How this Book is Organized

This book is written primarily for students. Emphasis is on presenting information in a logical, systematic, clear and concise manner for better, easier and faster memorization. Text is presented at two levels – regular information is given in normal font; extra information including conceptual and historical information and case studies has been rendered in small type. This enables the student to quickly differentiate between what is essential for exam, and what can be read at leisure for building of concepts. In addition, the book presents following essential features: court cases, appendices and an extensive index have been included.

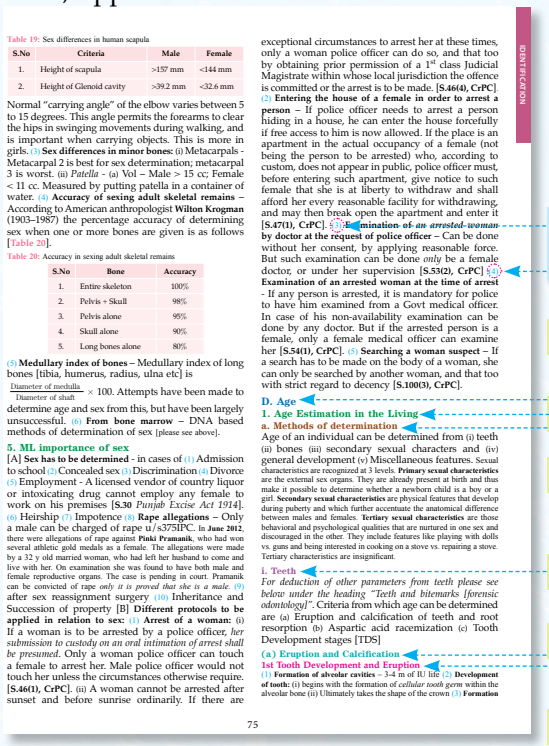


Table 19: Sex differences in human scapula

S.No	Criteria	Male	Female
1.	Height of scapula	>157 mm	<144 mm
2.	Height of Glenoid cavity	>39.2 mm	<32.6 mm

Normal "carrying angle" of the elbow varies between 5 to 15 degrees. This angle permits the forearms to clear the hips in swinging movements during walking, and is important when carrying objects. This is more in girls. (3) **Sex differences in minor bones**: (i) Metacarpals - Metacarpal 2 is best for sex determination; metacarpal 3 is worst. (ii) *Patella* - (a) Vol – Male > 15 cc; Female < 11 cc. Measured by putting patella in a container of water. (4) **Accuracy of sexing adult skeletal remains** – According to American anthropologist **Wilton Krogman** (1903–1987) the percentage accuracy of determining sex when one or more bones are given is as follows [Table 20].

Table 20: Accuracy in sexing adult skeletal remains

S.No	Bone	Accuracy
1.	Entire skeleton	100%
2.	Pelvis + Skull	98%
3.	Pelvis alone	95%
4.	Skull alone	90%
5.	Long bones alone	80%

(5) **Medullary index of bones** – Medullary index of long bones [tibia, humerus, radius, ulna etc] is

$$\frac{\text{Diameter of medulla}}{\text{Diameter of shaft}} \times 100$$

. Attempts have been made to determine age and sex from this, but have been largely unsuccessful. (6) **From bone marrow** – DNA based methods of determination of sex [please see above].

5. ML importance of sex

[A] **Sex has to be determined** - in cases of (1) Admission to school (2) Concealed sex (3) Discrimination (4) Divorce (5) Employment - A licensed vendor of country liquor or intoxicating drug cannot employ any female to work on his premises [**S.30** *Punjab Excise Act 1914*]. (6) Heirship (7) Impotence (8) **Rape allegations** – Only a male can be charged of rape u/s375IPC. In **June 2012**, there were allegations of rape against **Pinki Pramanik**, who had won several athletic gold medals as a female. The allegations were made by a 32 y old married woman, who had left her husband to come and live with her. On examination she was found to have both male and female reproductive organs. The case is pending in court. Pramanik can be convicted of rape only *if it is proved that she is a male*. (9) after sex reassignment surgery (10) Inheritance and Succession of property [B] **Different protocols to be applied in relation to sex:** (1) **Arrest of a woman:** (i) If a woman is to be arrested by a police officer, *her submission to custody on an oral intimation of arrest shall be presumed*. Only a woman police officer can touch a female to arrest her. Male police officer would not touch her unless the circumstances otherwise require. **[S.46(1), CrPC]**. (ii) A woman cannot be arrested after sunset and before sunrise ordinarily. If there are exceptional circumstances to arrest her at these times, only a woman police officer can do so, and that too by obtaining prior permission of a 1st class Judicial Magistrate within whose local jurisdiction the offence is committed or the arrest is to be made. **[S.46(4), CrPC]**. (2) **Entering the house of a female in order to arrest a person** – If police officer needs to arrest a person hiding in a house, he can enter the house forcefully if free access to him is now allowed. If the place is an apartment in the actual occupancy of a female (not being the person to be arrested) who, according to custom, does not appear in public, police officer must, before entering such apartment, give notice to such female that she is at liberty to withdraw and shall afford her every reasonable facility for withdrawing, and may then break open the apartment and enter it **[S.47(1), CrPC]**. (3) ~~**Examination of an arrested woman by doctor at the request of police officer**~~ – Can be done without her consent, by applying reasonable force. But such examination can be done *only* be a female doctor, or under her supervision **[S.53(2), CrPC]** (4) **Examination of an arrested woman at the time of arrest** - If any person is arrested, it is mandatory for police to have him examined from a Govt medical officer. In case of his non-availability examination can be done by any doctor. But if the arrested person is a female, only a female medical officer can examine her **[S.54(1), CrPC]**. (5) **Searching a woman suspect** – If a search has to be made on the body of a woman, she can only be searched by another woman, and that too with strict regard to decency **[S.100(3), CrPC]**.

D. Age

1. Age Estimation in the Living

a. Methods of determination

Age of an individual can be determined from (i) teeth (ii) bones (iii) secondary sexual characters and (iv) general development (v) Miscellaneous features. Sexual characteristics are recognized at 3 levels. **Primary sexual characteristics** are the external sex organs. They are already present at birth and thus make it possible to determine whether a newborn child is a boy or a girl. **Secondary sexual characteristics** are physical features that develop during puberty and which further accentuate the anatomical difference between males and females. **Tertiary sexual characteristics** are those behavioral and psychological qualities that are nurtured in one sex and discouraged in the other. They include features like playing with dolls vs. guns and being interested in cooking on a stove vs. repairing a stove. Tertiary characteristics are insignificant.

i. Teeth

For deduction of other parameters from teeth please see below under the heading "Teeth and bitemarks [forensic odontology]". Criteria from which age can be determined are (a) Eruption and calcification of teeth and root resorption (b) Aspartic acid racemization (c) Tooth Development stages [TDS]

(a) Eruption and Calcification

1st Tooth Development and Eruption

(1) **Formation of alveolar cavities** – 3-4 m of IU life (2) **Development of teeth**: (i) begins with the formation of *cellular tooth germ* within the alveolar bone (ii) Ultimately takes the shape of the crown (3) **Formation**

Information presented in points for easy memorization.

The points are in blue color, so student can easily search all points.

Heading 2

Heading 3

Heading 4

Heading 5

Heading 6

Heading 7

This book presents data under seven levels of headings, each heading being a subset of its predecessor. For ease of differentiation, the ~~colour~~ of each level has been made different.

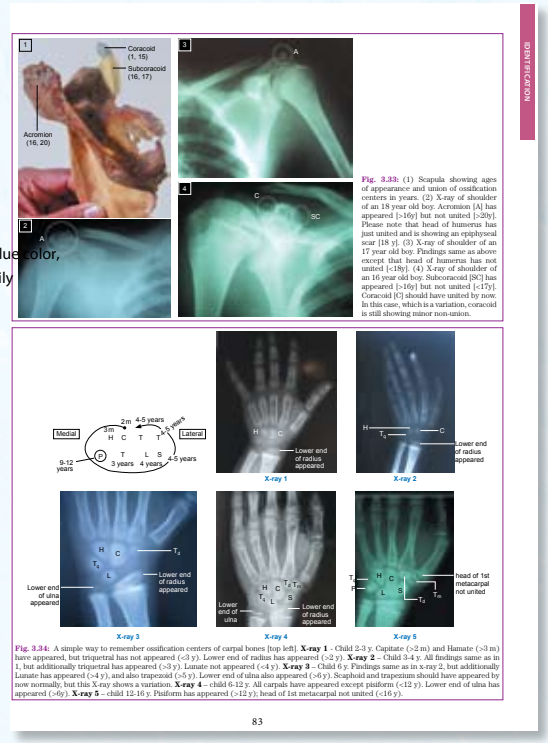
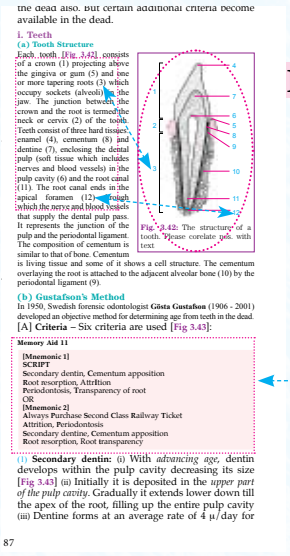


Fig. 3.33: (1) Scapula showing ages of appearance and union of ossification centers in years. (2) X-ray of shoulder of an 18 year old boy. Acromion [A] has appeared [>16y] but not united [>20y]. Please note that head of humerus has just united and is showing an epiphyseal scar [18 y]. (3) X-ray of shoulder of an 17 year old boy. Findings same as above except that head of humerus has not united [<18y]. (4) X-ray of shoulder of an 16 year old boy. Subcoracoid [SC] has appeared [>16y] but not united [<17y]. Coracoid [C] should have united by now. In this case, which is a variation, coracoid is still showing minor non-union.

Fig. 3.34: A simple way to remember ossification centers of carpal bones [top left]. **X-ray 1** - Child 2-3 y. Capitate (>2 m) and Hamate (>3 m) have appeared, but triquetral has not appeared (<3 y). Lower end of radius has appeared (>2 y). **X-ray 2** - Child 3-4 y. All findings same as in 1, but additionally triquetral has appeared (>3 y). Lunate not appeared (<4 y). **X-ray 3** – Child 6 y. Findings same as in x-ray 2, but additionally Lunate has appeared (>4 y), and also trapezoid (>5 y). Lower end of ulna also appeared (>6 y). Scaphoid and trapezium should have appeared by now normally, but this X-ray shows a variation. **X-ray 4** - child 6-12 y. All carpals have appeared except pisiform (<12 y). Lower end of ulna has appeared (>6y). **X-ray 5** – child 12-16 y. Pisiform has appeared (>12 y); head of 1st metacarpal not united (<16 y).

Full of illustrative color photographs and X-rays all of which are fully labeled for better comprehension.



the dead also. But certain additional criteria become available in the dead.

i. Teeth

(a) Tooth Structure

Each tooth [Fig. 3.42] consists of a crown (1) projecting above the gingiva or gum (5) and one or more tapering roots (3) which occupy sockets (alveoli) in the jaw. The junction between the crown and the root is termed the neck or cervix (2) of the tooth. Teeth consist of three hard tissues, enamel (4), cementum (8) and dentine (7), enclosing the dental pulp (soft tissue which includes nerves and blood vessels) in the pulp cavity (6) and the root canal (11). The root canal ends in the apical foramen (12) through which the nerve and blood vessels that supply the dental pulp pass. It represents the junction of the pulp and the periodontal ligament. The composition of cementum is similar to that of bone. Cementum is living tissue and some of it shows a cell structure. The cementum overlaying the root is attached to the adjacent alveolar bone (10) by the periodontal ligament (9).

Fig. 3.42: The structure of a tooth. Please corelate nos. with text

(b) Gustafson's Method

In 1950, Swedish forensic odontologist **Gösta Gustafson** (1906 - 2001) developed an objective method for determining age from teeth in the dead. [A] **Criteria** – Six criteria are used [Fig 3.43]:

Memory Aid 11

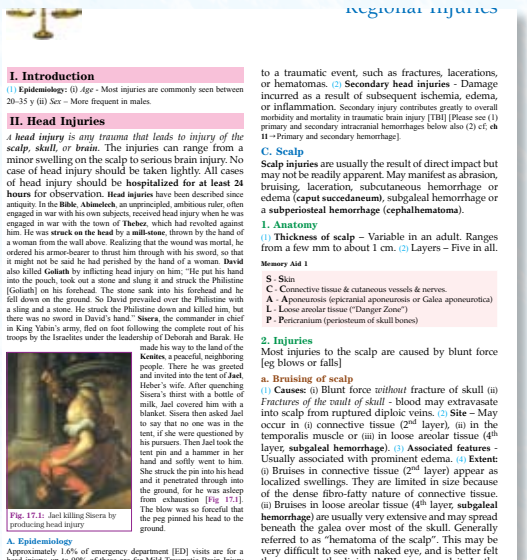
[Mnemonic 1]
SCRIPT
Secondary dentin, Cementum apposition
Root resorption, Attrition
Periodontosis, Transparency of root
OR
[Mnemonic 2]
Always Purchase Second Class Railway Ticket
Attrition, Periodontosis
Secondary dentine, Cementum apposition
Root resorption, Root transparency

(1) **Secondary dentin:** (i) With *advancing age*, dentin develops within the pulp cavity decreasing its size [Fig 3.43] (ii) Initially it is deposited in the *upper part of the pulp cavity*. Gradually it extends lower down till the apex of the root, filling up the entire pulp cavity (iii) Dentine forms at an average rate of 4 µ/day for

Heading 1

Memory Aids

Numerical co-relation of labeling with text. What is given in text can be co-related with numerals in accompanying diagrams and photographs for better comprehension. Several memory aids provided for quick memorization and revision.



I. Introduction

(1) **Epidemiology:** (i) *Age* - Most injuries are commonly seen between 20–35 y (ii) *Sex* – More frequent in males.

II. Head Injuries

A ***head injury*** *is any trauma that leads to injury of the* ***scalp***, ***skull***, *or* ***brain***. The injuries can range from a minor swelling on the scalp to serious brain injury. No case of head injury should be taken lightly. All cases of head injury should be **hospitalized for at least 24 hours** for observation. **Head injuries** have been described since antiquity. In the **Bible**, **Ahimelech**, an unprincipled, ambitious ruler, often engaged in war with his own subjects, received head injury when he was engaged in war with the town of **Thebez**, which had revolted against him. He was **struck on the head by a mill-stone**, thrown by the hand of a woman from the wall above. Realizing that the wound was mortal, he ordered his armor-bearer to thrust him through with his sword, so that it might not be said he had perished by the hand of a woman. **David** also killed **Goliath** by inflicting head injury on him; "He put his hand into the pouch, took out a stone and slung it and struck the Philistine [Goliath] on his forehead. The stone sank into his forehead and he fell down on the ground. So David prevailed over the Philistine with a sling and a stone. He struck the Philistine down and killed him, but there was no sword in David's hand." **Sisera**, the commander in chief in King Yabin's army, fled on foot following the complete rout of his troops by the Israelites under the leadership of Deborah and Barak. He made his way to the land of the **Kenites**, a peaceful, neighboring people. There he was greeted and invited into the tent of **Jael**, Heber's wife. After quenching Sisera's thirst with a bottle of milk, Jael covered him with a blanket. Sisera then asked Jael to say that no one was in the tent, if she were questioned by his pursuers. Then Jael took the tent pin and a hammer in her hand and softly went to him. She struck the pin into his head and it penetrated through into the ground, for he was asleep from exhaustion [Fig. 17.1]. The blow was so forceful that the peg pinned his head to the ground.

Fig. 17.1: Jael killing Sisera by producing head injury

A. Epidemiology

Approximately 1.6% of emergency department [ED] visits are for a head injury; up to 90% of these are for Mild Traumatic Brain Injury [mTBI; Table 1]. Risk factors for intracranial injury include male sex, increasing age, and alcohol intoxication.

B. Classification

(1) **Primary head injuries** - Damage directly related to a traumatic event, such as fractures, lacerations, or hematomas. (2) **Secondary head injuries** - Damage incurred as a result of subsequent ischemia, edema, or inflammation. Secondary injury contributes greatly to overall morbidity and mortality in traumatic brain injury [TBI] [Please see (1) primary and secondary intracranial hemorrhages below also (2) cf; **ch 11**→Primary and secondary hemorrhage].

C. Scalp

Scalp injuries are usually the result of direct impact but may not be readily apparent. May manifest as abrasion, bruising, laceration, subcutaneous hemorrhage or edema (**caput succedaneum**), subgaleal hemorrhage or a **subperiosteal hemorrhage (cephalhematoma)**.

1. Anatomy

(1) **Thickness of scalp** – Variable in an adult. Ranges from a few mm to about 1 cm. (2) Layers – Five in all.

Memory Aid 1

S - Skin
C - Connective tissue & cutaneous vessels & nerves.
A - Aponeurosis (epicranial aponeurosis or Galea aponeurotica)
L - Loose areolar tissue ("Danger Zone")
P - Pericranium (periosteum of skull bones)

2. Injuries

Most injuries to the scalp are caused by blunt force [eg blows or falls]

a. Bruising of scalp

(1) **Causes:** (i) Blunt force *without* fracture of skull (ii) *Fractures of the vault of skull* – blood may extravasate into scalp from ruptured diploic veins. (2) **Site** – May occur in (i) connective tissue (2nd layer), (ii) in the temporalis muscle or (iii) in loose areolar tissue (4th layer, **subgaleal hemorrhage**). (3) **Associated features** - Usually associated with prominent edema. (4) **Extent:** (i) Bruises in connective tissue (2nd layer) appear as localized swellings. They are limited in size because of the dense fibro-fatty nature of connective tissue. (ii) Bruises in loose areolar tissue (4th layer, **subgaleal hemorrhage**) are usually very extensive and may spread beneath the galea over most of the skull. Generally referred to as "hematoma of the scalp". This may be very difficult to see with naked eye, and is better felt than seen. In the living, MRI may reveal it. In the dead, becomes visible when the scalp is dissected and reflected. **Caution** - Its firm edges may feel like the edges of a depressed fracture of the skull. (5) Several blows can give rise to different bruises. They can join

Historical information wherever necessary for better understanding. Historical information is always given in small type.

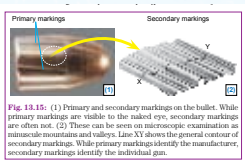
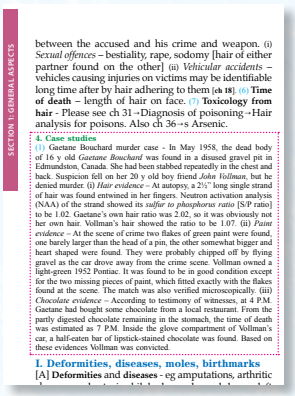


Fig. 13.15: (1) Primary and secondary markings on the bullet. While primary markings are visible to the naked eye, secondary markings are often not. (2) These can be seen on microscopic examination as minuscule mountains and valleys. Line XY shows the general contour of secondary markings. While primary markings identify the manufacturer, secondary markings identify the individual gun.

Microscopic features shown enlarged by "lens technique" wherever required.



between the accused and his crime and weapon. (i) *Sexual offences* – bestiality, rape, sodomy [hair of either partner found on the other] (ii) *Vehicular accidents* – vehicles causing injuries on victims may be identifiable long time after by hair adhering to them [**ch 18**] (6) **Time of death** – length of hair on face. (7) **Toxicology from hair** - Please see ch 31→Diagnosis of poisoning→Hair analysis for poisons. Also ch 36→s Arsenic.

4. Case studies

(1) Gaetane Bouchard murder case - In May 1958, the dead body of 16 y old *Gaetane Bouchard* was found in a disused gravel pit in Edmundston, Canada. She had been stabbed repeatedly in the chest and back. Suspicion fell on her 20 y old boy friend *John Vollman*, but he denied murder. (i) *Hair evidence* - At autopsy, a 2½" long single strand of hair was found entwined in her fingers. Neutron activation analysis (NAA) of the strand showed its *sulfur to phosphorus ratio* [S/P ratio] to be 1.02. Gaetane's own hair ratio was 2.02, so it was obviously not her own hair. Vollman's hair showed the ratio to be 1.07. (ii) *Paint evidence* – At the scene of crime two flakes of green paint were found, one barely larger than the head of a pin, the other somewhat bigger and heart shaped were found. They were probably chipped off by flying gravel as the car drove away from the crime scene. Vollman owned a light-green 1952 Pontiac. It was found to be in good condition except for the two missing pieces of paint, which fitted exactly with the flakes found at the scene. The match was also verified microscopically. (iii) *Chocolate evidence* – According to testimony of witnesses, at 4 P.M. Gaetane had bought some chocolate from a local restaurant. From the partly digested chocolate remaining in the stomach, the time of death was estimated as 7 P.M. Inside the glove compartment of Vollman's car, a half-eaten bar of lipstick-stained chocolate was found. Based on these evidences Vollman was convicted.

I. Deformities, diseases, moles, birthmarks

[A] **Deformities** and **diseases** - eg amputations, arthritic

Case studies for better grasp of subject. All case studies are given in small type.

persons of high social status avoid tattoos. (2) **Country** of origin (3) **Perversions** – drawing of indecent figures (4) May reflect **travel history, involvement in wars, sex interests** etc. (5) May cause hypersensitivity reactions.

L. Occupation marks

Occupational marks *or* ***stigmata*** *are special marks on the body of a person, produced as a result of his profession or habits.* These may sometimes be helpful in identifying a person. Sherlock Holmes often impressed his colleague Watson by telling the occupation of his clients simply by observing occupational marks. Occupational marks may be temporary or permanent.

[A] **Recent and temporary:** (1) **Bakers and millers** – flour (2) **Dye workers** – dyes (3) **Engineers and mechanics** – grease (4) **Painters** – paint spots. In dead bodies, examine microscopically dust and debris (i) on clothing (ii) in pockets (iii) trouser turn-ups at the lower end (iv) under fingernails and (v) in the ear wax. This would often tell the occupation of the dead person.

[B] **Permanent** – If marks are due to constant friction between body part and some object of work, the marks are termed **frictional occupational dermatosis** [eg callosities on manual workers]. These are relatively permanent; may disappear a few months or years after the profession is discontinued. (1) **Athletes** – Black discoloration of toenail (Tennis Toe, Jogger's Toe). Due to subungual hematoma resulting from repeated minor trauma to the nail plate. Related to quick stops or slamming of the toe into the toe-box of the shoe. Occur under the large toenails of tennis, squash, and racquetball players; the second and third toes of soccer and football players, and in the fourth and fifth toes of runners and joggers. (2) **Basketball, racquetball, and tennis players** - Irregular, black macular lesion on the heel (Black Heel, Calcaneal Petechiae, Talon Noir). Caused by hemorrhage due to sudden stopping and starting (3) **Battery Charger** - Contact with sulphuric acid in the batteries Blackens the skin which will not wash off. In addition there is some roughening and thickening of the skin on the outer side of the tip of the index finger due to screwing on terminals. (4) **Boxers** - Fibromatous nodules overlying the finger joints (*knuckle pads* or *Garrod's pads* because first described by Garrod in 1893). (5) **Blacksmiths** – Scars on hands, caused by burns from hot fragments (6) **Bricklayers** – Flattening of the thumb and index finger of left hand due to constant picking up of bricks (7) **Butchers** – Gripping the knife in the right hand thickens the skin on the right palm (8) **Carpenters** – Callosities on thumb, index finger and palms. One shoulder is usually higher than the other (9) **Clerks** – Callosities on fingers, especially on the last joint of the right middle finger (*pen callosities*). Was seen especially in olden days, when clerks used to write with rough pens grasped between fingers (10) **Coal miners** - Blue scar over the hands and face, caused by coal-dust entering small lacerations. (11) **Coconut tree climbers** - Forearms on the flexural aspect are hyperpigmented and lichenified with linear striations, due to constant friction with coconut tree bark. (12) **Guitarists** - Inflamed nipples because the edge of the guitar constantly presses against their chests (*guitar nipple*) (13) **Long distance runners:** (i) A small area of ecchymosis in the gluteal cleft [*runner's rump*] (ii) Crusted, erythematous, painful, fissured erosions on nipples that can occasionally bleed (*Jogger's Nipples*). Caused by constant friction from hard fabrics against the unprotected nipple and areola. Women suffer less due to wearing of bras. (14) **Manual workers** - callosities, cuts, hyperkeratosis and scars on the hands (15) **Opticians** – Small cuts on the tips of index finger and thumb inflicted during preparation of glass lenses. Glass dust is found under and around the nails. (16) **Rowers:** (i) Painful and pruritic macules, plaques, and vesicles on hands due to mechanical trauma from rowing (*Pulling boat hands*). (ii) Gluteal callosities from prolonged rowing on unpadded seats (*rower's rump*) (17) **Shoemaker** - A depression on the sternum due to the constant pressure of the "shoemaker's last" against it. (18) **Tailors**- multiple needle prick marks on hands. (19) **Violinist:** (i) Hardened tips on the fingers of the left hand. (ii) Thick, leathery, bark-like, discolored neck skin, because of constant contact with violin (*Fiddler's neck*) (20) **Workers involved with chemicals** – have discolored skin, hair and fingernails (21) Some occupation marks are seen in teeth – please see Forensic odontology below.

M. Anthropometry (Bertillon system, Bertillonage)

Anthropometry *(Gk anthropos, man; metron, measure→literally "measurement of man") refers to the measurement of* ***eleven key dimensions*** *of the individual for the purposes of identification.* **Salient features:** (1) **Earliest** system of criminal identification (2) Started by **Alphonse Bertillon** (1853 –1914) in the year **1883**. (3) **Principle** - Based on the two facts (i) Dimensions of the skeleton *do not change after the age of 21 years* (ii) *Quetelet's law* [please see above under "Stature"]. According to **Quetelet's law**, there is *one in four chance* of two persons having exactly same height. Bertillon reasoned that if one more measurement was added - for example the length of the trunk - the chance of finding the both measurements exactly the same decreased to one in sixteen. By extending the number of measurements to eleven, the cumulative probability of two criminals having exactly the same measurements would be 4^{11} or over 4 million to one. (4) The system included (i) **Descriptive data** – e.g. (a) *color* - of hair, eye and skin [complexion], (b) *shape* - of ears, nose and chin (ii) **Body marks** – e.g. tattoos, scars, moles (iii) **Body measurements** - 11 parameters were used by Bertillon. No individual has all 11 parameters exactly the same. The parameters used were: (1) Height: Standing (2) Height: Sitting (3) Reach: Arms outstretched (middle finger-tip of one hand to middle finger tip of other) (4) Length of head (5) Width of head (6) Length of right ear (7) Width of right ear (8) Length of left foot (9) Length of left forearm (10) Length of left middle finger (11) Length of left little finger (d) Front and side photographs. Also called *portrait parlé* (Fr. The Speaking Portrait), because it was like making a speaking portrait of a person. (5) **Disadvantages** - (a) Measurement requires use of instruments and trained operators. Otherwise two operators may give different values for same person (b) applicable only to adults (c) Calculation errors are there (d) photographs are not reliable (e) Like fingerprinting, anthropometric data is not left at the scene of crime. Presence of criminal at the scene cannot be established by anthropometry (6) **Current status** - This system has now been replaced by dactylography.

N. Dactylography

Dactylography **(Gk** *daktylos*, **finger;** *graphein*, **to write) [syn.** Fingerprinting, dermatoglyphics, Galton system**]** *is a method of identification, based on unique epidermal ridge pattern on the tips of fingers.* **Salient features:** (1) It is the *most important, accurate* and *unfailing* method of positive identification. (2) It is a better modified method of identification than even DNA profiling. *DNA profiling would be same in identical twins, but fingerprints are different even in identical twins.* (3) **Paternity by fingerprints** – Patterns are not inherited and paternity *cannot be proved through fingerprint patterns.* (4) ***Epidermal ridges*** *(also called* ***friction ridges****) are raised portions of the epidermis on the fingers* (also seen on toes, palms, soles). Their function is to amplify vibrations and to assist in gripping rough surfaces and wet surfaces. Sweat gland pores open on their top [Fig 3.61]→Responsible for fingerprints. A subsidiary ridge [syn incipient, nascent

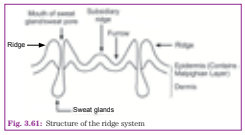


Fig. 3.61: Structure of the ridge system

thigh and the lower part of a leg. Other parts of the body including more than 150 bones and fragments were also recovered.[B] **How body was identified:** (1) Mrs. Parkman identified the body as her husband's from markings near the penis and on the lower back. (2) His brother-in-law said that he had seen the extreme hairiness of Parkman's body and confirmed that the body was his. (3) At his arrest, Webster had claimed that the body parts were from a cadaver used by medical students. Dr. **Jeffries Wyman** along with a team of experts worked with the bone fragments, and concluded that (i) the remains were human, (ii) belonged to a male, (iii) whose height was 5'10" and (iv) who was between 50-60 y of age. All details exactly matched George Parkman. (v) The level of decomposition equaled 7-8 days. This coincided with the length of time Parkman had been missing. (vi) Furthermore there were no traces of embalming fluid, which should have been present, had the body belonged to an anatomy dissection hall. (4) Dr **Nathan Keep**, who had constructed the denture for Parkman identified him from fragments of mineral teeth fused to his gold denture base. (5) Dr. **Lester Noble**, Dr. Keep's assistant, had in his possession, some study models of Parman's lower jaw, which he had made. Recovered portion of porcelain denture fitted accurately the model. [C] **Outcome** – Webster was found guilty of murder and hanged on Aug 30th, 1850. [D] **Significance** – This was the first time that evidence of dental identification was presented in an American court. Such was the interest generated in Boston, that spectators in the court gallery were only allowed to remain for 10 min before relinquishing their places to those waiting outside.

b. Acid Bath Murder Case (1949)

Please see **ch 6**

T. Clothes, ornaments and personal articles

(1) Indicate social status [texture, value of clothes] (2) People of different nationality and races may wear different types of clothes (kurta, pajama, sherwani, tie, necktie, hat, caps). Helpful only rarely. (3) The clothing may bear laundry marks or tailors' tabs (4) quality and condition of the garments may assist in establishing the social status (5) Identity card, ration card, driver's license, cell phone, peculiar rings, shoes etc (6) Forensic examination of clothings - **ch 5**

U. Molecular Methods

Telomere Shortening: (i) There is continuous shortening of telomeres during cell division [50–100 base pairs/cell division]. Thus telomere length decreases with age, mostly in somatic cells. Based on this fact, attempts have been made to predict age of individual from his DNA left at crime scene. (ii) **Weaknesses** – There are other factors which regulate telomere length [eg heritability (telomere length varies among individuals at birth), gender (males lose telomere length more rapidly than females), diet etc.]

V. Miscellaneous methods of identification

1. Biometric methods

Biometrics (Gk *bios*, life; *metros*, measure) *is the science of identification based on a person's unique physical or behavioral traits.* **Salient features:** (1) Most physical and behavioral traits can be accurately captured using sensors and can be compared using computers. (2) **Divisions of biometric methods:** (i) *Physical characteristics* - related to the shape (or other physical characteristics) of the body. **Ex** (a) body odor (b) face recognition (c) Fingerprint (d) hand geometry (e) iris scan (f) Palm print (g) retina scan etc (ii) *Behavioral characteristics* [*behaviometrics*] - related to the behavior of a person. **Ex** (a) gait (b) signature (c) voice etc.

a. Physical characteristics

i. Bone comparisons

If X-ray records of some bone anomalies are available, bones may be compared with antemortem x-rays for identification. (1) **Trabecular meshwork** - of the bones is unique in each individual. (2) **Congenital** - abnormalities, cervical rib, deformities [for *skull deformities*, please see above under "skull"], malunion (3) **Transitional vertebrae:** (i) Developmental variants of the spine. (ii) Found in app 20% individuals (iii) Often involve the sacrococcygeal and lumbosacral junctions. The L5 vertebra can be incorporated into the sacrum ("*sacralized*") or the S1 vertebra can be incorporated into the lumbar spine ("*lumbarized*") [**Fig 3.81**]. (iv) Transitional vertebrae are usually incidental findings during radiologic evaluation. (4) **Implants** [nails, plates etc]. Even if implants are subsequently removed, intra-bone metal particles can still be detected by histopathology and scanning electron microscope-energy dispersive electroscopy (5) **Foreign bodies in the bones** [souvenir bullets, pellets]. (6) **Wormian bones** [syn, extra sutural bones]: (i) Extra bone pieces that occur within a suture in the cranium. Named after Danish anatomist **Ole Worm** [1558–1654] who first described them. (ii) Occur most frequently in the course of the lambdoid suture. Less frequently within sagittal and coronal sutures. (iii) A large wormian bone at lambda is known as an Inca bone (*Os Incae*), due to the relatively high frequency of occurrence in Peruvian mummies. (iv) *Pterion ossicle* [syn, epipteric bone, Flower's bone] – Wormian bone seen between sphenoidal angle of the parietal bone and the great wing of the sphenoid bone. (7) **Miscellaneous** - double articular facets, Ununited sutures [eg metopic suture]



Fig. 3.81: Transitional vertebra – Lumbarization of sacral vertebra

ii. DNA profiling

Please see **ch 29**

iii. Frontal sinus pattern

Besides fingerprints, the ***frontal sinus pattern*** *is another major identification criteria, that is different even in identical twins.* **Salient features:** (1) **History** - The idea of establishing identity by frontal sinus patterns was first suggested in **1921** by **Schuller**. In 1931 Poole corroborated the idea by showing that the pattern was different even in identical twins. (2) **Anatomy and Development:** (i) Appear in **2nd year** of life. (ii) keep growing in size during the first two decades. (iii) Good for identification after they have stabilized, especially in cases where the bodies have been badly burnt or mutilated [eg air disasters]. Antemortem X-rays may be obtained from deceased person's medical records/physicians. (iv) absent in 5% (v) unilateral in 1% (3) **Method of use** - The scalloped upper margins of the sinuses are used. These are smaller and more numerous in the females. Several different techniques are used for comparison (i) tracing out the patterns and compare. (ii) tracing out the patterns on a cardboard, cut it out and then weigh it. Weight derived from both antemortem and postmortem films must be same (iii) computed tomography of frontal sinuses.

iv. Iris scans

Iris patterns of all people are different. In 1987, Leonard Flom and Aram Safir patented the use of the iris as a personal identifier. In 1994 John Daugman at Cambridge University of England, developed the technology for iris scanning [**Fig 3.82**].

Fig. 3.82: The principle behind iris scan

v. Nails

(1) **Nails are helpful in:** (i) decomposed and dismembered bodies (ii) disaster victims (iii) Broken or clipped nails may be present at the scene of crime, or may be found in some hidden place (iv) In kidnapping cases, clipped nails of kidnapped persons might be available from the place where they were held for hostage. (2) **Information from nails:** (i) *identification*

Extra information is given in small type. May profitably be read to get extra credit.

Extensive cross-references to avoid duplication of text.

2. MLI of algor mortis

(1) Helps to estimate TSD. Sometimes two dead bodies lying side by side may show remarkable diff in rectal temp. This may be because of individual body variations, and also because one died earlier. In one case brought before the author bodies of a couple were found inside a closed room. Female's body was significantly cooler than the husband's indicating that it had died earlier. It turned out that the husband had killed wife first, than after some time committed suicide.

3. PM Caloricity

PM caloricity *is a condition when the temperature of body ↑es after death instead of ↓ing.* **Salient features:** (1) **Conditions when it occurs:** (i) **Dead body is lying in the open in hot summers** – Most common [body temp is 37°C, while in hot summers environmental temp may be as high as 45°C] (ii) **Infections** – like cholera, malaria, septicemia, tetanus, typhoid etc. *Cause* - (a) ↑ in temp may already be ↑ed at the time of death (b) Bacterial and other microorganism metabolism continuing after death] (iii) **Other Conditions**- (a) **Sunstroke** - It is due to body lying in the open [sunstroke occurs in open sun]; also the temp of victim is ↑ed at the time of death itself, which may be wrongly taken as pm caloricity. (b) **Strychnine** – Due to excessive convulsions, the temp may be ↑ed at the time of death itself. There is no physiological reason why it should occur in sunstroke and strychnine poisoning.

D. Postmortem lividity (Livor mortis)

Postmortem lividity **(syn**: cadaveric lividity, darkening of death, hypostasis, livor mortis *L. Livor*, blueness; *mortis*, death**)**, livores, postmortem hypostasis, postmortem lividity, Postmortem staining of the cutaneous hypostasis, suggillation) *is the* (i) *bluish-purple or purplish-red discoloration* (ii) *which appears after death,* (iii) *on the most dependent parts of the skin* (iv) *due to collection of blood in the capillaries and small veins (rete mucosam) of the most superficials of the dermis* (v) *due to gravity* [Fig 9.1]. **Salient features:** Cause: (i) Stoppage of circulation (ii) tendency of blood to sink by gravity to the most dependent parts; its collection in toneless BV and capillaries (iii) Backward flow – of venous blood to the capillaries from the venular end [adds to the blueness of pm staining] (2) **Color:** (i) *Hue* – **Bluish purple**, but may vary in different parts of the body (ii) *Intensity* – depends upon the amount of reduced Hb in the blood. Large amounts of reduced Hb produce deep purplish coloration (iii) Portions drained of blood – become correspondingly pale (iv) may depend on cause of death [Table 1]. (3) **Place:** (i) In general – well marked in lobes of ears and in tissues underneath fingernails (ii) back of chest and abdomen in supine position. *Most common* (iii) front of chest and abdomen in prone position; (iv) lower legs and hands in hanging (v) Face in drowning [in drowning, face is the most dependent part]. On the contrary, antigravity regions of the body are drained of blood and become **pale**. (4) **Visibility:** (i) *More clearly seen in* (a) fair skinned people (b) young having good nutrition and normal hemogram (ii) *Less clearly appreciated in* (a) dark colored people (b) old, anemic persons (5) **PM staining and congestion:** (i) *True congestion* - Table 3, (ii) *Hypostatic congestion* – may occur even a few hours before death in persons dying slowly with circulatory failure, eg, asphyxia, CCF, cholera, coma [deep], poisonings [barbiturate (barbiturate blisters also appear because of same mechanism [**ch 40**]), morphine], tuberculosis, typhus and uremia. It is not true congestion, but only because of passive stasis of blood. In such cases, pm staining is quicker to develop. (6) **PM staining and cyanosis** – It is not possible to distinguish between the two [both are bluish purple]. Many pathologists refuse, because, asserting that it cannot reflect the true ante-mortem situation. (7) **Vibices** [syn, **Postmortem Ecchymoses**, **Death Spots**]: (i) *Appearance* - Vibices are tiny, spot-like, sometimes confluent, oval-to-round, bluish-blackish hemorrhages of postmortem origin exclusively limited to areas of livor mortis. (ii) *Cause* - (a) ↑in intravascular hydrostatic pressure [IVHP] due to pooling of blood → PM mechanical rupture of s/c capillaries and smaller vessels [predominantly veins]. (b) IVHP is itself dependent upon (i) total amount of the circulating blood volume [vibices more common in obese] and (ii) posture of the body after death [more common in legs in hanging, where hydrostatic pressure develops too much] (iii) *Microscopy* – RBCs are intact within vibices in the early PM interval. As putrefaction starts, vibices diminish in number and intensity due to the breakdown of erythrocyte membranes with subsequent hemolysis and diffusion of hemoglobin and its derivates into the surrounding tissue. (iv) *D/d* – May be confused with AM petechial bleeding due to asphyxia or DIC. Vibices are however confined only to areas of PM staining.



Fig. 9.6: PM staining. (1) shows a fresh death, where PM staining has not yet appeared. (2) shows a body lying on the back for about 12 hours. Full pm staining has appeared. Note that pressure areas, including those caused by clothes are devoid of pm staining. (3)PM Staining in a person dead for 18 h. Note intense PM staining, and especially its absence on pressure areas, which is typical "butterfly-like" over the scapular region. A peculiar tattoo is also visible on right side of back and right arm.

Numbering at 4 levels (1) → (i) → (a) → (I)

Conceptual information

Topic → definition in italics → salient features

Every topic starts with a definition in italics, followed by salient features. Synonyms of each term are given in brackets. Numbering at 4 levels helps to remember salient features easily. Every term is followed by all possible synonyms in brackets. Etymologies are explained wherever they help to grasp the subject better. Conceptual information is given in small type and wherever necessary, is followed by appropriate examples.

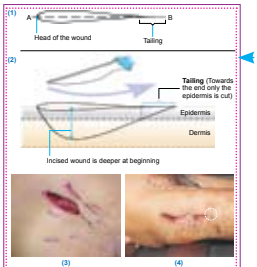


Fig. 12.33: Incised wound is deeper at the beginning and less deep towards the end (1). (2) is a vertical section of the incised wound along the broken line "AB" showing its depth at various points. (3) two incised wounds showing tailing. Sometimes a stitched wound may have to be opened to reveal tailing (4). White dotted circle highlights tailing.

D. Age of incised wounds

1. Gross

(1) **Fresh** – Hematoma formation (2) **12 h** – (i) Edges red, swollen, adherent with blood and lymph (ii) Leukocytic infiltration. (3) **24 h** – Dried clot in the form of crust or scab

2. Histopathology

Following changes are for uninfected wounds and healing by first intention. Figures are considerably different when infection sets in [healing by second intention]. In the latter the inflammatory reaction is more intense and much larger amounts of granulation tissue are formed. Scarring is more. (1) **Few min** – (i) Reactive changes in tissue histiocytes (ii) Dilatation of capillaries (iii) Swelling of vascular endothelium (iv) Margination and emigration of neutrophils (2) **12 h** – (i) Reactive changes in fibroblasts (ii) Monocytes appear in exudate (3) **16 h** – Mitotic divisions begin in monocytes (4) **24 h** – (i) Epithelium begins to grow at the edges (ii) A continuous layer of endothelial cells cover the surface (iii) Vascular buds begin to form (5) **72 h** – Formation of vascularized granulation tissue (6) **4-5 d** – New fibrils are formed (7) **1 wk** – scar formation if wound is small.

E. MLI of incised wounds

(1) **Reconstruction of crime** – Incised wounds help to reconstruct the crime and to corroborate or refute the story of the victim by enabling to determine (a) *the nature of the weapon* – sharp edged (b) *Age of injury* and (c) *Direction of force* (2) **Decomposed body** - Differentiation between incised and lacerated body is difficult (3) **Body with incised wounds immersed in water soon after death**



Fig. 12.35: Homicidal cut throat

an angle >90° with the skin surface (**beveled edge**). The other edge (under mined edge) makes an angle <90° with the skin surface. It mostly lies submerged under the surface. (3) **Nearly horizontal** – If weapon enters nearly horizontally [Fig 12.34(3)], a wound with a flap is produced. [C] **Manner** – Beveling usually indicates homicide, and may indicate relative position of the assailant and victim.

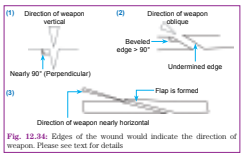


Fig. 12.34: Edges of the wound would indicate the direction of weapon. Please see text for details

7. Hemorrhage

(1) Hemorrhage is **more** as the vessels are cut cleanly. (2) Spurting will occur if an artery has been cut.

C. Cut throat wounds

1. Suicidal and homicidal

2. Cause of death

Death depends upon extent and severity of wounds. Causes are (1) hemorrhage from jugular veins (2) choking due to blood if trachea or larynx are cut (3) air embolism.

Photographs with corresponding line diagrams

Co-relation of photographs with corresponding line diagrams for better comprehension of concepts.