide may decrease on storage.

CHAPTER 38
FOOD POISONING

The term food poisoning in its wider sense includes all illnesses which result from ingestion of food containing non-bacterial or bacterial products. But the term is usually restricted to acute gastroenteritis due to the bacterial infection of food or drink.

Causes: **(I)** Poisoning due to bacteria and toxins.

(II) Poisons of vegetable origin (natural food poisons): (1) Lathyrus sativus. (2) Poisonous mushrooms. (3) Rye, oats, barley, etc. (4) Poisonous berries, such as atropa belladonna. (5) Lolium temulentum. (6) Paspalam scrobiculatum. (7) Argemone mexicana. (8) Cotton seeds. (9) Groundnuts. (10) Vitia fava. (11) Cabbage. (12) Solanine. (13) Soyabean. (14) Sweet clover.

(III) Poisons of **animal origin**: (1) Poisonous fish. (2) Mussel.

(IV) Chemical: (1) Intentionally added, such as flavouring agents in processed food, colouring agents, preservatives, extraction of fat by solvents like hydrocarbons. (2) Accidentally added, such as pesticides and insecticides. (3) Products of food processing, e.g. smoking of fleshy foods. (4) Radionucleides.

BACTERIAL FOOD POISONING

Bacterial food poisoning is divided into two groups: (1) The infection type, which follows the multiplication within the body of pathogenic organisms contained in the food. (2) The toxin type, which follows the ingestion of food in which poisonous substances have been formed due to bacterial proliferation. In the **infection type** the organisms belong mainly to the salmonella group, e.g. S. enteritidis of Gaertner, S. typhimurium, S.cholerasuis, and less commonly the paratyphoid bacilli. Salmonella invade and destroy mucosa of small intestine. Watery diarrhoea stained with blood or mucus occurs in 12 hours to two days. Other organisms like Proteus, Coli group, Streptococci, Sh.flexneri, and Sh. sonnei are also involved, and also certain poisonous food, such as fish, toadstools, eggs, ergot, etc. Vibrio parahaemolyticus contained in sea food invades intestinal mucosa and produces watery diarrhoea and vomiting in 6 hours to 4 days. Bacterial food poisoning results from the ingestion of contaminated food, uncooked food or imperfectly cooked food. Diarrhoea in several patients after 24 to 48 hours of eating the same meal indicates ingestion of the salmonella.

The **toxic type** is due to ingestion of preformed toxin in prepared food, such as canned or preserved food. Exotoxins, e.g. enterotoxin of staphylococci and the botulinum toxin, produce intoxication. Cl. perfringens types A and C and Bacillus cereus also produces enterotoxins. The materials usually affected are meat, milk, fish or egg. Less frequently, vegetables and cereals, and very rarely fruits are affected. Cheese, meat, fish, sandwiches, and other canned and preserved meats and imperfectly cooked and uncooked food often serve as vehicles. The food may not be altered in look, smell or taste. Meat and other food materials may be infected due to disease in the animal, e.g., sick cattle or pigs. Enterotoxin, which resist boiling for thirty minutes and the action of intestinal enzymes, is an important cause of food poisoning. Symptoms such as diarrhoea, nausea, abdominal cramps, and vomiting occur for a short time and the patient recovers as soon as the enterotoxins have been neutralised and metabolised, usually within 24 hours of poisoning. Extraneous infection may occur by a human carrier transmitting it during slaughtering of animals or during preparation of the food. Rats and mice harbouring infection may contaminate the food by their excreta before or after preparation.

Food poisoning is common in summer, because the warm temperature favours multiplication of microorganisms. It may occur as isolated cases or small outbreaks. The main diseases spread by infected food are: (1) The enteric group. (2) Cholera. (3) Bacillary dysentery. (4) Staphylococcal and other bacterial infections. (5) Amoebic dysentery and other protozoal infections. (6) Acute infective hepatitis. (7) Brucellosis. (8) Various worm infestations. (9) Schistosomiasis. (10) Traveller's diarrhoea (due to pathogenic E.coli).

E. Coli invade intestinal mucosa and elaborate enterotoxin. Infection occurs through water and meat. Incubation period is 1 to 3 days. Symptoms resemble dysentery or cholera.

At autopsy, the mucosa of the stomach and

intestines is swollen and often intensely congested and there may be minute ulcers. Microscopic examination shows fatty degeneration of the liver. The causative organism can be isolated from the blood and viscera.

In the toxin type, the incubation period is one to six hours. The symptoms resemble those of infection type but vomiting tends to be more violent, diarrhoea is less, prostration is greater, fever may be absent and recovery more rapid, often within 24 hours. The mortality is very low, being about 1%.

Diagnosis : This is made from: (1) History. (2) Clinical features. (3) Isolation of the organism from the remnants of suspected food and from vomit, faeces, blood, etc. from sick person. (4) The injection of portion of left off food into mice or guinea pigs should be performed. If the animals get sick, attempt should be made to isolate organisms from them.

Treatment and Prophylaxis: Wash-out the stomach and give purgatives. Glucose-saline infusion should be given to promote elimination of the toxins from the system. Meat inspection at the slaughter house is very important. The rodents should be driven out from places where food industry is carried on. Carriers should not be employed in dairies and in food industry. Preserved foods and dried egg powder should be properly cooked.

Botulism: This form of food poisoning differs from the other two types, in that there are no symptoms of gastroenteritis, although poisoning results from absorption of a specific toxin from the alimentary canal. Cl. botulinum does not grow in body, but produces a potent neurotoxin. It is normally present in the soil and by soil contamination, food may become infected, especially fruits and vegetables. Eight distinct strains (type A to G) of Cl. botulinum have been identified. Food contaminated by types A and B often appear putrefied due to the action of proteolytic enzymes. Food contaminated with type E toxin may look and taste normal. The toxin inhibits acetylcholine. The toxin is destroyed by heat at 80°C for 30 min. or 100°C for 10 min.

Botulism is an intoxication, not an infection. The causative organisum Cl. botulinum multiplies in the food, e.g., sausages, tinned meat, fish, fruits, etc. before it is consumed, and produces a powerful exotoxin. The fatal dose for an adult is 0.01 mg. or even less. The toxin paralyses the nerve endings, by blocking the nerve impulses at the myoneural junctions. It blocks the action of acetylcholine. Its action is selective being confined to the cholinergic fibres of the autonomic nervous system.

Signs and Symptoms: The incubation period varies from 12 to 30 hours, but may be prolonged to 72 hours. Symptoms are mainly due to the action of the toxin on the central nervous system. The initial GI symptoms include nausea, vomiting, abdominal distension and pain. Later symptoms are: dry or sore mouth or throat, difficulty with visual accommodation, dysphonia, diplopia, descending bilaterally symmertrical motor paralysis initiated by abducent (VI) or oculomotor (III) nerve palsy, dysphagia, constipation, respiratory insufficiency, and urinary retention. The patient is conscious until death, which is preceded by coma or delirium. The temperature is usually subnormal. Death may occur within 24 hours from the onset of symptoms, but may be delayed for a week. In those who survive, complete recovery of ocular movements may not take place for 6 to 8 months. Mortality varies from 25 to 100%.

Botulism has to be differentiated from encephalitis, multiple sclerosis, Guillain Barre syndrome, diphtheria, tetanus, and poisoning from CO, organophosphates and elapid snake bite.

At autopsy, the kidneys, liver and meninges are congested. Histological examination of the organs may show thrombosis.

Diagnosis: This is made from : (1) History. (2) Clinical features. (3) Demonstration of the toxin in the suspected food. (4) Isolation of the bacillus from the food. (5) Isolation of the toxin in the blood and tissues. (6) Isolation of the bacillus fom the patient's faeces or vomit, intestinal contents and viscera.

Treatment: (1) Gastric lavage or emesis. (2) Activated charcoal. (3) Purgative (sorbitol). (4) Whole bowel irrigation. (5) Botulinum antitoxin (types A, B and E) one vial by slow i.v. in normal saline and one vial i.m., and repeated at 2 to 4 hour intervals i.v. (6) Botulism immune globulin (BIG) is a pentavalent types A, B, C, D, and E. 50 ml is given i.v. daily, till the patient recovers. (7) Guanidine 15 to 30 mg/kg/day orally. (8) Adequate respiration. (9) Alcohol precipitates toxin; frequent small doses of brandy are benficial.

Food Allergy: It is not food poisoning, for in this the abnormality is not in the food but in the allergic person. Some persons are hypersensitive to

certain types of protein, e.g., meat, fish, eggs, milk, etc. which are ordinarily quite harmless and suffer from gastroenteritis, local urticarial rashes, or asthmatic attack.

Ptomaines: These are alkaloidal bodies which are formed as the result of bacterial decomposition of protein. When they are formed in the dead tissues, they are known as **cadaveric alkaloids.** Alkaloids secreted by living cells during metabolism are called **leucomaines,** which are slightly toxic when injected into an animal but have no action when ingested. They are not bacterial poisons and are not derived from bacteria. They are found only when the food becomes too disagreeable to be eaten. Most of the ptomaines are non-poisonous except neurine and mydalein, which are produced in traces 5 to 7 days after death. The symptoms resemble that of atropine. Ptomaines are not the causative agents of food poisoning.

Mycotoxicosis: The spores of moulds grow on the food of man and animals and release highly toxic mycotoxins. They can remain in meat and be passed into milk or eggs. Mycotoxins are heat stable and survive cooking. The consumption of contaminated food causes poisoning in man. Aspergillus flavus can grow on any food. They produce aflatoxins. It can produce carcinoma of liver and acute encephalitis. The fungus penicillium islandicum growing on yellowed rice produce islandotoxin which is a potent hepatotoxin.

POISONOUS FOODS

Poisonous foods are those which contain poison dervied from plants, animals and inorganic chemicals.

Lathyrus Sativus (kesari dhal): This is a veriety of pulse which grows under extreme conditions of drought. It is a staple food for the low income groups in some areas of Central India. Consumption of L. sativus seeds in quantities exceeding 30% of the total diet for more than six months have been known to cause paralysis. The overall incidence of the disease in the endemic area is about 4%. Men are more susceptible than women. The active neurotoxic principle is B(N) oxalyl amino-alanine (BOAA), which is present as a free aminoacid in the seed cotyledons to the extent of about one percent.

Onset is of three types: (1) acute, (2) subacute, and (3) insidious. The continued use of L.sativus produces neurolathyrism, which is characterised by progressive spastic paraplegia with preservation of sphincters, sensation and mental activity. It progresses irreversibly into four stages of physical disability.

Fig. (38–1). Mushrooms.

There may be pain in the back or weakness of legs, and difficulty in sitting down and getting up. Later the patient is unable to walk without the aid of a stick, the legs tremble and dragged along with difficulty and spastic gait characterised by a walk on tiptoes with the legs crossing scissor-wise. Later complete paraplegia occurs. There is no atrophy or loss of the tone of muscles, and no reaction of degeneration. The knee jerks are increased, ankle clonus is marked and Babinski's sign is present.

Steeping the pulse in hot water and parboiling remove 90% of toxic aminoacid. Rich diet with exclusion of the pulse, massage and application of electricity are useful. Death is very rare. At autopsy lateral columns of the spinal cord show sclerosis.

Mushrooms: Some species are non-poisonous and are used as food. Amanita phalloides and Amanita muscaria are the common varieties of poisonous fungi. Poisonous mushrooms usually have a bitter, astringent, acid or salt taste, and on section and exposure change colour; a brown, green or blue colour developing on the cut surface. But there are no easy rules to exclude poisonous varieties. Amanita muscaria grows singly in sandy soil and is of large size. It has a hollow stalk which is solid and bulbous at the base, and has gills which are white. The pileus (top) varies in colour from yellow to orange or red, and is covered by warty scales. It contains an alkaloid muscarine, the action of which resembles stimulation of parasympathetic post-ganglionic nerves. Amanita phalloides is also called the deadly agaric or death cap. It is white in colour having an unpleasant taste and when old

the odour is offensive. It grows in woody places to a height of 15 to 20 cm. It has a hollow stalk with a prominent bulb at the base, the upper margin of which is formed into a cup. The pileus is usually white, but may be pale yellow or olive, and has gills covered with white spores on its undersurface. The fungus is a powerful poison and contains phalloidin, phallon, B amanatin, which are cyclopeptides and virotoxins. These polypeptides are heat stable and insoluble in water. They are powerful inhibitors of cellular protein synthesis. Muscarine stimulates post-ganglionic cholinergic fibres.

Symptoms: In some cases irritant symptoms may be present, and in others neurotic or a combination of both. The irritant symptoms are delayed for 6 to 12 hours. There is constriction of the throat, burning pain in the stomach, nausea, vomiting and diarrhoea followed by cyanosis, slow pulse, laboured respirations, convulsions, sweating, collapse and death. The neurotic symptoms are giddiness, headache, delirium, diplopia, constriction of pupils, cramps, twitching of the limbs, convulsions, salivation, bradycardia and coma. Hepatic and sometimes renal toxicity occurs between 3 to 6 days.

Fatal Dose: Two to 3 mushrooms.

Fatal Period: Usually 24 hours.

Treatment: (1) Stomach wash with potassium permanganate. (2) Activated charcoal. (3) Forced diuresis. (4) Benzyl penicillin 3 lakhs to one million units daily. (5) Atropine sulphate. (6) Anti-phalloidien serum. (7) Thioctic acid is obsolete. (8) Haemodialysis. (9) Symptomatic.

Autopsy: Inflammation of the mucous membrane of the alimentary canal, fatty degeneration of the liver, kidneys and heart may be found. In case of neurotic symptoms, congestion of the brain, and petechial haemorrhages in serous membranes are seen.

Poisoning is usually accidental, and rarely homicidal.

Argemone Mexicana: *(Ujar-kanta; kutila; sial-kanta)* : It grows wild all over India in the cold season. It has sessile, spiny, thistle-like leaves. The flowers are yellow. The seeds are contained in prickly oblong or elliptic capsules two to four cm. long. The seeds are dark-brown in colour, globular, smaller than mustard seeds and covered with minute, regularly arranged projections, and depressions. When the seeds are pressed on a slide they burst with a report, whereas mustard seeds collapse quietly. The plant contains two alkaloids berberine and protopine. The oil contains two alkaloids, sanguinarine and dihydrosanguinarine. All parts of the plant are poisonous. The oil causes **epidemic dropsy**. The oil from the seeds is sometimes used as an adulterant of mustard oil, or other edible oil. It causes abnormal permeability of blood vessels.

Symptoms: Symptoms appear slowly with loss of appetite, diarrhoea, marked oedema of the legs, sometimes generalised anasarca. In severe cases, myocardial damage and dilatation of the heart is seen. Blood pressure is low and pulse feeble and rapid. Liver may be enlarged and tender. Patient becomes breathless. Tingling and hyperaesthesia of skin and tenderness of the calf muscles may be seen. The jerks are feeble or absent. Dimness of vision is seen in about 10% of cases due to increased intraocular pressure of glaucoma. Bluish mottling of the skin is seen due to dilation of the peripheral vessels. Some of these areas may develop into subcutaneous telangiectasis or haemangiomata. Death occurs from severe damage to the heart.

Treatment: Good diet and supportive treatment of heart.

Rye, Wheat, Oats, Barley and Bajra: These grains are attacked by the fungus Claviceps purpurea. The ear of the plant contains deep-purple diseased grains, which when dried is called ergot.

Action: Blood vessels become abnormally permeable. The target organs are liver, heart, kidneys and lungs.

LOLIUM TEMULENTUM (DARNEL): This weed grows in wheat fields. The grains are similar to wheat, but much smaller in size. The grains are attacked by a fungus which contains toxin temuline. The symptoms are headache, muscular weakness, tremors, gastrointestinal irritation, stupor and coma. It does not cause death.

PASPALAM SCROBICULATUM *(kodra):* This corn contains a poison which is destroyed by boiling. The symptoms are similar to those of Lolium temulentum.

COTTON SEEDS: It has toxin gossypol (cake) which makes lysine unavailable to the body.

GROUNDNUTS: Groundnuts stored under humid conditions are contaminated with metabolites of strains of Aspergillus flavus to which the collective name "aflatoxins' is given. A wide range of domestic and laboratory animals are affected by the toxin. Hepatic damage occurs in almost all cases, and death if the concentration of toxin is sufficiently high. With

chronic exposure, the toxic agents have carcinogenic property. In rhesus monkeys, hepatic cirrhosis has been observed.

VITIA FLAVA: It is a legume producing flavism. The toxin is divicine.

CABBAGE: Brassia family has sulphur-containing compounds, which inhibit thyroxine secretion.

SOYABEAN : It has trypsin inhibitor which makes protein unavailable to the body. The toxin is destroyed by heat.

SWEET CLOVER: Cattle fed on spoiled sweet clover develop haemorrhagic disease due to the presence of clover of dicoumarin, which is chemically related to vitamin K and blocks its action.

POTATO: Potato contains solanine 0.002 to 0.01% mainly in the skin. Potatoes that are partly exposed above the soil and 'sunburned' (the skin of exposed part being green) contain considerable solanine, and cause poisoning when not thoroughly cooked. Immature and sprouting potatoes contain up to 0.06% of solanine, and cause severe or fatal poisoning. Raw potato peeling, the plant and its fruit also cause poisoning.

STIGMATA MAIDES (MAIZE) causes pellagra when eaten, due to lack of nicotinic acid.

FISH AND MARINE ANIMALS: Fish poisoning: (Icthyotoxicosis; icthyotoxism); A large number of marine fish are inherently poisonous. Ciguatera poisoning and tetradon (puffer-fish) poisoning are common examples. Ingestion of fish causes two types of poisoning. The first is due to bacterial growth in partially decomposed fish. The other is a primary toxicity caused by eating some types of sea fishes such as toad fish, cat fish, lion fish, dragon fish due to the presence of a neurotoxin. 99% of cases of fish poisoning are **icthyosarcotoxic** (involving toxins from muscles, viscera, skin, gonads and mucous surfaces) characterised by various G.I. and neurological disturbances. Rarely, toxicity involves the fish blood or skeleton.

(1) CIGUATERA POISONING: It is the most common poisoning accounting for 50%. Species involved are: barracudas, sea bass, parrot fish, red snapper. Symptoms appear two to six hours after ingestion. Ciguatoxin found in certain algae and protozoa are eaten by herbivorous fish, which in turn are eaten by large fish which become poisonous. Poisoning occurs after eating fresh or frozen fish prepared by boiling, baking, frying, stewing or broiling. Symptoms set in 12 to 24 hours are: abodminal pain with cramps, nausea, vomiting, profuse watery diarrhoea, diaphoresis, headache, dysaraesthesias and paraesthesias, tingling and numbness of the tongue, lips, throat and perioral area, myalgias, arthralgias and weakness. Hot substances feel cold and cold substances feel hot. Death may occur due to respiratory paralysis. Treatment is symptomatic.

(2) SCOMBROID POISONING: The species involved are: mahimahi, tuna, amberjack, albacore, bonito, mackerel, and skipjack. All of them have a high concentration of histidine in their dark meat, which is converted to histamine. Symptoms begin in minutes to hours; and subside in a few hours.

(3) GYMNOTHORAX POISONING: The moray, conger and anguillid eels carry a ciguatoxin-like neurotoxin in their viscera, muscles and gonads. Symptoms appear in half to thirty hours. They cause neurotoxic symptoms or signs of cholinergic toxicity.

(4) TETRODON POISONING: The species involved are: globe fish, ballon fish, blowfish, toad fish and blue-ringed octopus. Symptoms appear in minutes to hours. They contain tetrodotoxin mainly in the skin, liver, ovary, and intestine. They cause neurotoxicity.

(5) SHELL FISH POISONING: The species include clans, oysters, mussels and scallops. They contain saxitoxin, which is a potent paralytic neurotoxin. The symptoms begin in half hour. It acts on the peripheral and autonomic nervous systems. Like curare, it effectively blocks depolarisation at the neuromuscular junction.

VENOMOUS FISH: Some fish such as cat fish, muraena (eel), dragon fish, lion fish, etc. have extremely sharp dorsal spines equipped with large poisonous sacs. The lesions consist of a row of intensely painful rounded punctures which may bleed freely. The rare systemic symptoms are variable.

The BOX JELLY FISH has been described as the worlds most venomous animal. The injected toxin has both dermatonecrotic and cardiotoxic properties.