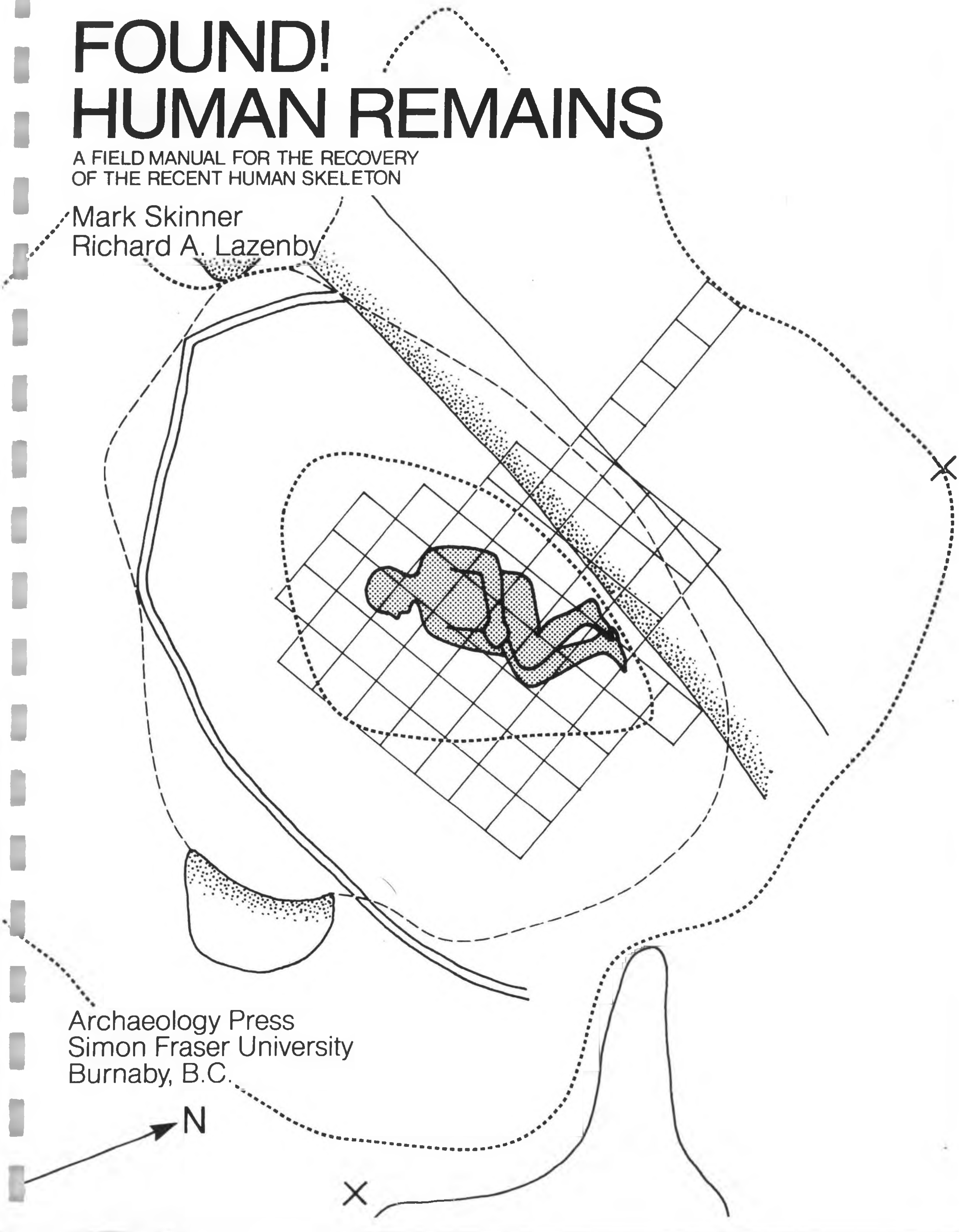
FOUND! HUMAN REMAINS

A FIELD MANUAL FOR THE RECOVERY OF THE RECENT HUMAN SKELETON

Mark Skinner
Richard A. Lazenby



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TO

DR. T.W. McKERN

1920-1974

who introduced forensic anthropology to British Columbia

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Preface

For more than a century archaeologists and physical anthropologists have been engaged in the recovery and analysis of ancient human skeletons and artifacts, in order to understand the appearance and behavior of past peoples. Their aim, *maximum information retrieval*, parallels that of the police officer confronted with recent bones which might be human and possibly of forensic significance.

The methods employed by archaeologists and physical anthropologists, both in the field and in the laboratory, are of immediate and obvious use to the investigating officer. Unfortunately, a gap in communication and cooperation persists between the police and the academic, to the disadvantage of both. The investigation of suspected crime can be significantly enhanced by application of the techniques of archaeological excavation. Similarly, physical anthropologists, with skills freshly honed by investigations leading to the identification of missing individuals, can turn to prehistoric and fossil bones with heightened confidence in their ability to do creditable work. A positively identified skeleton is a touchstone with reality for physical anthropologists who normally work with prehistoric bones which, sadly, cannot talk back.

This manual describes how to recover more or less skeletonized human remains and associated evidence for forensic purposes. It also explains what a forensic anthropologist can learn about an individual from a careful study of the bones. The authors hope the manual will bring the identification officer in the field and the archaeologist and physical anthropologist closer together. Although the manual will enable the investigating officer to recover human skeletal material adequately, it is our recommendation that, with enhanced cooperation between the law officer and the forensic anthropologist trained in archaeological techniques, they share the task of recovering the bones and related evidence.

Only experience in the use of this manual will show if it is helpful. In the spirit of closer communication the authors welcome any and all suggestions for its improvement.

Mark Skinner

Richard A. Lazenby

Simon Fraser University, 1983

Acknowledgements

Respect for a colleague's work is a sensitive measure of how good a job he or she is doing. Our experience with the Crime Detection Laboratory, Royal Canadian Mounted Police (Vancouver) and in the field with various local police detachments in British Columbia has not only been enjoyable and stimulating, but has consistently shown the involved personnel to be men and women of goodwill working conscientiously at a socially relevant task. We wish to acknowledge the help and experiences afforded us by our involvement with these individuals. Specifically, the following 'crime lab' members have provided material and moral support for our work: Detective Inspector 'Sid' Sadowsky, Inspector Shel Payton, and section members Rick Sumner, Earl Hall, Stefano Mazzega, Julie Graham, Ron Schiefke, Doug Bateman and Nancy Ziegler. We appreciate their patience and forbearance in our continuing, and at times perhaps fumbling, foray into the rigorous methods of forensic investigation. Similarly, we wish to thank the Department of Archaeology, Simon Fraser University, for providing space, equipment, and materials for our identification service through which we hope to build a bridge between the university and the community-based police investigative agencies. In this regard, Sgt. Brian Strongman, Identification Officer with the Coquitlam R.C.M.P., deserves our special gratitude.

The authors wish to express their gratitude to Fran West for her insistence on quality in all things, to Laura Perley, Cathy Driver, and Kjerstin Smith for the cartoons and illustrations and finally to Mike Hoskins for the photographs.

"He who would separate an ego from the universe to make a name for himself must learn that the very definition of individuality is limitation; the form of a thing is described by its edge, and the edge of being is death."

[From W.I. Thompson (1981) *The Time Falling Bodies Take To Light* St. Martin's Press, New York, p. 200.]

CHAPTER I

Forensic Evidence and the Human Skeleton

Too often, we hear that a human body reduced to pieces of bone is beyond telling us anything; that the identity of the victim or assailant can never be known. Occasionally this is true, but one man who thought so awaits extradition to Canada to face a charge of homicide. This derives from our recovery, five years after the fact, of a human body reduced through deliberate cremation and extreme fragmentation to less than 900 grams of bone and tooth fragments, with dental work, numbering in the many thousands.

Another case involved a prospector who disappeared from his cabin in a remote valley in the southern interior of British Columbia. Near his camp were found four objects suspected to be human remains. Examination indicated that two of these were the chewed collarbone and first rib of an adult human being, likely male. The other two items were fingernails. Adhering to the bones were two types of hair: one long, slightly wavy, and light brown; the other, suspected to be beard hair, red and kinked. Combining this information with the remoteness of the camp meant that a death certificate in the name of the missing person could be issued.

Recently, burned bones were found in a secluded corner of a known criminal's property. Police suspicions of foul play were quickly dispelled by having one of us flown to the scene where excavation revealed the bones to be from a bear. Considerable time and expense were saved by this means.

Other cases could be cited, demonstrating that in most instances a significant amount of information can be obtained from even the most seemingly inconsequential skeletal material.

Skeletal remains come to light through a variety of means. The resulting investigation attempts to answer such general questions as: 1) are the remains animal or human; 2) if human, are they archaeological, historic, or recent; 3) if recent, who was the individual and what were the manner and cause of death; and 4) what postmortem events, acting for how long, have resulted in the current state of the remains?

Most identification officers can answer the first question with little difficulty, providing the remains are distinctive enough -- for instance, a skull. Answers beyond this require the services of a specialist in the analysis of human skeletal remains.

In most cases of unidentified found skeletal remains, the bones will have been submitted to a pathologist for autopsy before they are passed on to a forensic anthropologist. A medicolegal autopsy is an examination of a body to determine cause of death. The pathologist will also try to identify the remains and determine everything else of forensic importance.

However, forensic anthropologists are sometimes more familiar with or able to derive information from 'just bones'. Experience has shown that rarely does a local physician or even pathologist possess the requisite familiarity with the variability of detailed bony anatomy, particularly if the remains show the usual postmortem deterioration. Ideally, there should be close cooperation between the two specialists. In our experience this is a rare occurrence. Some accepted autopsy procedures, such as sawing open the top of the skull or cutting out the jaws, are not necessary on skeletonized remains and are positively inimical to the methods of the forensic anthropologist. The investigating officer can play an important role here if he is aware of the procedures preferred by different specialists.

In our opinion the goals of the pathologist and forensic anthropologist are identical. Examination of the bones by a forensic anthropologist is a second chance. It is in effect a second autopsy.

Where human skeletal remains are recovered directly by a forensic anthropologist or an archaeologist with expertise in bones, the bones may remain with this individual for analysis. On occasion, particularly with fragmented bones or 'possibly animal' bones, the remains will be submitted immediately to the forensic anthropologist. This places a great deal of responsibility on the forensic anthropologist, who should attempt to acquire some knowledge about the sorts of evidence encountered by forensic pathologists (see list of recommended readings).

A list of anthropologists, archaeologists and anatomists throughout Canada and the United States who have expressed their interest in helping the authorities to recover and analyse human skeletal remains is included as Appendix 1.

This manual is meant to be a useful guide to the recovery of human bones. Our wish is simply to make the investigating officer's task more effective. It has been our experience that such individuals are very good at observing and recovering the kinds of evidence they have been trained to see. However, they cannot be expected to recover that which they do not perceive; for example, an empty tooth socket lacking the soil discoloration of other empty sockets, indicating a tooth has recently fallen out and lies nearby; empty fly pupae, little bigger than grains of dirt, signalling a significant lapse of time between death and burial; dental fillings released from a tooth crown exploded in the heat of a fire. In other words, a poor return of information for one's efforts is not usually due to errors of commission, but to natural omission through lack of awareness of: a) the appearance of the human skeleton; and b) how its innate variability, and that deriving from postmortem decomposition, can tell us so much.

The manual is divided into four basic sections. The first deals with archaeological techniques, suitably modified for forensic cases, for the recovery of surface and buried human skeletal material (Chapter II). The second part explains how such basic information as age and sex, plus uniquely individual traits, are derived from bones and teeth (Chapter III). Our intent is to ensure that the investigating officer understands the strengths and weaknesses of both the evidence he is collecting and the conclusions drawn by the specialist. The next section deals with the contribution that the forensic anthropologist can make to interpreting the manner and cause of death (Chapter IV). The difficult topic of determining elapsed time since death is discussed in Chapter V, with an emphasis on how plants and insects associated with the remains can help with this problem. The final major section explores the expanding role that anthropologists and archaeologists can play as forensic investigators, particularly in the analysis of animal bones, and human cremations. Anatomical reconstruction of bone fragmented by firearms trauma and modelling a face onto the skull are techniques that are relatively new in their application to forensic cases in Canada. These topics are discussed in Chapter VI.

We have tried to avoid complex terms. Words which are likely to be unfamiliar to the non-specialist are expressed in bold face where they first appear in the text and are defined in the Glossary.

All investigating officers will appreciate the nature of an autopsy and the wealth of often startling data to be had from a pathologist's careful analyses. Human skeletal remains, perhaps with dried soft tissue remnants and often visibly altered by events at or subsequent to death, are in their own way no less important or informative and should be handled with the same rigour, reverence, and motives.

Evidence has been defined as "information, whether in the form of personal testimony, the language of documents, or the production of material objects, that is given in a legal investigation to establish the fact or point in question" (Oxford English Dictionary). The human **SKELETON** constitutes physical evidence. It can be used to establish new facts or to corroborate the testimony of witnesses.

Many of the bones brought to the attention of the police are non-human. Most of the remainder represent the remains of often identifiable missing persons who have died by misadventure or suicide. A small but significant portion, the victims of homicide, were never meant to be found. The fact that an unidentified person has died, regardless of the manner of death, is of interest to the courts of law; that is, the bones are of **FORENSIC** significance. Our society demands that the death of every individual be noted. Surviving relatives, beneficiaries of insurance policies and wills, business partners of the deceased -- all have a legitimate interest in knowing of a particular someone's death.

These remains may have suffered variable degrees of destruction as a result of natural agents, such as animals or climate, or through deliberate acts of violence contributing to death, or in attempts to cover up the death subsequently. Bones and teeth are, however, highly resistant biological materials and the individual characteristics of these **HARD TISSUES** plus the consequences of **PREMORTEM** and **POSTMORTEM** physical trauma affecting them, may preserve remarkably well. Usually sufficient detail will preserve to permit the **FORENSIC ANTHROPOLOGIST** to determine at a minimum the age at death, sex, race and stature of the individual concerned with a known degree of confidence. Furthermore, individual identification is possible when diagnostic portions are preserved for comparison with premortem records.

Apart from cases of violent death producing, for example, such evidence as bone **CRATERING** in gunshot wounds, rarely can one discern specific features of the bone directly related to death. Investigation can show however which features are definitely not associated with the person's death; such as premortem fractures, postmortem **DISMEMBERMENT**, **CREMATION**, or animal activity (Fig. 1). The appearance of traumatized skeletal remains can suggest the **INSTRUMENT** or class of instrument responsible for the effects observed (Fig. 2). A direct physical match between an alleged instrument and **TOOL MARKS** imparted to the bone may be possible (Fig. 3). Such marks may indicate the manner and direction of assault.

It cannot be overemphasized that thorough analysis and correct interpretation of the evidence obtained from the human skeleton require as complete a recovery as possible of the remains and associated materials (for example, projectiles and personal effects). This includes accurate notation of the precise relationships both among the various recovered skeletal elements and associated items and between these and their physical and climatic contexts, as this information can be especially significant.

In summary, it is possible from the skeletal material, associated items, and the context of each to identify the individual and to reconstruct some of the events occurring at, around and after death; all of which can constitute evidence in subsequent legal proceedings.

a

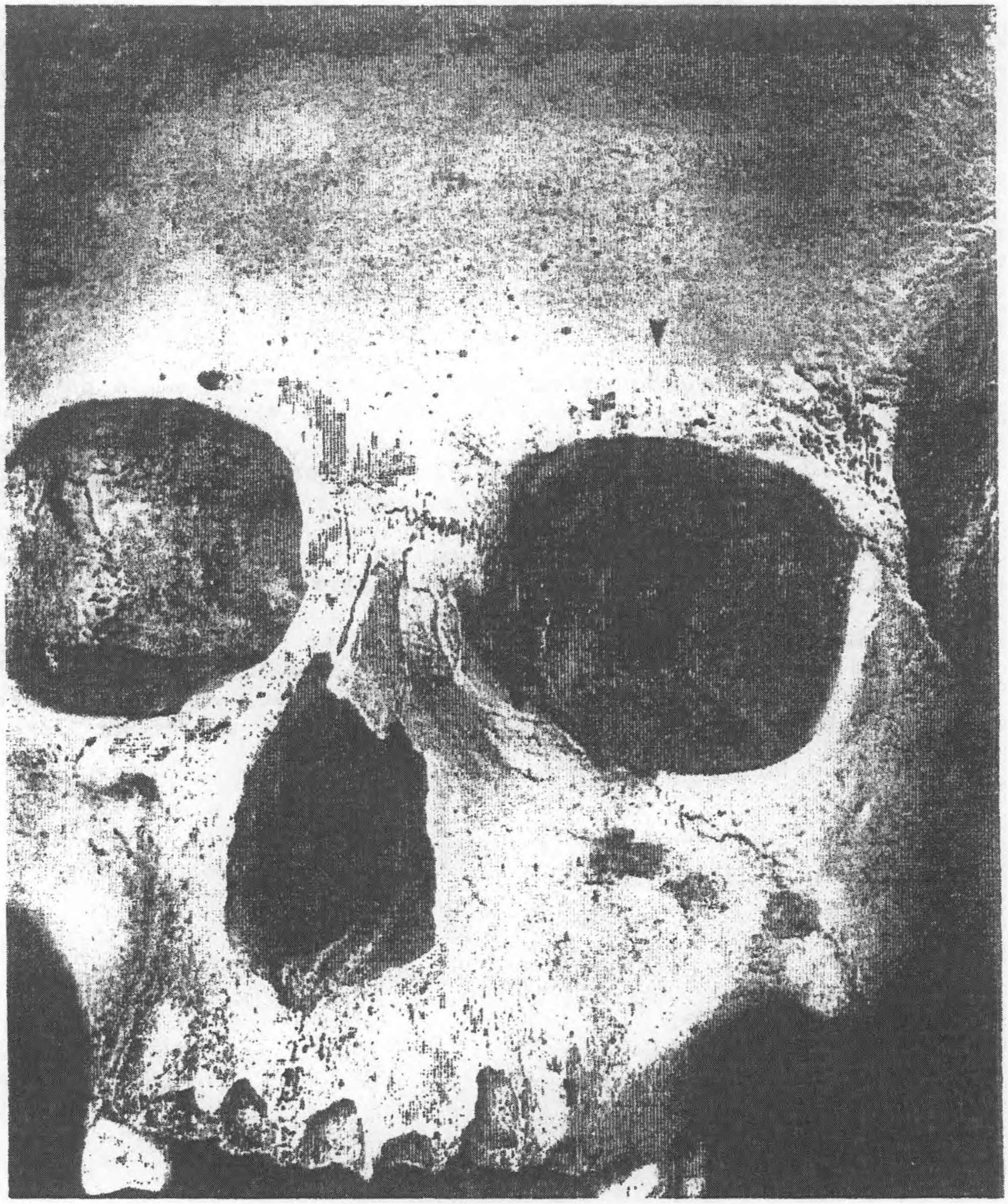
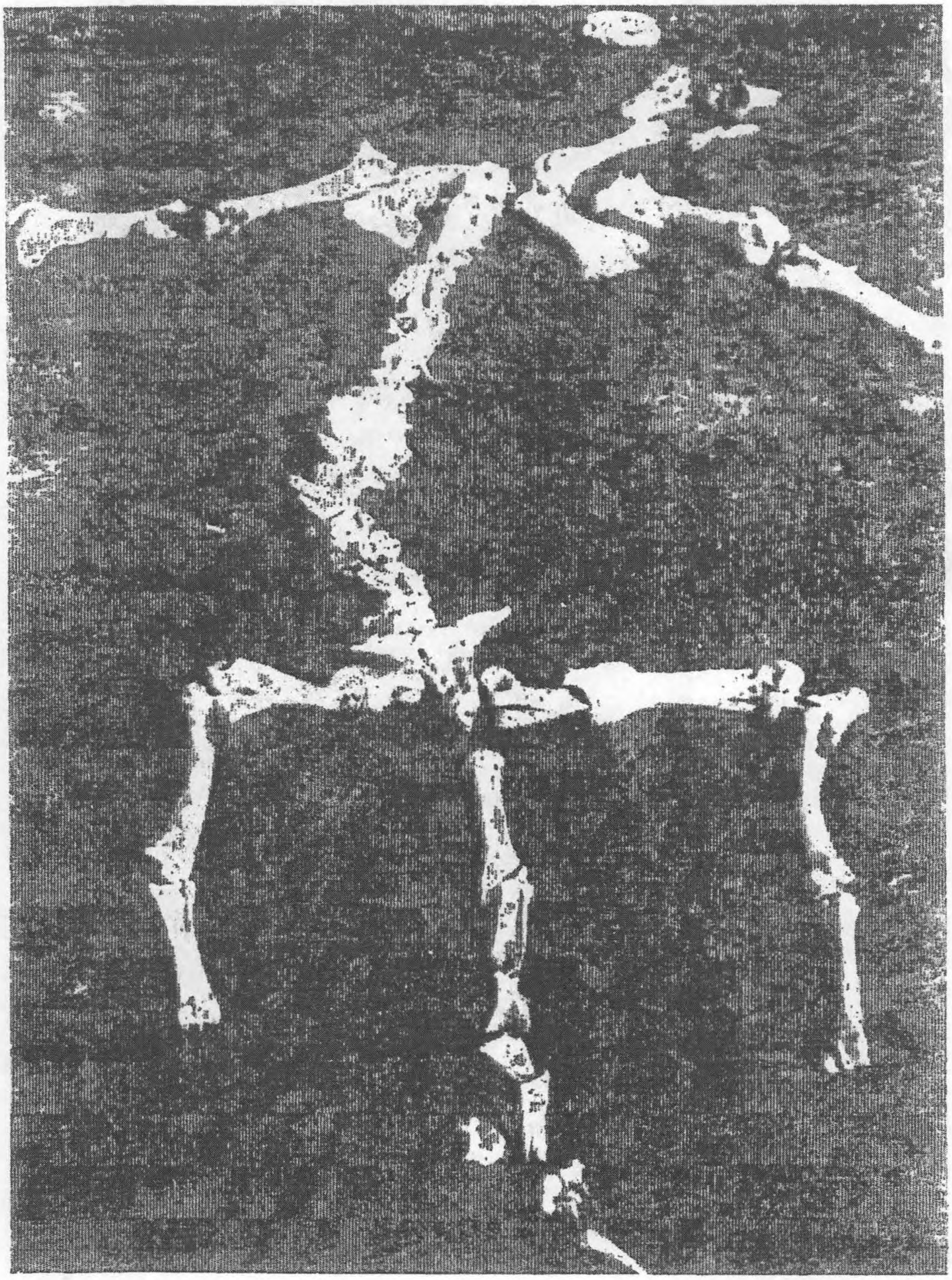


Figure 1. Postmortem appearance of bone: a) Effect of animal activity on human bone: striations above the left eye produced by rodent incisors (Case 77-3). b) Effect of human activity on animal bone (courtesy of J. McIvor).

b



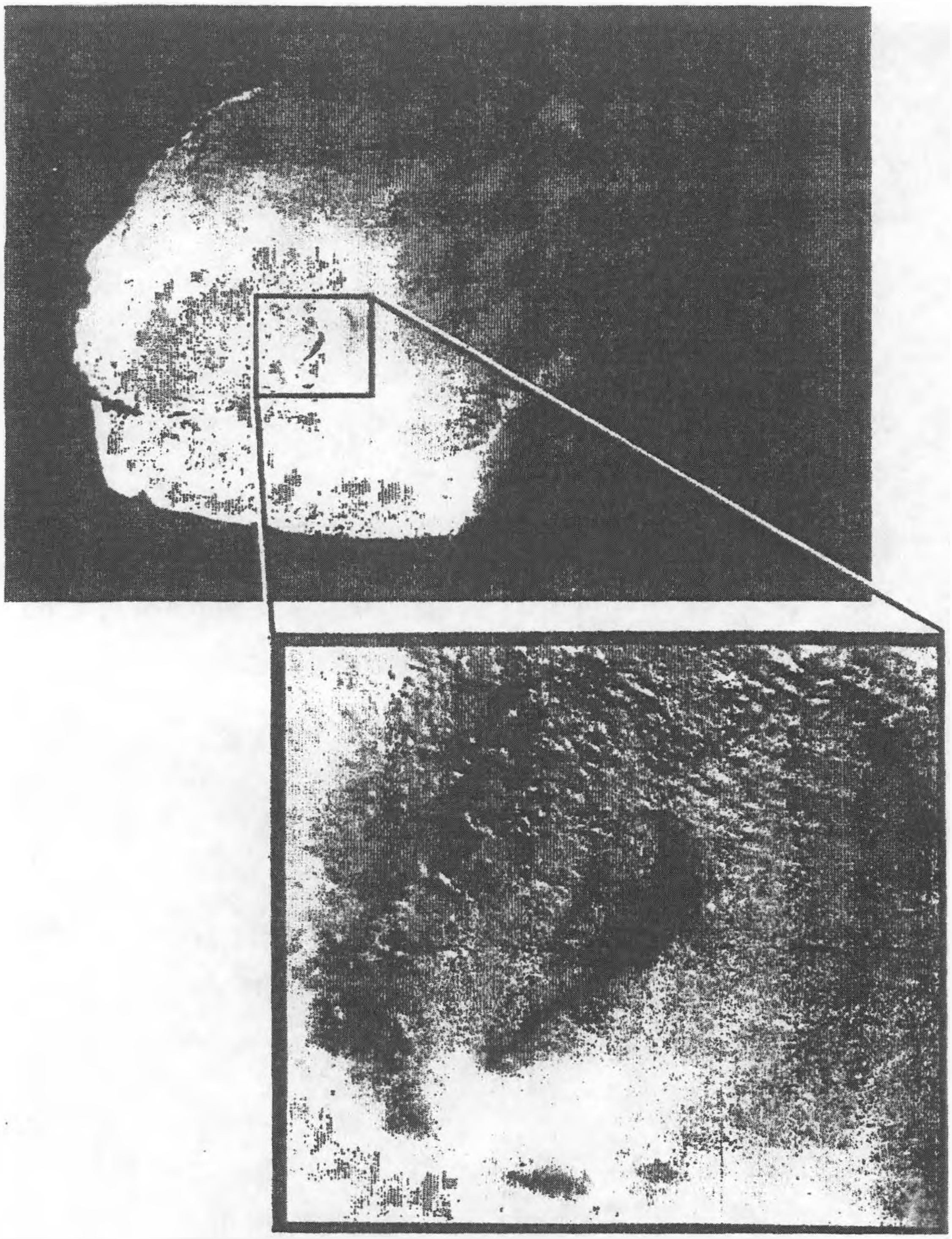


Figure 2. Class of instrument producing tool mark on bone. Typical wedge-shaped penetrating wound on right parietal (see inset) produced by single-edged knife point (Case 80-16).

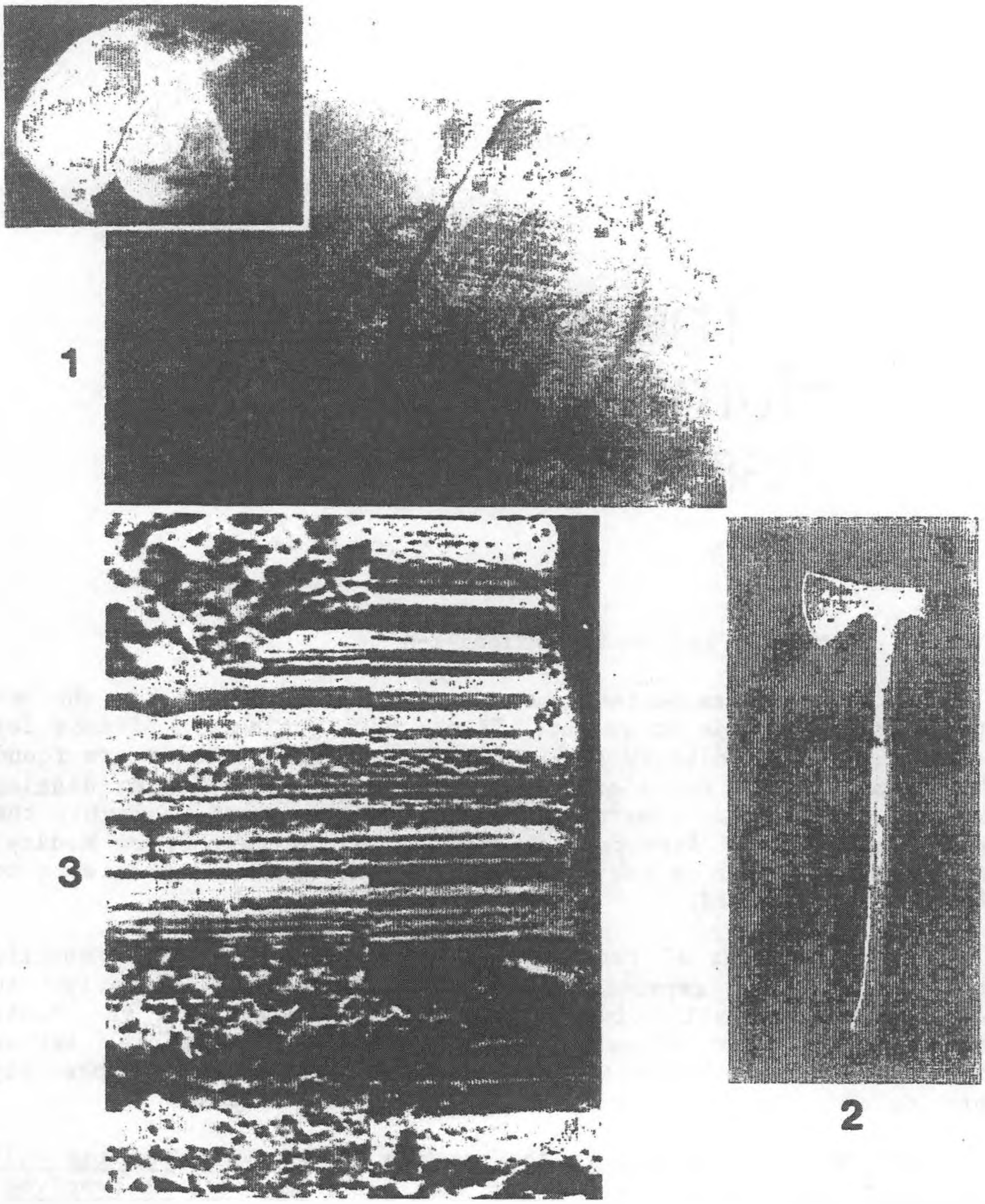


Figure 3. Specific instrument producing tool mark on bone. 1) Left frontal showing shallow, scooped-out appearance with striations produced by a glancing blow from a hatchet (inset shows top of skull). 2) The hatchet. 3) Stereocomparison view of scratches on bone (left) matched to those in test cut from hatchet in wax block (Case 80-16).

CHAPTER II

The Recovery of Human Remains and Associated Evidence

II. A. Rationale and General Principles

All known or suspected human bones are protected by law whether they are prehistoric or recent. It can be a punishable offence for casual persons to disturb them. Yet most skeletal remains are found by ordinary people doing ordinary things, such as hunting or digging a house foundation. Regardless of how the bones come to light, the police are usually directed or empowered by the Coroner or Medical Examiner to recover or take possession of the remains and attempt to have them identified.

The objectives of recovery are twofold: firstly, to identify the individual(s) represented by the remains and, secondly, to collect any and all evidence which might explain how the bones arrived at their present state and location. This latter information could indicate the commission of a crime and possibly provide clues to the identity of the criminal(s) involved.

The methods employed in the recovery of skeletal remains will determine the ease and reliability with which the case is resolved. Indeed, the bones themselves may constitute the only physical evidence contributing to the apprehension and conviction of the person(s) responsible. As such, the techniques and procedures followed in the retrieval of the remains become most important. A thorough recovery operation strives to gather much more than the skeletal material alone.

A number of general principles must be borne in mind throughout the process of recovery:

1) The collection of information is invariably accompanied by the loss of information. It is the responsibility of those individuals involved in the recovery to insure that as much information as possible is discovered and retained. Only certainty of complete recovery will allow the specialist examining the remains to ascertain the significance of absences. For example, upon receipt of a jumble of bones it is discovered that those of the hands are missing. Is their absence due to poor recovery, animal activities, or to their deliberate removal by an assailant to deter fingerprint identification of the victim?

2) Not all important and recoverable evidence has been intentionally deposited. For example, a body deposited and cremated outdoors may include in the debris, plants and insects burned and preserved at a particular season of their life cycle. Further instances of this adventitious inclusion of evidence are insect species invading the corpse and a beer bottle discarded by an assailant.

3) Not all potentially significant evidence is physically retrievable. For example, orientation and location of body parts, exposure to sunlight, and extremes of temperature in the immediate locale promote or retard decay of the body. This information may be crucial to establishing elapsed time since death. In these instances accurate, detailed notes, sketches, and photographs are an absolute necessity.

4) The evidence may not be obvious. The importance of certain features, items, and physical relationships is not always immediately appreciated or even apparent. This is of course the most easily lost of all potentially recoverable information. For example, *IN SITU* (in place) cremation can scorch nearby trees affecting their growth. The year and even the season of this event can be subsequently determined from the altered tree ring widths. Personnel should refrain from ascribing relative degrees of significance to evidence encountered in the field; rather, they should record and collect everything that could be important, regardless of whether it proves to be so in the final analysis.

5) Be equipped to recover the evidence. Appendix 2 lists recommended equipment (Fig. 4) for surface collection and burial excavation. There is no substitute for prior practice with this equipment under field conditions. As a useful exercise we recommend the systematic excavation of animal remains (for example, road

kills) which have been intentionally buried and left for at least a year. This type of practice will go a long way towards alleviating that overwhelming feeling of unpreparedness when faced for the first time with the field recovery of forensically significant human remains.

II. B. Recovery Procedures

The following is a recommended sequence of procedures for the recovery of human skeletal remains in the field:

1. Appraising constraints on recovery

2. Evaluating the search and recovery areas

3. Establishing spatial controls

4. Excavating to expose the remains

5. Excavating to remove the remains

6. Cataloguing, packing, and transport

Each step is outlined in some detail below. Aspects of procedure specific to either surface or buried remains are noted. The most significant difference between the two is that in the case of a burial one is definitely dealing in three dimensions, rather than basically two. In order to recover buried remains it is necessary to remove the associated matrix (soil, sand, gravel) surrounding the bones. If excavation of the matrix is not systematic then the spatial and possibly **TEMPORAL** relationships of the evidence will go unrecognized and unrecorded.

II. B. 1. *Appraising constraints on recovery*

A 'constraint' for our purposes is anything which requires modification of standard procedure even to postponing the recovery. It is essential that the recovery team be aware beforehand of any such constraints. This is not always possible of course but every effort should be made to anticipate these events.

The nature of constraints can vary, but generally belong to one of the following categories: legal, financial, physiographic, or technical.

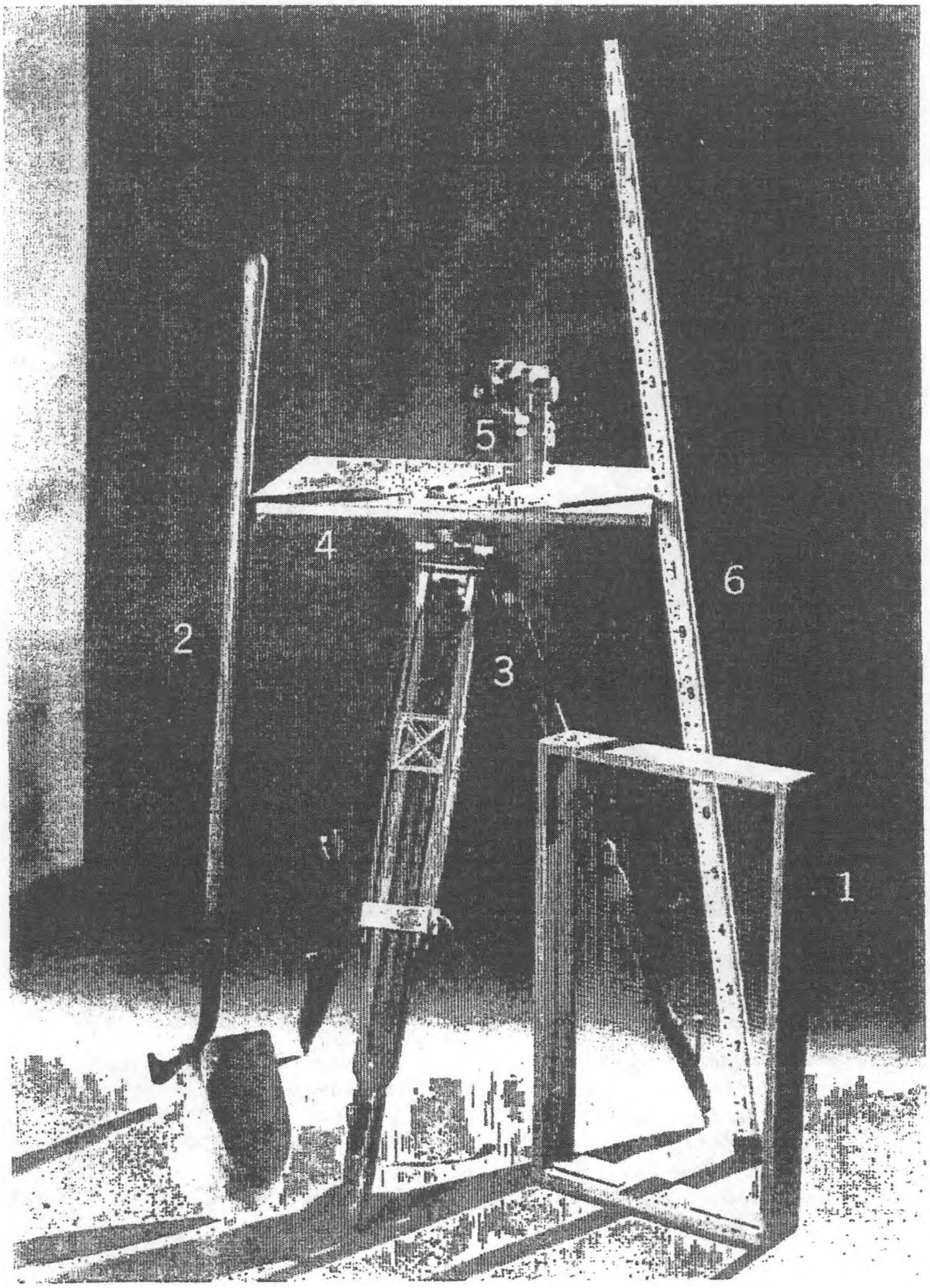


Figure 4a. Standard equipment for the recovery of recent human skeletal remains. 1) Screen, 2) Shovel (for minimum use), 3) Tripod, 4) Plane table, 5) Alidade, 6) Stadia rod.

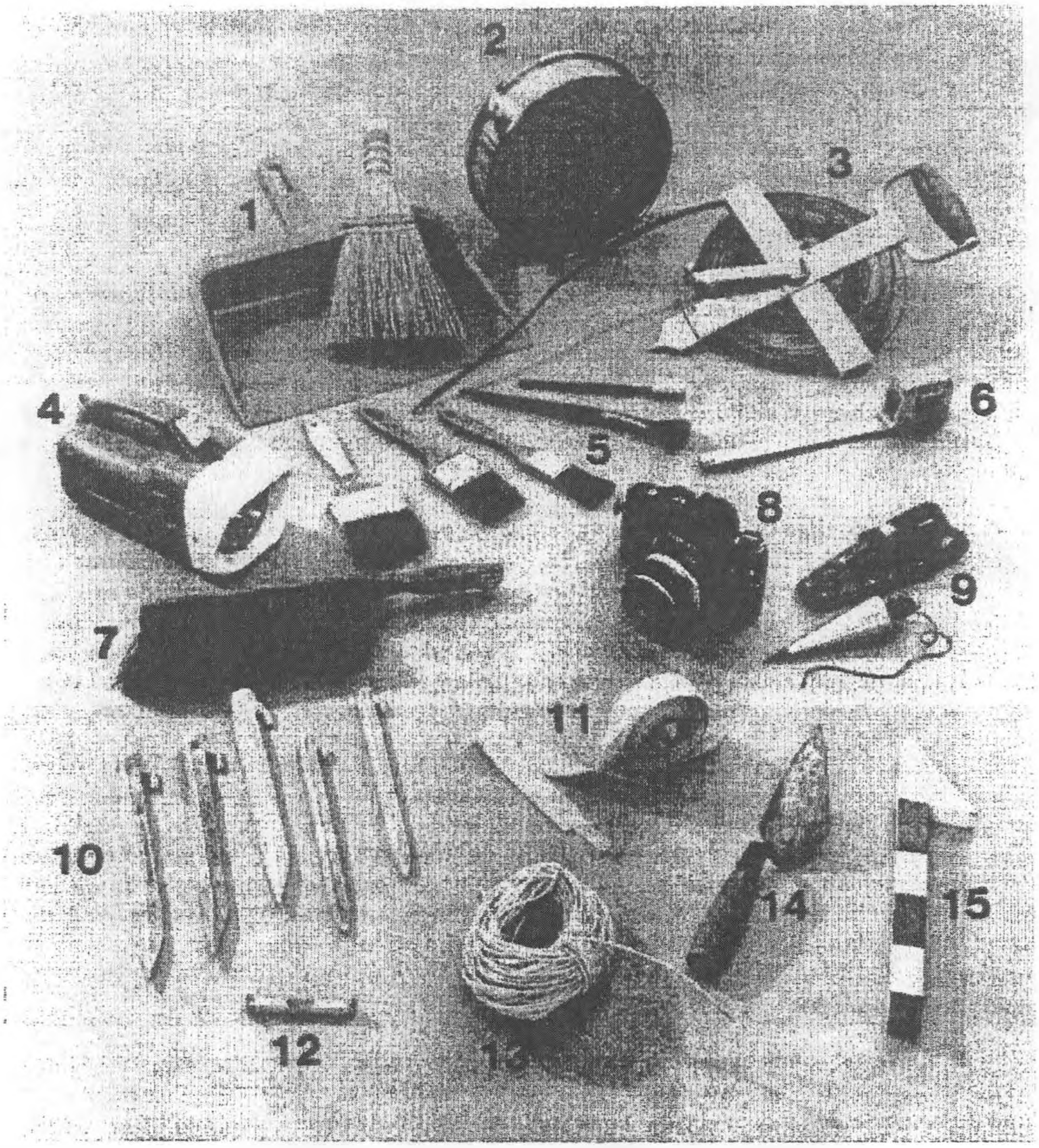


Figure 4b. Standard equipment for the recovery of recent human skeletal remains. 1) Whisk broom and dust pan, 2) Nesting screen, 3) Steel tape, 4) Flashlight, 5) Selection of brushes, 6) Meter tape, 7) Hand brush, 8) Camera, 9) Plumb bob, 10) Pegs, 11) Flagging tape, 12) Line level, 13) Nylon cord, 14) Trowel, 15) North arrow/scale.

Legal constraints might involve obtaining a search and seizure warrant or other authorization, or notifying the local coroner or native band council in case the find locale is an unrecorded (but locally known) burial ground.

Financial constraints usually occur with respect to special cases. Some recovery situations (for example, cremations and multiple burials) are best left alone until personnal with requisite skills can be employed, sometimes at significant expense.

PHYSIOGRAPHIC and technical constraints are no doubt the most common restrictions encountered in the field. The first refers to those aspects of terrain or climate which force change in procedure, while technical constraints develop when the requisite personnel or equipment necessary for recovery are not immediately available; but if obtainable later would enhance the quality of recovery technique and evidence.

A recent case can illustrate how several constraints can operate together, any one of which should have dictated the postponement of recovery. This case involved an alleged sudden infant death in which the mother volunteered information, five years after the fact, indicating the approximate locale ("behind the cabin") where she had buried the naked body of the child, wrapped in a blanket. The local non-commissioned officer in charge, realizing a snowfall was imminent, decided to look for the infant's bones himself, armed only with a shovel. The officer lacked any familiarity with the infant human skeleton, intact or **DISARTICULATED**. As well, the area had been disturbed by heavy logging machinery in the interim. Several holes were dug by the officer with no results. In this situation the recovery should have been put off till spring when a specialist familiar with immature human skeletal remains could have assisted. As an added note, no follow-up investigation has occurred to date in this matter, possibly because this initial attempt, however cursory, was unproductive.

Technical constraints can arise in other ways. In northern British Columbia a man was seen very early one morning dumping a bundle onto a conveyor belt leading up to the top of a 'beehive' sawdust burner. His report that his wife had 'run off' was viewed with some suspicion and it was decided to check out the contents of the burner. After a week the slag had cooled to the point where it could be bulldozed into the open for examination. Repeated clambering over the sharp glassy slag, looking for bone, yielded nothing, except the remark that townsfolk customarily disposed of dead pets into the burner. Consideration of this and the enormous heat and duration of the fire prompted us to search the river instead!

II. B. 2. *Evaluating the search and recovery areas*

It is at this stage that accurate documentation must be initiated. No matter how technically elaborate and perfectly executed are the recovery methods employed, they are wasted effort if the evidence brought to light is not recorded properly. This entails photographs, sketches, maps, detailed notes and possibly even video taped recording of every phase of the recovery, material collected or exposed, and of the contextual relationships.

The investigating officer should distinguish between the **RECOVERY AREA** and the **SEARCH AREA**.

The search area

This larger unit, surrounding the recovery area, constitutes the maximum areal extent in which observations should be made. Both the field worker and the villain are likely to take the 'path of least resistance' to where the body will be found. Particular attention should be paid to approaches and exits from the find locale looking for discarded objects and evidence of a person or persons passing that way (for example, snapped branches, footprints, tiretracks). It may be essential to obtain a statement from the original discoverer of the remains in order to interpret this sort of evidence. Within the search area, observations should be made of the following:

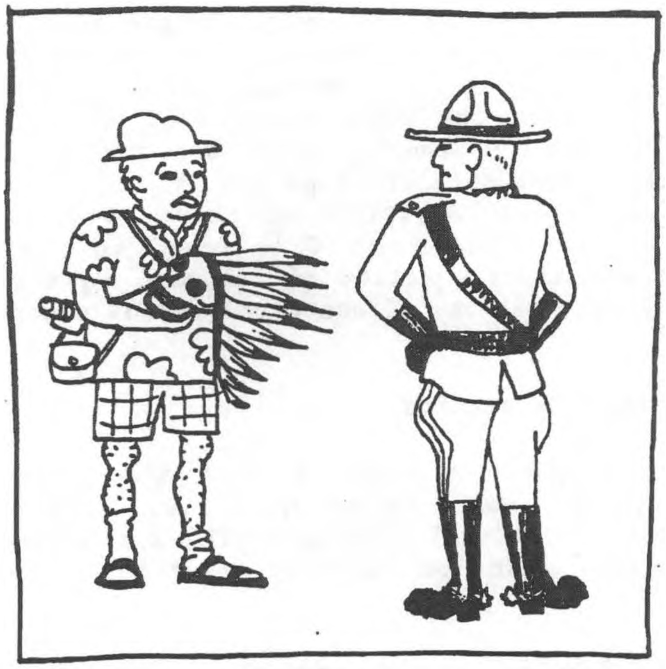
1) surface features, such as relief, vegetation type and amount, large boulders, trees, the proximity of water;

2) local climatic conditions, such as weather conditions at the time of appraisal, shaded and sunny areas, freezing altitude, recent climatic history;

3) degree of disturbance of vegetation and soil; and

4) evidence: note and mark (with taped pins or stakes) the position of surface material; do <u>not</u> collect the evidence at this time.

A paramount consideration is the need to maintain security of the site and **CONTINUITY OF EVIDENCE** recovered. Human remains are fascinating to many people, not just **FORENSIC ANTHROPOLOGISTS**. Invariably the matter of public relations and the media arises. These should be handled by the appropriate personnel. At no time should unauthorized persons be allowed to approach the site. It has proved embarrassing in the past to lose a **SKULL** to trophy hunters part way through the recovery operation.



"You mean I can't keep it?"

II. B. 3. *Establishing spatial controls*

The recovery area

In that this represents the area from which evidence is to be recovered it must be mapped. Establishing spatial controls is undertaken so as to record and reveal spatial relationships among recovered items, and between these and the immediately surrounding area. The meaning of spatial relationships, although not apparent in the field, may be even more important than the physical evidence; the most obvious example being cases of bone scattering due to animal activity differentiated from deliberate secretion of body parts over an area.

The investigating officer is likely to be faced with one of two situations: either the remains are clustered, perhaps still largely **ARTICULATED** or even buried, or the evidence is scattered and usually much more sparse. In either case the recovery area must be mapped. This is most easily accomplished in such field situations by laying out a rectangular area based on multiples of the familiar 3-4-5 triangle of high school geometry. This method starts with producing a straight base line, usually along a compass direction, of measured length exceeding the limit of the recovery area in either direction (line A-B in Fig. 5). Corner post D is found by utilizing two measuring tapes -- one each anchored at A and B. Assuming a base line of '4' units in length, point D marks the intersection of '3' units on the "perpendicular' tape and '5' units on the "diagonal" tape (or any proportional multiple of these, for example, 4, 3, 5 increased to 20, 15, 25). Point C is found in a similar fashion. Check opposite sides for equality of length. We shall now turn to mapping the two alternatives of scattered versus clustered remains.

(1) Mapping scattered remains

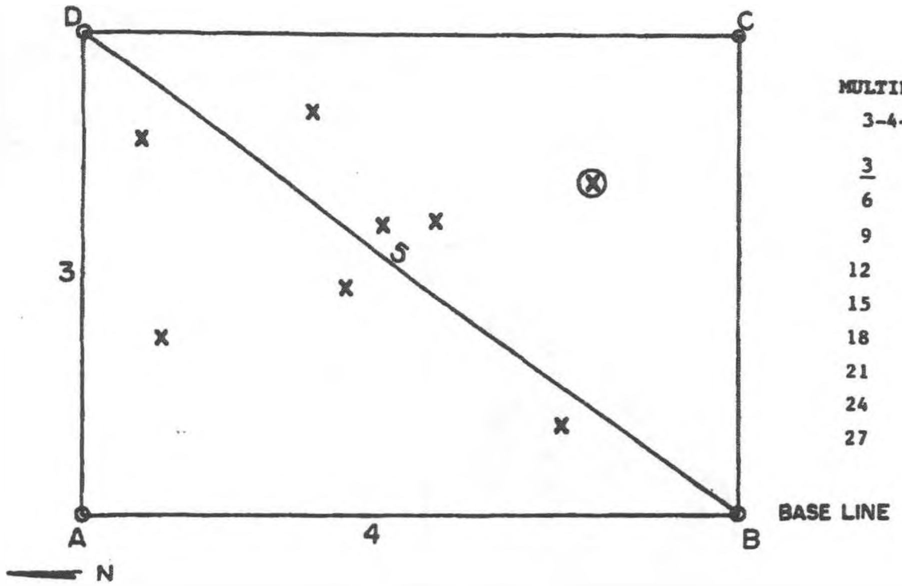
The major preposition here is that when scattered skeletal remains are encountered, there has also usually occurred a significant loss of skeletal elements. The sparsely represented and scattered skeleton can be mapped using a simple and rapid technique.[1]

Equipment required is as follows: two 50 meter tapes, a compass, four corner posts, four nails and a recording form. After laying out the basic rectangle (see above) label the corner posts A to D as shown in Fig. 5. Drive a nail partially into the centre of each post. Each tape is anchored by the pull ring to the protruding nail on each post of a side of the rectangle. The distance of an object to each of the two corner posts (Fig. 6) is read directly from each tape and recorded as follows:

OBJECT	POSTS USED	DIRECTION	DISTANCE TO POST A	B
skull	A and B	east of line	3.75 m	2.25 m

If the terrain is markedly rough or sloping it may be necessary to hold the tapes horizontal and with the aid of a plumb bob record the location of the object in both vertical and horizontal directions.

1. Technique suggested by M. Wright, Department of Archaeology, Simon Fraser University.



MULTIPLES OF BASIC
3-4-5 TRIANGLE

3	4	5
6	8	10
9	12	15
12	16	20
15	20	25
18	24	30
21	28	35
24	32	40
27	36	45

Figure 5. Laying out spatial controls for the recovery area (based on '3-4-5' triangle).

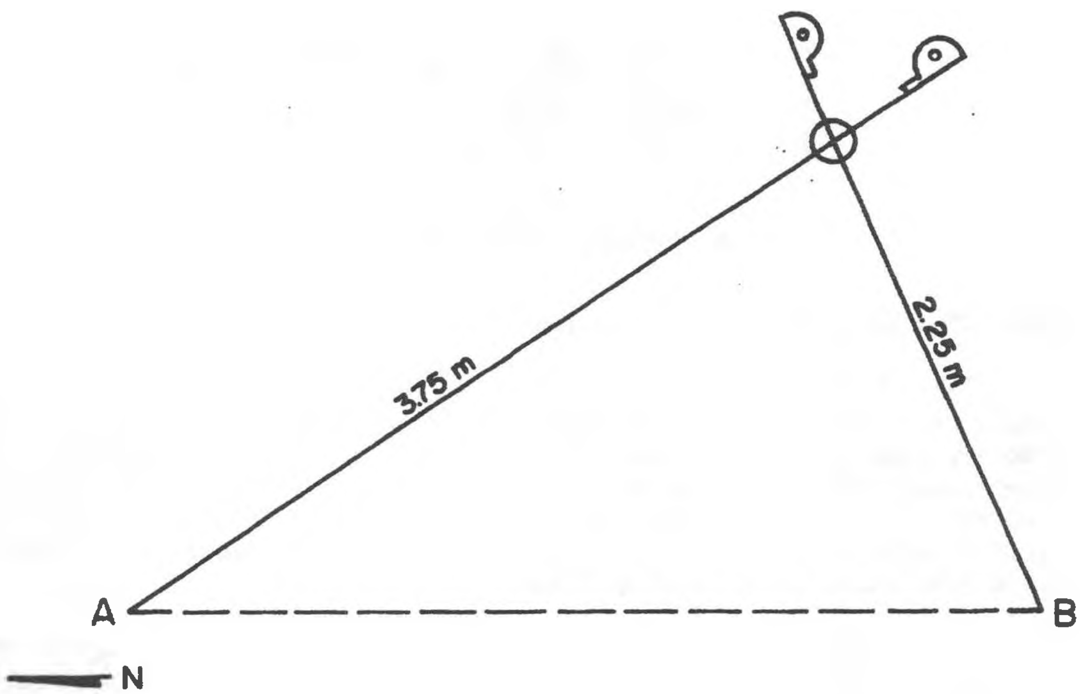
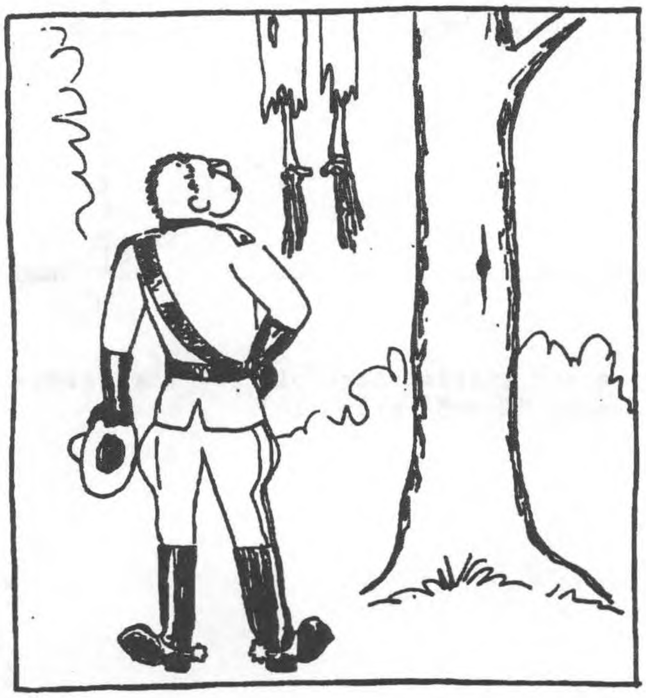


Figure 6. Recording location of objects by triangulation.

The advantage of this method is its field simplicity. The disadvantage is the necessity, back in the office, of converting the recorded dimensions into scaled equivalents for reproduction. Each pair of scaled radial distances is then drawn on a map (using a pair of compasses). The intersection of the two arcs marks the location of an object relative to the base line and to other objects.



"I'm supposed to map this?!"

(2) Clustered or buried remains

The object here is to create a mapping area surrounding the evidence. The area is gridded out into still smaller areas. This can be done either in actuality, by means of nylon string placed along each axis at regular intervals or, in effect, by laying out the relevant grid square. An object can be precisely related to the grid square by measuring it in or, roughly, by noting its presence in a particular grid square (Fig. 7).

The first question that will arise is how large an area should be mapped, particularly if the remains are not on the surface but are buried, with the orientation of the body unknown. A little thought about the general size of an adult skeleton and the chances

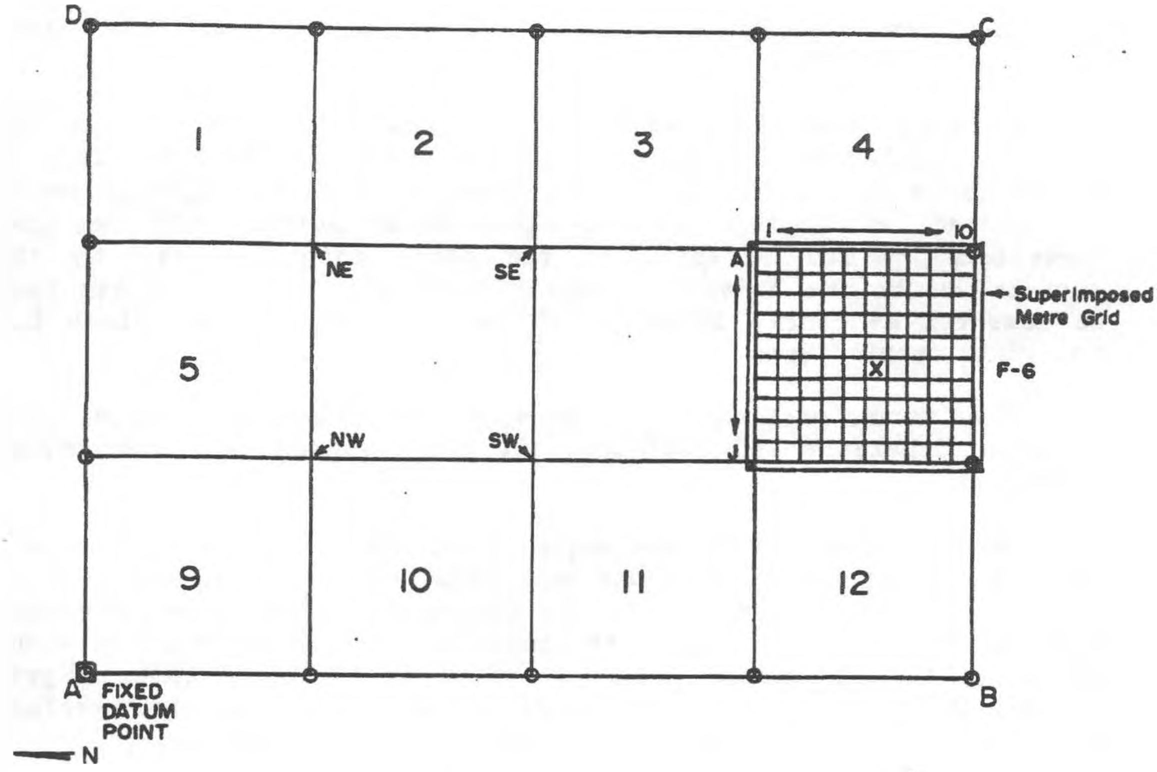


Figure 7. Grid for horizontal spatial control. The location of objects can be specified by: Major grid square (G.S.) number (e.g., G.S. 1); Triangulation to corners of a grid square (e.g., G.S. 6), and/or Reference to a particular sub-square indicated by the meter grid (e.g., F6 in G.S. 8).

of the initial discovery evidence (for example, disturbed soil or a protruding bone) being located at the extreme end of the body will indicate that a 3 x 4 meter rectangle should in most cases be sufficient. This may seem excessive but it should be noted that the whole area need not be excavated, while marking off such a generous area may serve to keep uninvolved personnel out of the way.

If, after laying out the gridded rectangular area, more evidence is noticed lying outside the grid boundaries, this can still be mapped with reference to the established grid, in the same manner as those items enclosed within it. It is not necessary to expand the gridded area. Rather it should simply be noted that **TRIANGULATION** distances to a particular object outside the gridded area have been recorded to one side (for example, west) of a grid boundary defined by a pair of posts.

Assuming that the basic rectangle has been laid out in the manner described at the beginning of this section, the first step is to designate the top of one of the corner posts (the highest one if the ground is sloping) as the **FIXED DATUM** point. All vertical dimensions -- for example, to the other corner posts, to the surface, or to the objects excavated below the surface -- can then be measured as "**DEPTH BELOW DATUM**" using a line level, plumb bob and small metric tape.

This corner post will also serve as the fixed datum point from which to demarcate and designate all grid squares in a horizontal direction.

In the basic mapping rectangle, demarcation of each grid square is at one meter intervals along each axis, which in the 3 x 4 meter case will yield 12 squares. It is recommended that non-stretchable nylon string be used, tying each length to long spikes sunk into the ground at the one meter points as shown in Fig. 7. (Note: grid strings should be placed sufficiently above the ground that surface features are not contacted and the grid remains undistorted.)

With the recovery area now marked off in one meter squares it becomes possible to record the location of surface or previously buried features precisely within a square. Two options are available depending in part on the size of the feature to be recorded and on the likely significance of its location relative to other objects. For example, with a defleshed but otherwise undisturbed skeleton composed of fairly large elements in approximate articulation it will be sufficient to measure in precisely, by triangulation within designated squares, certain key points of the skeleton (for example, head, feet and hands) and sketch in the rest of the skeleton on graph paper ruled off in the same manner as the gridded area. In this system the precise location of an object in Grid Square 6 of Fig. 7 would be recorded as follows: 6NW-35, 6NE-85 where

6 = grid square

NW = northwest corner

NE = northeast corner

35 = distance in centimeters of object from NW corner

85 = distance in centimeters of object from NE corner

Alternatively you may be faced with the need to map a highly fragmented and disturbed skeleton or a dense concentration of evidence. In such a case it is not practical to measure everything in. Rather it is easier to subdivide the relevant meter squares into smaller sub-squares -- say 10 to 20 centimeters on a side -- noting the location of each fragment within a designated sub-square. This latter procedure is most easily accomplished by utilizing a previously prepared **METER GRID** (Fig. 8) divided into 100 sub-squares by strings on a frame. The sub-squares on a meter grid are designated by letters (A-J) on one axis and numbers (1-10) on the other. In this system the approximate location of an object in grid square 8 of Fig. 7 is recorded as 8F6 where

8 = grid square number

F6 = 10 centimeter sub-square within the meter grid designated by these coordinates.

Using the latter system of rough location, should the precise spot at which a particularly significant object (for example, a bullet) is lying need to be recorded, this can of course still be done through triangulation.

The entire gridded area should be sketched and all material which has been recovered from the surface should be mapped and photographed *in situ*, including in the photograph an object which will serve as a scale (for example, a metric rule) and some indicator of which portion of the recovery area is being photographed. Fig. 9 shows a child's slate doubling as a site board.

It may be necessary, especially where long limb bones are concerned, to take more than the minimal two measurements to show the bone's location. This would entail recording each end of the bone in reference to the grid. In such cases it is important to specify which measurement belongs to which end of the bone; that is, either that end closest (**PROXIMAL**) or furthest (**DISTAL**) from the trunk of the body when in normal articulated anatomical position. Such measurements should be accompanied by a sketch showing the location of the items relative to the grid system (Fig. 10).

It is very important, in regards to scattered surface evidence, to record by photographs and notes which way up an object is oriented. This will enable the specialist examining the remains to interpret correctly the significance of soil or plant discoloration, **EXPOSURE CRACKING**, animal disturbance subsequent to death, etc. With such factors understood it may be possible to reconstruct the original position of the body.

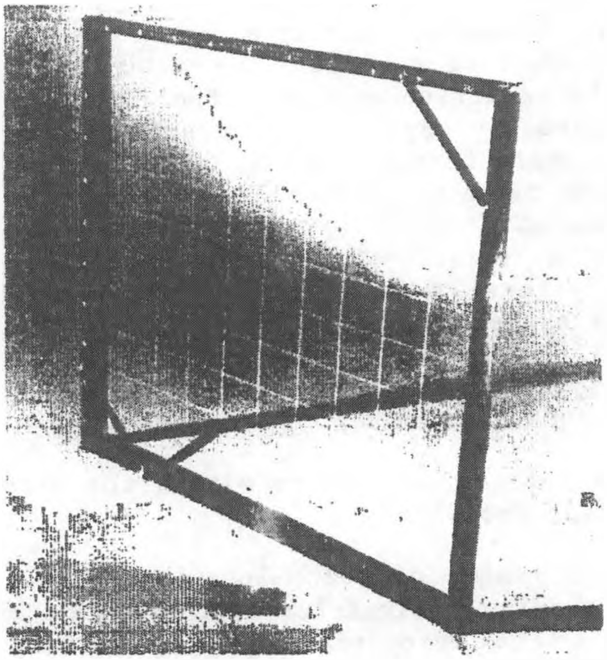


Figure 8. Meter grid. This version can be dismantled for ease of transport.

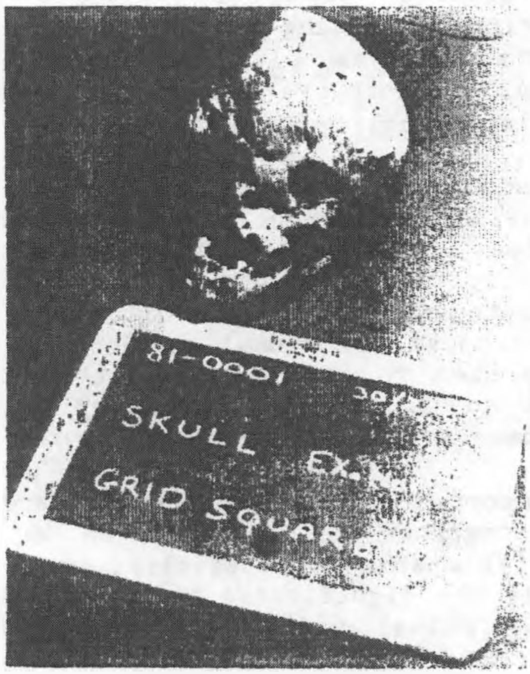


Figure 9. A simple site board (child's slate).

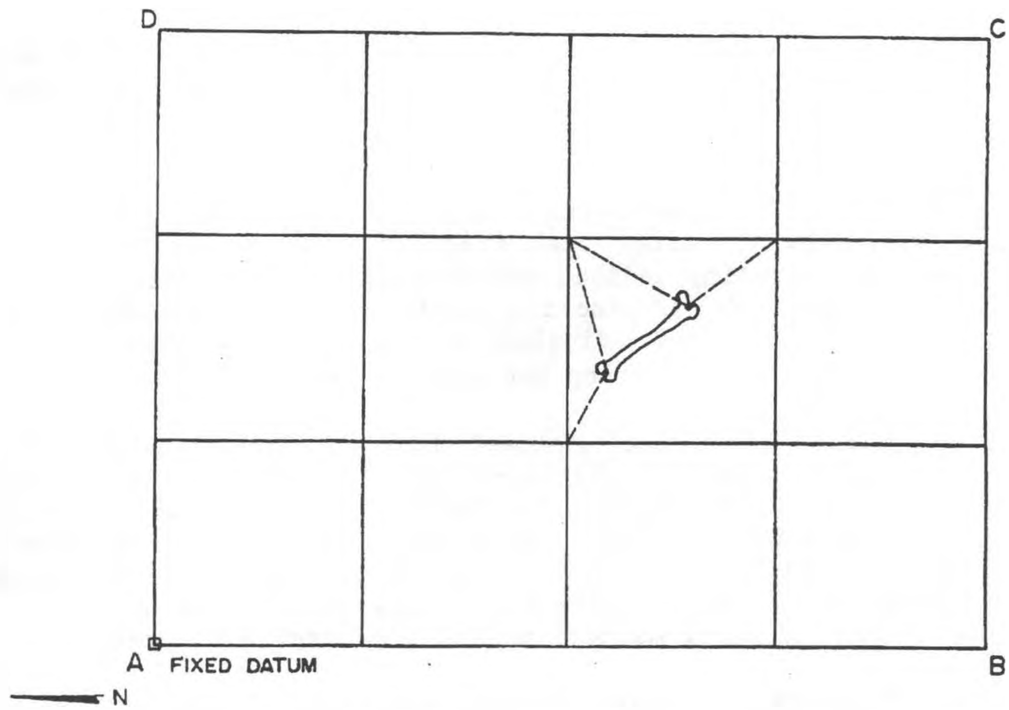


Figure 10. Recording the orientation of an elongated item.

II. B. 4. *Excavating to expose the remains*

This and the following section are primarily concerned with the excavation of buried skeletal remains. Separate descriptions of the collection and treatment of plant and insect samples may be found in Chapter V and should be consulted prior to examining the surface litter and proceeding with excavation.

Once the horizontal limits of the grave have been determined (by reference to soil colour changes, signs of disturbance, retarded/advanced or different vegetation cover, etc.) excavation can proceed. The grid system established earlier should be left intact until the end of the recovery operation.

The following points should be kept in mind while excavating:

1) All surface plant growth should be systematically removed, examined thoroughly, or screened, and samples retained in labelled containers. Any insects encountered should be saved in a like manner. This sort of evidence may be crucial for determining elapsed time since death.

2) Remove dirt systematically, one grid unit at a time, one level (for example, 10 centimeters) at a time. Avoid the temptation to dig all the way to the bottom of what seems to be the most promising area.

3) Use small implements, such as a mason's trowel, whisk broom, and/or small paint brush (Fig. 4). Do not use shovels and the like in excavating undisturbed burials as these could duplicate, and thereby preclude distinction from, implement features left at the time of the initial digging of the grave. Also, much more control can be exercised using the smaller tools.

4) All matrix (dirt) removed (except soil samples and that kept for examination for plant and insect remains) must be sieved through a fine mesh screen (preferably nylon). Each sample of matrix put through the screen should be referable to a specific grid location and depth, which will allow any physical evidence found in the screen (for example, bullets, buttons, coins, metal sherds from edges of shovels) to be mapped in with some degree of precision.

5) Excavate the grave margin carefully, as this is a likely area in which to find implement impressions should such exist. Also delimiting the size of the grave may help to indicate whether the grave digger was rushed or not.

6) The human remains may or may not be in a container (for example, plastic garbage bag). In either case, the excavator should expose the entire horizontal extent of the remains and/or container, map, photograph, sketch and make notes. (See Chapter V.C.3. on taking soil samples for pollen analysis.) At this time do not remove matrix from around the bones, nor the bones themselves.

7) If items are encountered *in situ* while excavating down to the remains, these must be mapped in three dimensions. This involves triangulation as described earlier, as well as recording the depth below datum by suspending a plumb bob, to the item in question, from a level line attached to a notched, specified, corner stake. Measure this distance.

8) Once the skeleton or container has been exposed to its full horizontal extent (while still firmly embedded in the grave fill), and the appropriate samples have been taken, a forensic anthropologist should be allowed to conduct a preliminary examination if possible. From this examination the necessity for *in situ* preservation of the bone should be determined, as well as an understanding to what to expect, and look for, when removing the bones from their matrix. Preferably, the actual removal of the

skeleton should be performed by a forensic anthropologist who would be able to distinguish any unusual aspect of the remains.

In certain situations the **SOFT TISSUES** of the body may, instead of decomposing, change into a fatty white substance (**ADIPOCERE**) (Snyder 1977) which is somewhat resistant to further decay and may act to preserve deeper tissues, such as the uterus, and wound characteristics. This process, called **SAPONIFICATION**, can be anticipated to have occurred and still be evident in the case of well-nourished bodies buried in moist soils not longer than two to three years. Such remains should be recovered intact and considered for autopsy by a pathologist.

As noted previously, certain kinds of potential evidence are not retrievable in the same sense as are bone, clothing, jewelry and the like. One type has already been mentioned -- the impressions left by digging implements in the walls of the prepared grave. It is possible that similar impressions could be found in the grave fill itself, if subsequent compaction has not been too severe. Similarly footprints may persist as impressions on the grave floor, near or under the body (Morse, Stoutamire and Duncan 1976). Accurate records of these occurrences must be obtained and casts made if possible.

II. B. 5. *Excavating to remove the remains*

The manner in which human remains are removed from grave fill will be determined by a number of factors: soft tissue preservation, body orientation (back-lying, side-lying, face-lying, **FLEXED**, **EXTENDED**), degree of articulation (wholly, partially, or disarticulated), degree of bone fragmentation, the age of the individual (that is, whether separate **CENTRES OF OSSIFICATION** are present). The difficulty of recovery is compounded if more than one individual is represented by the remains. In many such situations, participation by a forensic anthropologist, archaeologist, or doctor will be very helpful to the recovery team. The excavator should in any case be familiar with the basic form of all separate bones (circa 194 in the adult, more in the child) as well as teeth (up to 32 'permanent' teeth in the adult and up to 20 'milk' teeth in the child) so that complete recovery can be assured (see skeletal illustrations at the back of the manual).

The following are recommended points of procedure for the removal of bones of the human skeleton from a burial environment:

1) Record the positions of all bones and bone fragments as

they become exposed during excavation. When further excavation requires removal of these superficial elements put them into labelled containers bearing this information.

2) Do not use tools with sharp edges when working close to the skeleton -- a small brush and blunt plastic knitting needle will usually suffice for removing the adhering matrix and loosening the bone. Wet or damp bone, when first exposed, tends to be very soft. It would be only too easy to add marks to the surfaces of the bone at this time, which only serve to confuse the final interpretation, and may obliterate marks present on the bone as a result of fatal trauma. Do not wash or unnecessarily clean any recovered evidence, including bones. Leave such tasks for the specialist in the laboratory.

3) Do not pull bones from the dirt in which they are embedded, as this can lead to breakage. Remove as much dirt from around the bone as possible, then loosen and lift gently.

4) <u>All</u> matrix found in and around the skeleton must be screened through the fine nylon mesh. This can be done immediately by wet-sieving already damp soil (a light spray on the screen from a hose, if available) or by air-drying samples and then screening. In either case, one must consider the types of evidence (for example, paper, fragile wood) which might be damaged or lost through sieving.

5) Watch for ossification centres and **EPIPHYSES** when dealing with immature remains (Chapter III.B.1).

6) If intact, the skull should be lifted <u>with both hands</u> providing support from underneath. Place masking tape over the ear holes to prevent loss of the tiny ear bones. Watch for loose teeth -- if it appears likely that teeth will fall out during subsequent handling and transport, note their anatomical position (that is, which socket), remove and package in separate labelled containers. Treat dental appliances accordingly. Any matrix observed *inside* the skull should either be left in place (for removal under laboratory conditions) or carefully extracted and sieved through a nylon screen for evidence (for example, bullets).

7) Remove long bones carefully. Try not, at this time, to disturb the bones of the hand and wrist areas, but look for fingernails, rings, and even skin (which, like hair, can preserve remarkably well, possibly retaining the fingerprint pattern). The possiblity of evidence of an assailant (hair, fabric) in this region should not be overlooked.

8) Count and remove the ribs (12 pairs) and **VERTEBRAE** (24,

not including **COCCYX**) individually. Due to their position in the body and their relative fragility, ribs may bear evidence of fatal assault (for example, stab wound to the neck or chest).

9) When removing such items as the skull, pelvis, and shoulder blades be aware of the possible preservation of soft tissues (hair and skin) or clothing between these bones and the underlying earth.

10) All previously disturbed earth beneath the body or skeleton should be screened through the fine nylon mesh to sufficient depth below the disturbed level; remember that, beneath the body, evidence of an unsuspected container may yet be preserved. Recently we have seen an archaeological example of a double burial in which a two year old infant was buried right on top of a fetus.

It must be admitted that in the case of burials, police most often have to recover already badly disturbed remains (for example, heavy equipment has pushed the skeleton into view and dumped the remains in a great pile of earth). In such cases the first effort should be to locate any undisturbed areas, and excavate these properly. The dirt pile also should be examined most carefully, however daunting and tedious this may be. Most contractors will have the interest and equipment to help put together a lean screen (Fig. 11). This is one situation where use of shovels is an acknowledged necessity. A surprising volume of dirt can be screened and the results will often be rewarding. For example, single-rooted front teeth (**INCISORS** and **CANINES**) almost inevitably fall out of a skull that is rolled any distance, and yet these teeth are often indicative of race, particularly in native Canadian burials (usually but not invariably archaeological).

II. B. 6. *Cataloguing, packing and transport*

Identifying marks should not be placed directly on the bone at the time of recovery. Each bone or fragment should be packaged separately and each package identified both inside and outside, with the contained object's precise origin recorded. The size of the container should reflect the dimensions of the item within.

Non-skeletal items are treated using standard procedure for such evidence (for example see Geberth 1983). Samples for plant and insect analysis are handled in special ways described in Chapter V.

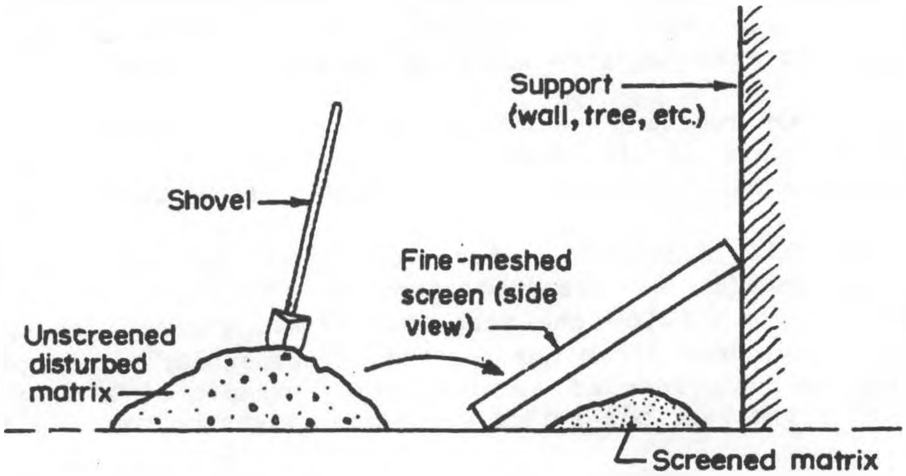


Figure 11. A lean screen, useful for rapid examination of disturbed matrix.

II. C. Timetable

The amount of time required for recovery will of course vary tremendously depending on such factors as site accessibility, weather conditions, availability of personnel and equipment, and skill of the recovery team. Since most human remains have been in the ground long enough for soft tissues to decompose, there is likely no rush.

One day should be allowed to reconnoiter the area and to make preparations. A second day may be necessary for establishing spatial controls, mapping and recovery of all surface materials. Our experience suggests that an additional two days should be allowed to excavate properly and to recover a skeleton in a container or discernible grave.

As a final note on recovery, it must be remembered that all excavators are expected to backfill (that is, fill in the holes they have created) and generally tidy up the disturbed area. Such an effort reflects good public relations.

CHAPTER III

Identification and Individualization

III. A. Rationale

The basic, but by no means only, question asked of skeletal material is "Who was this person?". Answering the question is usually done in two steps: **IDENTIFICATION** and **INDIVIDUALIZATION.** The first term is misleading and the second, obscure, and so are elaborated upon below.

Identification

Here the forensic anthropologist looks at the bones and teeth for characteristic inherited features or basic biological traits which indicate sex, age at death, race, and stature. With these determined he can narrow the range of possible persons from whom the remains derive to a small, but still numerous, subset of the whole population (for example, "a white male, 20-25 years old, 5 feet 8 inches to 6 feet 2 inches tall . . .").

To this 'police blotter' description may be added more or less accurate estimations of time elapsed since death and whether there is evidence of long distance travel of the body from some other locale (typically by water). This important information can only be obtained through careful observation of the find locale, noting contextual relationships such as distance from high water level of nearby creeks, rivers or lakes, and local environmental factors such as moisture, plant cover and insect infestation. Thus one might be able to add to the above description ". . . who died approximately

12 to 18 months ago, likely a considerable distance upstream from the find locale."

This completes the first phase of the forensic anthropologist's examination. The specialist should then provide the contributing law enforcement agency with this basic information for matching with records of missing persons. Often there will be one or two such persons who closely match the remains.

Incompatability with one of the diagnosed characteristics of the remains and that of a missing person is quite possible especially with respect to stature, less so in terms of race (but certainly if the remains were very fragmentary). Most forensic anthropologists will not mind advising the investigating officer on the relative imprecision or certainty of a particular interpretation. It is then up to the investigating officer to obtain as much premortem information of the kind likely to be preserved in hard tissues, concerning those missing persons. These premortem records can then be compared with information about the "individual" characteristics of the remains, derived from the second phase of analysis. (Chapter III.C. describes a variety of useful premortem records.)

Individualization

As is well known, no two individuals are identical, not even "identical" twins, if one looks closely enough. In terms of skeletal material, uniqueness, while not preserved to the same degree as in the whole body, is potentially there to be seen for a variety of reasons. Basic is the individuality derived from the unique combination of circumstances affecting the growing and adult human form during the individual's lifetime. For example, the minutiae of detail seen in premortem bone radiographs (x-ray pictures) have been successfully compared by specialists for matching traits in postmortem radiographs of the same bones (Fig. 12). Thus a person can acquire novel traits of the hard tissues, or modify inherited ones in sufficient number and in such combinations that they are virtually, if not absolutely, unique to that individual. The prime example of this is **DENTAL RESTORATIONS** (Gustafson 1966). A successful identification may involve several exchanges of information between the detachment and the forensic anthropologist as the list of matching missing persons is progressively reduced.

In summary, all people possess two identities: the **BIOLOGICAL IDENTITY** defined by age, sex, race and stature; and the personal

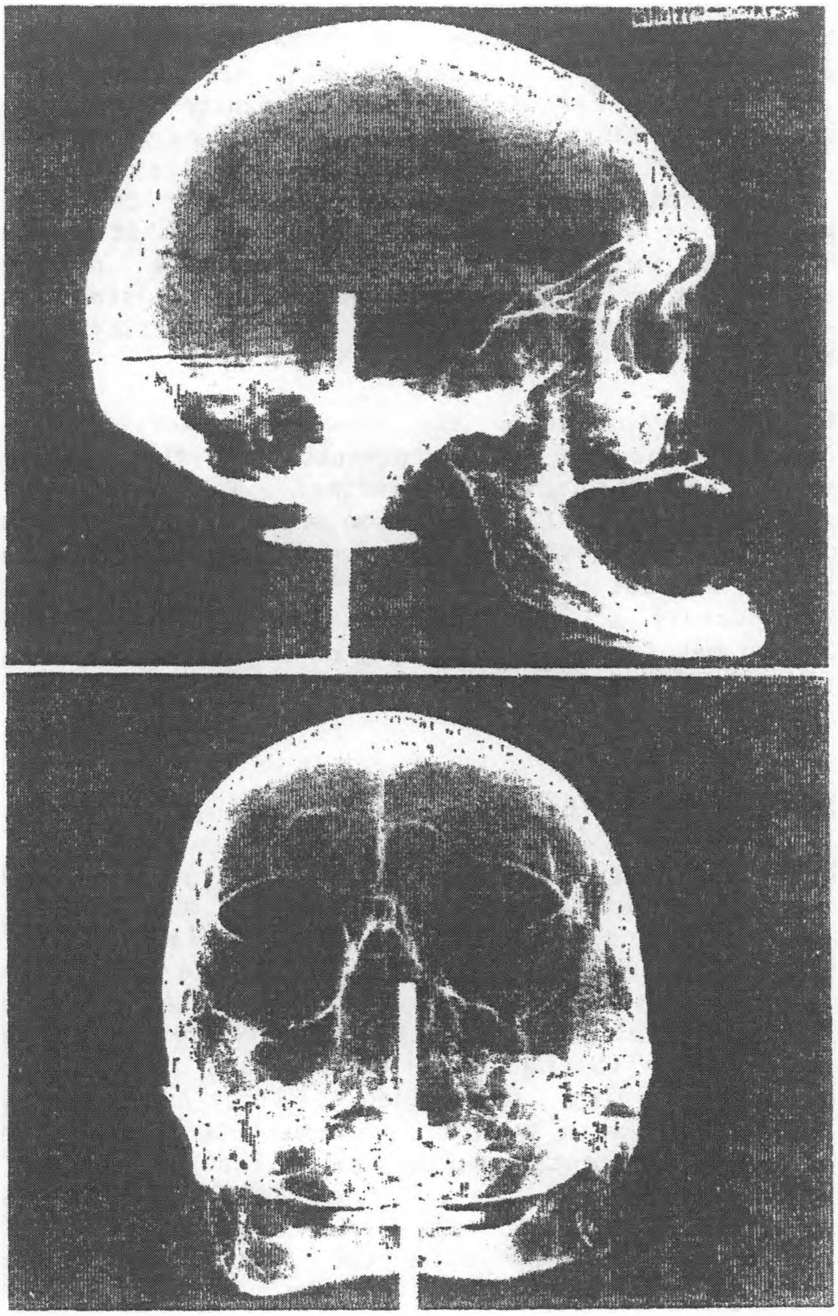


Figure 12. Radiographs showing individualizing features of the cranium: a) lateral view showing the distinctiveness of the external cranial contour, b) anterior view showing the distinctiveness of the flocculations forming the frontal sinus pattern (Case 81-29).

identity, the embodiment of which is the individual's name. In the case of **SKELETONIZED** remains or those which have been rendered visually or otherwise unidentifiable (for example, burned or mutilated), the process of identification proceeds from establishing the biological identity to determining the personal identity. The former provides the investigating officer with suggested possibilities and probabilities regarding the latter. The actual conclusion as to personal identity requires that the investigator possess some manner of premortem record or **IDIOSYNCRATIC** observation to which can be compared similar postmortem records or observations. (In the case of the **FETUS**, identity is derived from the parents.)

The methods by which the specialist derives the biological identity are necessarily determined by the completeness and condition of the recovered remains. The following discussion however, will consider the situation where the entire human skeleton is potentially retrievable. The techniques are described for two reasons: to emphasize the necessity for controlled, systematic and complete recovery of the remains, with associated materials, and secondly, to make the investigating officer appreciative of what the forensic anthropologist can and cannot do even with well-recovered remains.

III. B. Biological Identity

There are four basic aspects to biological identity -- age, sex, race, and stature. The accuracy with which these are determined reflects, firstly, the reliability of the methods employed to derive them, and secondly, the completeness of the remains. Thus the skull is less trustworthy as an indicator of sex than is the pelvis. Additionally, the reliability of a particular technique varies with changes in one or more of the basic biological characteristics being determined. For example, methods for revealing age at death tend to provide more accurate estimates for children and adolescents, while the reliability of sex and racial diagnoses increases with age to a maximum for adults. As well, age and stature are highly correlated during infancy and childhood and one can be used to estimate the other. The assumptions and limitations of each method will not be discussed in detail; rather their significance with respect to proper recovery technique is emphasized.

III. B. 1. *Age*

When dealing with unidentified remains, the forensic anthropologist cannot determine true or **CHRONOLOGIC AGE**, which is an attribute of the personal identity accorded great significance by society. Rather the specialist determines the maturational state of the remains, deriving a **PHYSIOLOGIC AGE** to which, on the assumption that the person is not abnormal but fairly typical, an equivalent chronologic age is assigned. The difference between chronologic and physiologic age increases from conception to old age, due to the interaction between the individual's genetic make-up and his or her developmental environment. However, because of this variation it is imperative that the recovery be complete so that all skeletal and dental elements which show progressive changes with increasing age can be used to derive the final estimate of age at death.

Over the years, standards of tissue maturation during growth and adulthood based on samples of normal individuals of known age have been developed. These "**NORMATIVE STANDARDS**" allow skeletal and dental material to be assigned an age with known degrees of precision. This precision varies with the tissue and region studied, for any given age group. Table 1 provides a list of suitable hard tissue criteria applicable to particular age categories in order of their reliability (1 is best, 2 is less so, etc.). Some comments regarding a few of these methods, with excavation procedures in mind, should be made.

DENTAL FORMATION (Fig. 13) provides a highly accurate age estimate up to adolescence. It is not necessary that the teeth be retained in their sockets to derive the estimate. If teeth are obviously missing (that is, if the root sockets are empty) every effort should be made to recover them. Since teeth grow from the crown to the root, the root portion on forming teeth is very fragile. The teeth of infants and **PERINATAL** remains are very small and demand a discerning examination of the matrix or place of deposition.

OSSIFICATION is the process in which bone forms directly or by replacing cartilage during growth. The skeleton is formed from **PRIMARY** and **SECONDARY** centres of ossification (Fig. 14). Primary centres grow to become the major bones of the skeleton and small isolated bones of the extremities. Secondary centres (epiphyses) form near the growing ends of major bones. Primary and secondary centres ultimately fuse together with the cessation of growth in a particular area.

The order of appearance of ossification centres and their subsequent growth changes are good indicators of age in younger children. This applies particularly to the hand and wrist region for which various standards are available. For these standards to be of use in finding the age of a skeletonized individual, it is essential

TABLE 1

Relative Accuracy of Age Indicators by Age Category

	Perinatal	Birth To Puberty	Adolescence	Young Adult	Mid-Adult	Old Adult
Dental formation	1	1	2			
Limb bone length	2	3	3			
Ossification	3	2				
Dental eruption		4	4			
Epiphyseal fusion			1	1		
Pubic symphysis changes				2	1	
Dental attrition (wear)				3		
Dental microstructure					2	1
Bone microstructure					3	2
Degenerative changes						3
Suture closure						4

that the separate ossification centres be correctly identified. This can be most reliably done by noting the physical relationships among the centres prior to their recovery. To the inexperienced they will appear as small nodules of bone of irregular shape. Extreme care in their recovery is necessary for they can be easily overlooked.

Epiphyseal **FUSION** can be a reliable age indicator for adolescents and young adults. An epiphysis represents a secondary centre of ossification and can be found at either end of long bones, many of the hand and foot bones, the collarbone and others. Fusion is the process by which cartilage separating a major bone from an epiphysis is replaced by bone thereby "fusing" the two together.

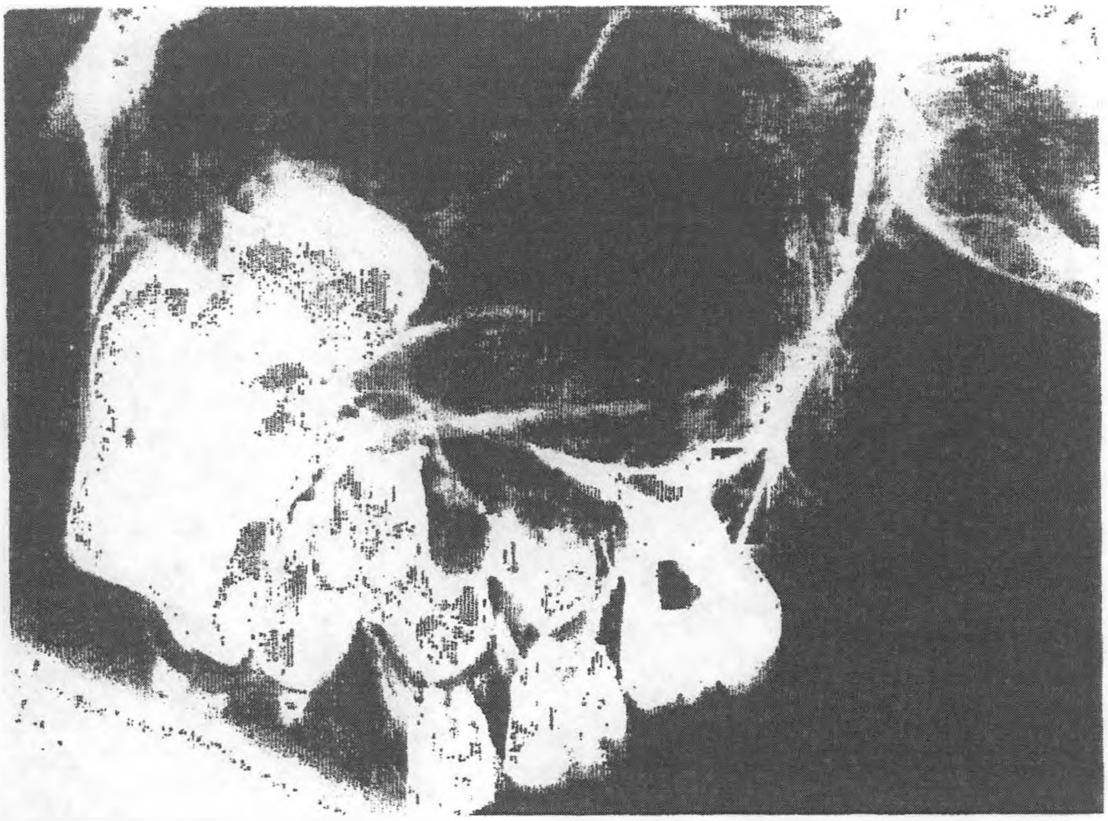


Figure 13. Lingual (tongue) view of right upper jaw. This is a child aged 5 years, 7 months showing erupted, unerupted and forming teeth -- all very useful age indicators for this age category (Case 80-2, North American native male).

Standards for finding age from epiphyseal fusion are based on the degree of fusion and therefore when excavating it is imperative that bones with epiphyses be handled with care. Rough handling can break off an epiphysis especially during the early stages of fusion.

Determining the age of adults is more difficult. Useful in males up to the age of 40 years is the progressive remodeling of the facing surfaces of the pubic bones of the pelvis where they meet in the mid-line (PUBIC SYMPHYSIS) (Stewart 1979). Another technique for determining age relies on the changes in microstructure of long bone shafts (Thompson 1979) and teeth (Maples 1978) as seen in thin-sections viewed microscopically (Fig. 15). Less reliable indeed, but nevertheless of some value in age estimation of older

Figure 14. Hand-wrist ossification in a six year old boy. Note the four carpal (wrist) centres of ossification and various unfused epiphyses.

Figure 15. Photomicrograph of cross-section from left femur. (Case 81-4, 56 year old male). Detailed are the Haversian system and other microstructural components used as age indicators: 1) Haversian system (= secondary osteon), 2) Osteon fragment, 3) Circumferential lamellar bone.

adults, are skull **SUTURE** closure (Workshop 1980) and degenerative osteoarthritic changes (Fig. 16).

Assuming the recovery of relatively complete remains, the imprecision of an age estimate increases from a matter of weeks at birth to more than a year during middle childhood; two to three years during adolescence; five to ten years in young adults and finally one to two decades in old adults.

III. B. 2. *Sex*

From the viewpoint of identification, diagnosis of the sex of the skeletal remains will substantially reduce the number of people from whom the remains might have come. An experienced forensic anthropologist can often determine sex of the remains in the field, particularly when dealing with pronounced skeletal expressions of male or female. However such immediate knowledge of sex is seldom required or warranted and a thorough laboratory analysis is recommended.

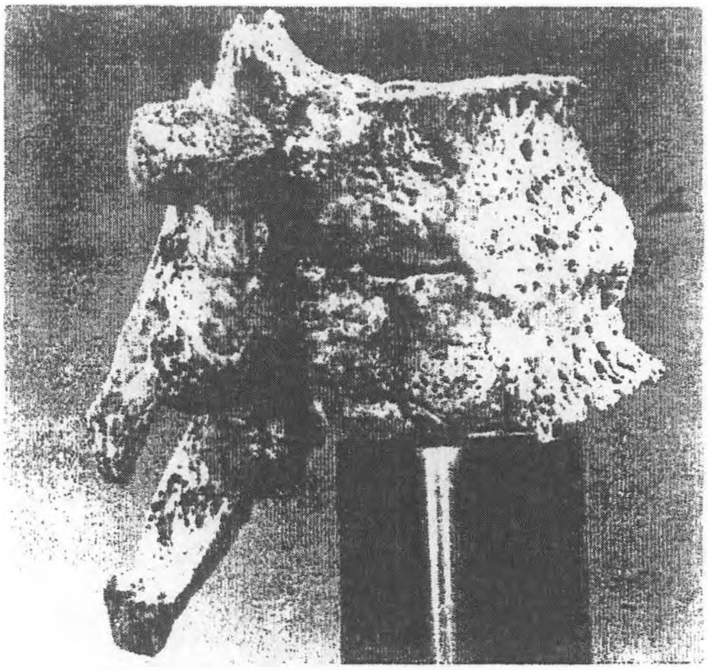


Figure 16. Advanced arthritic lipping of vertebrae. This has lead to fusion of thoracic vertebrae 8 and 9. (Case 81-4, subject medically examined for back pain some years prior to death.)

Many techniques and criteria for finding the sex of a human skeleton have been proposed. The best are those based on the pubic portion (Os pubis) of the pelvis which is modified for childbirth in mature females (Fig. 17). It is generally agreed, however, that the probability of correct sex determination from a **MORPHOLOGICAL** and/or **METRICAL ANALYSIS** of the adult (that is, post-pubescent) skull and pelvis, considered together is on the order of 95 percent. The pelvis preserves relatively poorly whether it is on the surface or buried. When only the skull or other non-pelvic skeletal elements are recovered, sex determination is less accurate and the analyst must consider how racial and idiosyncratic factors affect the degree to which sex is marked, or disguised, on the skeleton. Table 2 (after Bass 1971, Krogman 1962 and Stewart 1979) lists some of the traits used in determining the sex of the male skull, and by exclusion, the female (see also Fig. 18).

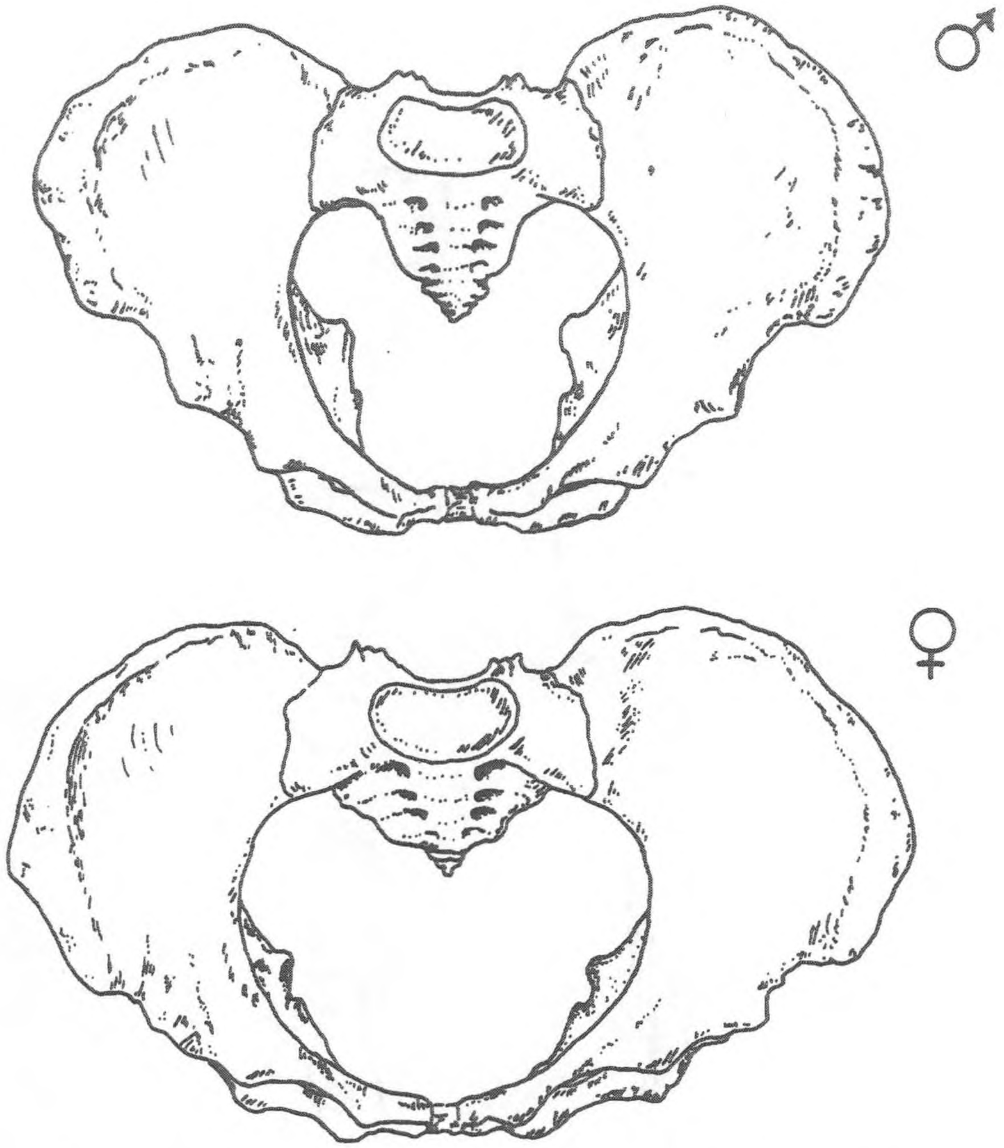


Figure 17a. Sex differences in the pelvis, superior view of pelvic girdle. Note that the pelvic opening is heart shaped in males due to encroachment by bony processes while in the female the opening is more oval and open for childbirth. (From W.M. Bass (1971), *Human Osteology*, Missouri Archaeological Society, Columbia, Missouri, used with permission of author and publisher.)

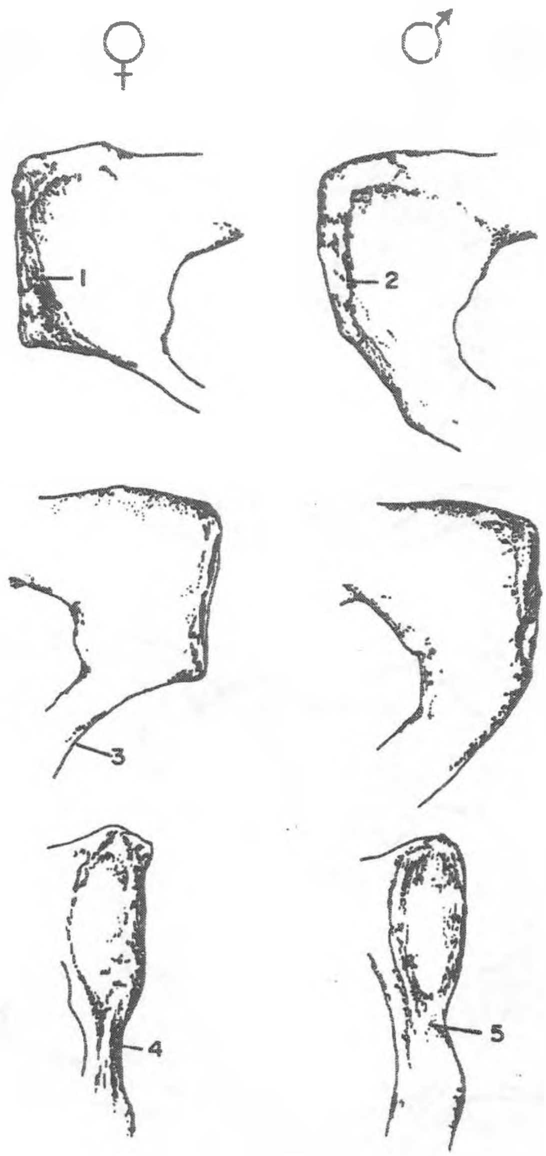


Figure 17b. Sex differences in the pubic bone. Note in the ventral view (at top) that the ventral arc in the female (1) is more distinct and directed more sideways than that of the male (2). The middle pair of figures shows the presence of a subpubic concavity in the female (3) and its absence in the male. The final pair shows that the facing surface in the mid-line below the pubic symphysis (medial aspect of ischio-pubic ramus) is thin and ridged in the female (4) but thick and rounded in the male (5). (From Phenice, T.W. (1969). A newly developed visual method of sexing the Os Pubis. *American Journal of Physical Anthropology* 30:297-302, used with permission of Alan R. Liss, Inc.).

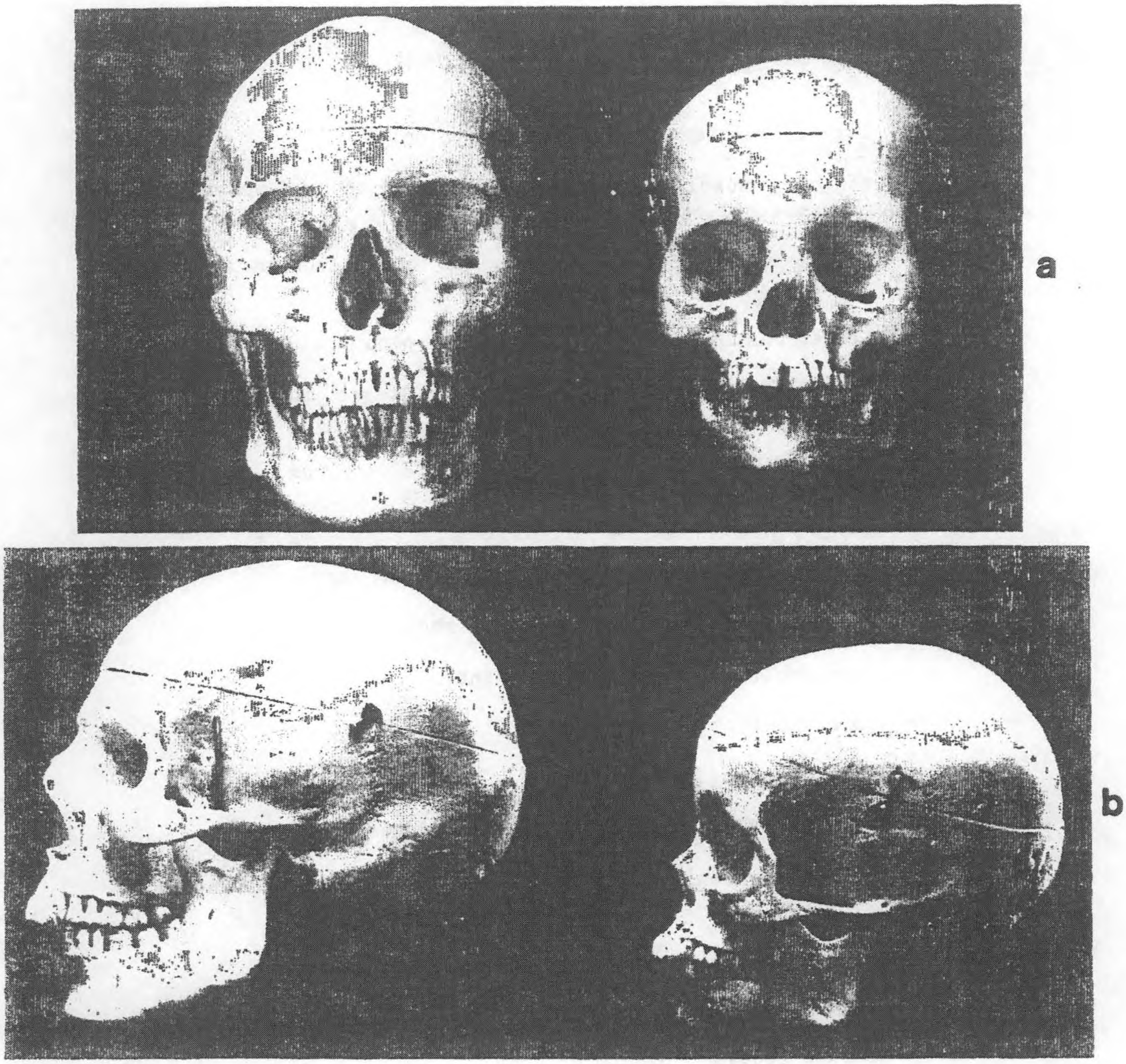


Figure 18. a) Frontal view of a male (left) and a female skull.
b) Lateral view of a male (left) and a female skull (see also Table 2). Sex differences are more marked in these specimens than is usual.

TABLE 2

Traits* of the Male Skull

CRANIUM

- larger, heavier with thicker vault walls
- rougher, muscle markings more pronounced (temporal lines, supramastoid crest, nuchal lines)
- larger cheek bones and occipital condyles (where backbone joins base of skull)
- larger mastoid process and external occipital protuberance
- foramina in skull base tend to be larger and base is more "sculptured"
- foramen magnum (between occipital condyles) more oval
- larger sinuses, teeth and palate
- orbits tend to be rectangular, less circular
- supraorbital margin rounded, not sharp
- supraorbital ridges often present
- no frontal or parietal bossing
- more receding forehead
- nasal sill is sharp, with pronounced nasal spine
- nasal root tends to be larger (not in natives or orientals)

MANDIBLE

- larger overall
- chin area squared off, perhaps double-pointed
- corpus (body) tends to be deep
- ascending portion (ramus) higher, broader
- eversion (out turning) of the angles of the jaw
- pronounced coronoid processes

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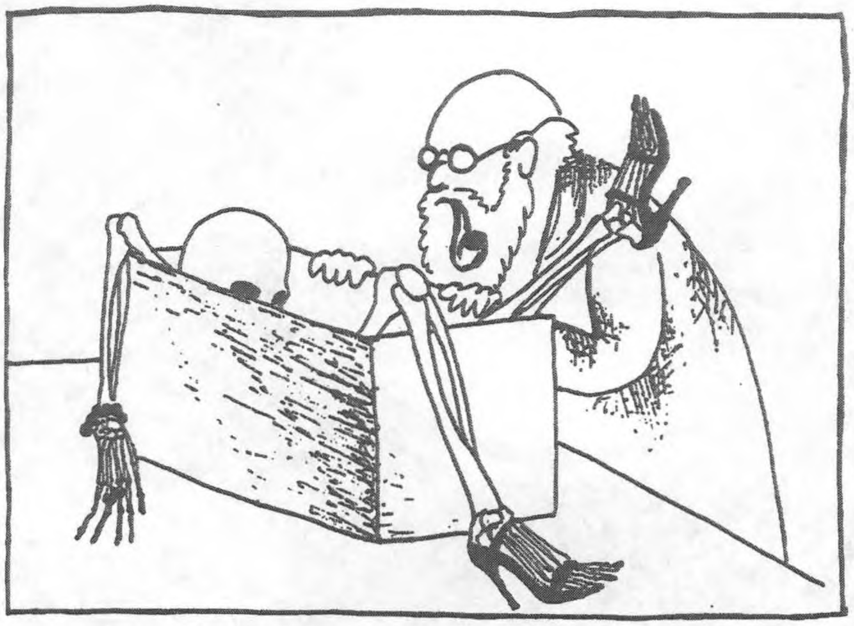
* Many of the anatomical terms used here are defined in the Glossary.

It should be mentioned that sex is not strongly expressed on the skeleton until puberty, when changing hormonal levels produce secondary sexual characteristics in the maturing skeleton.



"Hmm... sexing this is going to be a problem."

Some individuals acquire indirect skeletal indicators of sex. For example, habitual pipe smoking may produce a distinctive wear pattern on teeth or dentures. A person's occupation, for example, heavy manual labour, may leave a clue to sex on the bones in the form of strong muscle attachment areas. As well, both the investigating officer and the forensic anthropologist should look for non-skeletal indicators of sex; for instance, wedding bands and **INTRAUTERINE** contraceptives (Fig. 19).

III. B. 3. *Race*

The determination of race is a significant and justifiable pursuit when identification is sought. The subject of what constitutes a race is a large and justifiably difficult one. There are both biological and social definitions of race. For our purposes it may be sufficient to appeal to the reader's own sense of the meaning of the term noting that 'class' differences, a term sometimes used by the police as synonomous with race, is more specifically directed at expressing ethnic (cultural) differences. Thus the forensic anthropologist uses the term race in a very broad

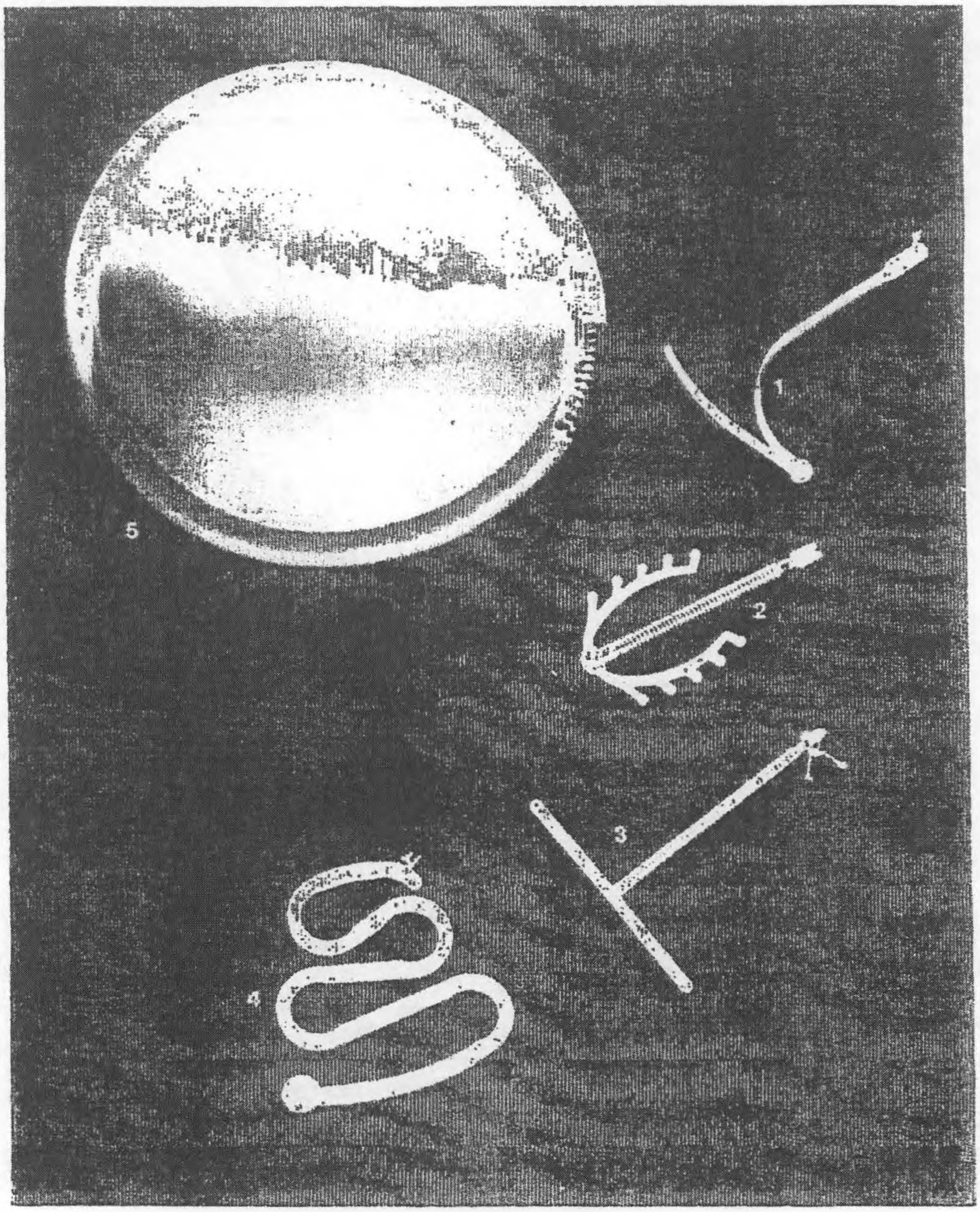


Figure 19. Sample of contraceptives used by females. Roughly 10% of females of reproductive age employ such contraceptive devices which may be preserved with skeletal remains.
Intrauterine: 1) Cu 7, 2) Multiload Cu 250, 3) Gyne-T, 4) Lippes Loop
Extrauterine: 5) Diaphragm (cut area exposes spring).

sense to differentiate what are commonly known as white, black, and yellow racial stocks. The physical differences implied by these terms are noted solely for the purposes of identifying human remains. Establishing race from the hard tissues is tenuous at best, and the excavator should always attempt to locate samples of hair and skin in areas where these tend to preserve (for example, where head and shoulder blades contact the ground, and in closed hands).

Techniques for estimating race from skeletal material are almost all based on observations and measurements of the skull and **DENTITION**. Table 3 provides a rather uncritical list of such traits for the three major racial stocks. Metrical techniques for determining race from skulls are described in Giles and Elliot (1962). Their accuracy appears to diminish when applied to Canadian Natives.

No single trait denotes race and not all traits are equally diagnostic. Few physical anthropologists would feel comfortable assigning race at a finer level than one of the three major racial stocks. The problem is compounded by racial admixture (crossing of racial stocks). Most studies of racial differences in the skeleton relate to American Blacks and Whites. Little work has been done in this area on Canadian natives, and on differentiating them from Japanese or Chinese Canadians, or even from Whites.

A few of the traits listed in Table 3 involve structures which are either very fragile (**NASAL SPINE**, cheekbones) or easily separated from the rest of the remains (upper incisors). Obviously, great care in skeletal recovery is demanded.

III. B. 4. *Stature*

Taller people owe their height in part to longer legs, which usually are associated with longer arms. Reliable estimates of stature are based on the observed relationship between the length of particular lower or upper limb bones and overall height. Standards have been derived and mathematical formulae made available which utilize the lengths of one, or preferably more, complete long bones to predict stature.

The most commonly used standards for predicting stature have been usefully summarized by Trotter in Stewart (1970). This publication provides formulae and tables describing the relationship between stature and length of each of the individual long bones from the arm and leg amongst various racial stocks and for both sexes. As well, the techniques for measuring the bones are described. The

TABLE 3

Criteria[1] of Race in the Skeleton

AREA/TRAIT	CAUCASOID Northern European derived White	NEGROID American BLACK	MONGOLOID Canadian INDIAN[2]
General Impression	rugged and ovoid	smooth and oval	smooth and rounded
Neurocranial Vault			
Length	long	long	long
Breadth	narrow	narrow	broad
Height	high	low	middle
Sagittal contour	round	flat (post-bregmatic depression)	arched
Forehead	sloping	steep	--[3]
Occipital profile	rounded	very rounded	angulated
Nuchal muscle	strong	slight, variable	moderate
Face			
Breadth	narrow	narrow	very wide
Height	high	low	high
Profile	straight	prognathic	middle
Brow	"beetling" glabella	smooth	--
Orbit	(tri)angular	rectangular	rounded
Interorbital	narrow	wider	--
Cheek bones	receding	--	broad, wide, outwardly sloping
Nasal opening	narrow and high	wide and low	narrow and high
Nasal root	deep	--	--
Nasal bones	salient	less so	very salient
Nasal spine	strong	small	--
Sub-nasal margin	sharp	guttered	sharp
Palate shape	narrow	wide	fairly wide

TABLE 3 (continued)

AREA/TRAIT	CAUCASOID Northern European derived White	NEGROID American BLACK	MONGOLOID Canadian INDIAN[2]
Miscellaneous Traits			
Femur	antero-posteriorly rounded, twisted	straight, flat untwisted	--
Dental	--	crenulated enamel	incisor shovelling

1. Criteria from teaching materials prepared by Dr. T.W. McKern, from Krogman (1962), and Stewart (1979).

2. The following traits, while not always present in native skulls, are frequently observed in combinations of two or three traits. In conjunction with those listed above, they are useful indicators of race: slit-like skeletal ear opening, **TYMPANIC DEHISCENCE**, mandibular torus (raised bony ridge on inside of lower jaw below teeth). In archaeological specimens of native Indians, squatting facets at the ankle joint, strong dental wear, and a **MYLOHYOID BRIDGE** are commonly observed.

3. -- = unreported.

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investigator should predict stature from the single bone or combination of bones which is known to have the smallest range of variability. Not surprisingly the best combination from which to predict stature is from the leg (femur and tibia).

Additional standards are available from which the preserved lengths of broken long bones can be used to predict total bone length and from which, in turn, an estimate of stature can be obtained (Steele in Stewart, 1970). The latter estimates are obviously less reliable.

Stature estimates are only accurate to within 12 to 20 centimeters (5 to 8 inches) with 95 percent confidence depending on race and sex. Even these are useful, especially if the predicted stature is quite tall or short. In one of our cases a complete skull and a portion of the **FEMORAL** shaft (thigh bone) were recovered. Stature was estimated from predicted total bone length to be between 6 feet and 6 feet, 3 inches but with a reliable error range of 5 feet, 8 inches to 6 feet, 9 inches. A search of missing persons records for the area yielded only one individual close to the indicated height -- 5 feet, 10 inches. A positive identification was obtained from this person's dental records matched to the recovered skull.

III. C. *Personal Identity*

Having established the biological identity, more or less reliably, determination of the personal identity can be attempted. This involves comparing even more detailed observations of the remains with premortem records from each individual whose bones these might be. This "short list" is usually obtained from the missing persons file of the local law enforcement agency, extracting only those who, should they be dead, have been missing sufficiently long that their bodies could be decomposed to the extent seen on the remains *and* who exhibit the appropriate biological characteristics of age, sex, race, and stature.

IT IS STRONGLY RECOMMENDED THAT WHENEVER A PERSON IS REPORTED MISSING, THE LOCAL LAW ENFORCEMENT AGENCY COLLECT ALL PREMORTEM RECORDS FOR SECURE STORAGE UNTIL SUCH TIME AS MATCHING REMAINS MAY BE FOUND. Dental and hospital radiographs often are not saved for more than two years after an examination.

The information from which personal identity can be determined is derived from two sources: directly from the remains themselves and, more rarely, from associated materials either unique to the individual or identifiable by family or friends as belonging to the individual. These sources are dealt with separately below.

Lack of positive identification is usually due, not to the uninformativeness of the remains, but to the absence of suitable and detailed premortem records. Transients passing through an area and meeting their death may go unidentified. Their absence from home will not likely have been reported and certainly there will be no premortem records held locally. Only widespread dissemination of the description of the remains provided by a forensic anthropologist can help to solve this problem. It is the investigating officer's responsibility to search for premortem records as widely and as far back in time as possible.

There is a rich variety of premortem records: medical/dental records and charts, dentures, clinical and dental radiographs, insurance medicals, military service documents, photographs, portraits, school health reports, worker's compensation files, police booking records, and even recollections by family members and associates. Some chiropractors record useful information on the timing and extent of injuries, particularly to the spine. On occasion, dental casts of living close relatives (for example, a **SIBLING**) may be useful for comparison of genetically controlled dental characteristics.

The results of such a comparison between pre- and postmortem records will yield one of several possible conclusions. These are: 1) inconsistencies are such that the suspected identity is repudiated; 2) lack of both correspondences and inconsistencies does not show one way or the other if the remains pertain to the missing person, 3) some consistencies are evident but are insufficient proof of identity; or 4) consistencies are present in such a variety and degree that identification is positive.

It must be emphasized that not always is a host of detailed correspondences between the remains and premortem records necessary for a positive identification. This situation arises when the list of locally missing persons is very small and the remains show a significant correlation with one distinctive individual. For example, in one case the remains were diagnosed as those of a native child, likely male, who died five to ten years previously, at the age of 5.6 +/-0.8 years (ascertained from tooth formation as seen radiographically). Only one such child, a native boy aged 5.62 years, had been reported missing eight years before. The correspondences, though few, were such that a positive identification was justified and the case closed.

In that techniques and expertise for complete skeletal recovery are available, failure to establish the identity should never be due to poor recovery methods. We recently had a case where a virtually complete skeleton, wrapped in a blanket, was encountered in a newly-extended graveyard! Between discovery and recovery the skull disappeared, along with, in this case, any chance of positive identification.

III. C. 1. *Individuality in Skeletal Remains*

To the uniqueness inherent in the hard tissues of all individuals (for example, extra teeth or **FRONTAL SINUS** patterns) may be added acquired features which in combination render the remains unique. Foremost among the latter are dental restorations and extractions which provide the majority of positive identifications in general forensic cases. Other sources are physiologic and pathologic insults to the body (for instance, **GROWTH ARREST LINES** in bones and teeth, osteoarthritis), non-pathologic trauma (for example, premortem fractures), operative procedures (plastic surgery, amputations), and habit or occupation (either of which may reflect socio-economic status of the individual).

How many characteristics of an individual have to be determined in order to distinguish that person from all others? Fingerprint specialists claim 6 to 16 correspondences between a suspect's print and that found at the scene of a crime are sufficient to indicate they could only have come from one person. Forensic odontologists have developed a similar approach based on details of dental work (Keiser-Nielsen 1980).

All positive identifications in the forensic sciences, whether of fingerprints, teeth, bullets or handwriting, are based on showing that the combination of identifying variables exhibited by an object renders that object unique and distinguishable from all other like objects in a defined parent population. There are two essential ingredients here: *variables which occur jointly* and a *parent population of finite size.*

Now consider the task of the investigator of a fingerprint left at a robbery or a bite mark left on a victim. After the contact leaves its trace, the finger or mouth moves on to rejoin a huge universe of like objects. In this situation, where the parent population remains so large as to be virtually without bounds, a positive identification can only be had by demonstrating that the particular combination of many variables (such as minutiae of ridge characteristics) is a unique occurrence. The presence of any one variable is assumed to be independent of any other variable, such that the investigator can find the probability of the variables occurring jointly by multiplying their individual frequencies of occurrence (expressed as a decimal) together. For example, 12 independent characteristics each of which occurs in fewer than 1 in 4 persons, say, will have a joint probability of co-occurrence in $(1/4)^{12}$ cases; i.e., 1 in 17 million persons approximately. So in all of Canada, with a population of 25 million, the investigator would expect only 1 or 2 instances of such a combination of variables. This "multiplication rule" is valid only for independent variables whose joint occurrence is purely a chance event. Fingerprint identification is based on this assumption. Emphasis is on finding a lot of rare variables while the parent population is treated as virtually infinite.

Now consider the case of a plane crash where, despite the usual loss of all identifying ridged skin characteristics, bodies are still able to be identified positively. This is possible because, even though the identifying variables may be few (say a healed fracture and a caesarian scar) and even though they are not independent (e.g., both the scar and fracture are sex-linked) their occurrence jointly, in a person of the right sex, age and so on is unique since the size of the parent population is limited to the crew and passengers. Here, emphasis is on the parent population.

III. C. 2. *A New Approach to Human Remains Identification*

The authors wish to advocate a new strategy for obtaining a positive identification of skeletonized human remains. This approach which uses joint probability is summarized in the following pages. We feel that the method is explicit and statistically defensible permitting the investigator to gauge the probability that a positive identification is correct. For the approach to work, the forensic anthropologist has to have the cooperation of the police.

In order to obtain a positive identification, fundamentally the investigator has to be able to determine:

a) the size of the parent population from which the remains have to be distinguished;

and

b) the probability with which an observed number of identifying variables will occur in combination.

So for example let us say the police have found a skeleton and it has been studied by the forensic anthropologist, who has shown the skeleton exhibits a particular combination of potentially identifying features. In addition, this postmortem information matches, with no inconsistencies, a premortem record from a person the police think could represent the remains. How can the forensic anthropologist know if this is likely to be a positive identification? Now if there are only a limited number of dead persons, say 1000, who could have contributed the remains (=the parent population) and if it can be shown that the particular combination of identifying variables can be expected to occur in let us say less than 1 in 1000 persons, then the forensic anthropologist can make a statistically logical argument that the premortem/postmortem match is probably a positive identification. In fact, the degree of probability can be stated as described below.

Forensic anthropologists appear to have been reluctant to attempt positive identifications because apparently it was felt they had knowledge neither of the size of the parent population nor of the frequency of the identifying variables, whether considered singly or in combination. This is a misconception nurtured by the prevailing lack of communication between the police and the forensic anthropologist. The police, naturally enough, look upon identification problems from the 'fingerprint' point of view, where the source of the evidence usually remains a part of a large universe of like objects -- the general population. Death and decomposition, however, irrevocably remove the source of the evidence -- in this case a person -- from the general population to a *much* smaller population of dead persons most of whom will be described by the *list of missing persons*. In British Columbia, for example, with a population of 2.7 million, only 967 were reported missing as of December 13, 1982. Since we can safely assume that the fraction of the missing persons population which is not dead but is simply "runaways" exceeds the unknown number of unreported dead, the size of the missing persons file will be a generous overestimate of the size of the parent population from which a single skeleton must be distinguished.

We can now turn to the second and more difficult requirement for obtaining a positive identification of a skeleton, that of predicting the probability with which a number of identifying variables will occur in combination. If all our variables were *independent* of each other we could simply proceed to multiply together the frequencies with which each variable is known to occur singly, to find the joint probability. Unfortunately, the data base of identifying variables available to the forensic anthropologist contains *dependent* variables such as age and sex, where for example, if one is very old one is more likely to be female. Similarly, stature is dependent on age, sex and race. To handle this problem the forensic anthropologist has to be able to treat linked (dependent) variables as a single unit; i.e., he has to be able to observe, not predict, what proportion of the parent population shows a particular combination of age, sex and so on. This information cannot be obtained from general census data because the missing persons population is a biased selection from the general population; composed, at least in British Columbia, of more males, more young adults, more non-whites and so on. But remarkably, and fortunately for forensic anthropology, the vital information on dependent variables *is* contained in the missing persons file where age, sex, race, stature, time and locality of disappearance are usually noted. The forensic anthropologist must have access to the *composition* of the missing persons population in the area so as to be able to assign a frequency figure to the combination of dependent variables observed on the remains.

The forensic anthropologist will collect data on three sorts of identifying variables: 1) *independent* single traits such as the interval of time when death occurred; 2) a core group of highly correlated variables as noted above which are *dependent* on each other, particularly age, sex, race, stature and locale, which must be treated as a single entity whose frequency of occurrence cannot be predicted but must be observed from analyses of the missing persons file; and, 3) variables which while dependent on variables of age, sex, race and locale are, otherwise, *independent* of other such variables. To illustrate this last group of variables we can imagine a skeleton which shows arthritis of the spine, a healed fracture of the left wrist, a naturally missing wisdom tooth and size ten boots. Manifestly, while backache and foot size are independent of each other they are not independent of age and sex. Thus, the forensic anthropologist will have to collect epidemiological data on the incidence of variables like broken left wrists in samples where age, sex, race and locality are known.

It should be stressed that incidence data, such as 1 in 17 males has broken his nose at some time, are necessarily derived from a sample other than the sample which contributed the remains. It must be made an explicit assumption that the incidence of the identifying variable will be the same in both samples. This judgement can be questioned by the police or the courts and can be defended by the experienced forensic anthropologist on the grounds that there is no reason to suspect otherwise.

The approach to human remains identification advocated here is summarized below and illustrated in Table 4 using a fictitious although realistic example.

The method may be summarized as follows:

1. Collect postmortem data -- male, white, 35 to 55 years old, who died more than 1 but less than 2 years ago in the Lower Mainland of British Columbia and who shows arthritic changes in the back, a well-healed fracture of the left wrist, a missing wisdom tooth and has size ten boots.

2. Obtain a complete missing persons record for at least the province or state so as to determine: a) a maximum size for the parent population from which the remains have to be distinguished (=967); and, b) the size of that portion which shares the dependent traits of age, sex, race and locality (n=54).

3. Collect epidemiological data on the relevant independent

variables (see above) in terms of that portion of the general population of 35 to 55 year old white males from the Lower Mainland who show them (=.65, .043, .20, .35).

4. Find portion of missing person population which disappeared 12 to 23 months ago (=.27).

5. Find joint probability (p) of independent traits co-occurring in a single individual by multiplying their individual incidences together (.65 x .043 x .20 x .35 x .27 = .00053, or once in 1893 persons).

6. The number of persons in the residual parent population which can be expected to show the observed combination of independent variables is found by multiplying n x p = λ = 54 x .00053 = .029; i.e., much less than a single instance.

7. Assuming that one has found a match between the postmortem evidence and a premortem record, the probability that this is a positive identification (where λ = .029) can be found from Kingston's equation: $1 - \lambda/4 = 1 - .007 = .993$ (Cullason 1969).

8. Thus, one can go to court and argue on explicit grounds that, in this case, the probability that the remains are from a suspected person is more than 99%.

Please note that we have presented above only an overview of a method (Skinner 1983) which we hope will come to be recognized as a useful technique for obtaining positive identifications of human remains. For the approach to work the police must provide the forensic anthropologist with access to the composition of the missing persons file for the area.

III. C. 3. *Indicators of identity in associated materials*

Apart from recovery of physical (non-skeletal) evidence of a criminal act such as bullets and cartridge cases, complete excavation may result in the retrieval of other non-skeletal items which can provide a positive identification.

Such artifacts may be clinical (e.g., hearing aids, heart pacemakers, dental or surgical applicances, female contraceptives, glasses, contact lenses) or they may be identifiable by relatives or associates (e.g., clothing, pocket contents, jewelry). Furthermore, in certain circumstances, it is conceivable that calcified organ contents (for example, gall stones), fetal remains **IN UTERO**, or

TABLE 4

Human Remains Identification from Joint Probability

Postmortem Observation	Variable	Premortem Incidence[a] (Missing persons = 967)
	Core Group of Dependent Variables	
Male	SEX	
35 to 55 years old	AGE	N = 54, from analysis of missing persons file
White	RACE	
Lower Mainland	LOCALE	
	Independent (but linked to core group)	
Back arthritis	PATHOLOGY	.65[b]
Healed break, left wrist	MEDICAL PROCEDURE	.043[c]
Missing wisdom tooth	MORPHOLOGY	.20[d]
Size ten boots	ARTIFACT	.35[b]
	Independent*	
12 to 23 months ago	DEATH INTERVAL	.27

CALCULATIONS

1. Joint probability ($p = .65 \times .043 \times .20 \times .35 \times .27 = .00053$).
2. Residual parent population (N) = 54.
3. Frequency with which identifying variables predicted to occur in combination ($\lambda = N \times P$) = $54 \times .00053 = .029$.
4. Probability of positive identification[e] = $1 - \lambda/4 = 99.3\%$.

NOTES

a. Unless otherwise specified, data are from Canadian Police Information Centre (CPIC), December 13, 1982.
b. Arbitrary over-estimate.
c. Hamilton (1982).
d. Pedersen (1949) in Bass (1971).
e. Cullason (1969).

*see footnote at end of chapter

other organic matter (for example, hair, skin, nails, stomach contents, FECES) might be recovered.

In our experience completely skeletonized remains which have not been exposed for more than six months will be found still associated with head hair; which after all is a dead tissue resistant to decay. Hair has a number of obvious characteristics (colour, length and curl) which taken together are quite personal.

*Strictly speaking, while elapsed time since death is largely an unpredictable interval of time deriving from (usually) accidental death and accidental discovery of the remains and thus is an independent occurrence, the missing persons file contains a number of young "runaways" whose elapsed time since'death'(=disappearance) is dependent on variable of age. Consequently it is more feasible to treat elapsed time since death as a dependent variable as in the 'core' group of traits from Table 4.

CHAPTER IV

Manner and Cause of Death

Forensic anthropologists normally deal with bodies devoid of flesh. The evidentiary universe available to them is circumscribed. Nevertheless some deaths, such as stabbings or shootings, leave evidence of the nature of that death on the bones. Forensic investigators have found it necessary to distinguish between cause and manner of death (see Adelson 1974, for a clear discussion of these important concepts). Briefly, *manner* of death describes whether death was due to homicide, suicide, accident, misadventure, or natural causes. Death due to disease is natural while being mauled to death by a bear is accidental. The *cause* of death is the trauma, disease or event which commences the physiological processes culminating in death. Landing at the foot of the stairs can be the cause of death. The fact of being tripped, rather than tripping, is the manner of death.

We can illustrate the use of these terms by reference to the somewhat decomposed body of an adult male found at the side of a road. The torso appeared to have been chewed by a bear. The head was shattered and upon cleaning and reconstruction showed the presence of loose lead shot plus lead fragments embedded into the lower left facial bones. It seemed likely that the shooting preceded the bear activity. Consequently the cause of death was judged to be a shotgun blast. An informant readily admitted to shooting his friend, claiming that as he was driving down the road in his pick-up with his friend in the passenger seat, they spotted some game on the right hand side of the road. The driver grabbed his gun, leapt out of the left side of the truck and, leaning over the box behind the cab of the truck, aimed his shotgun over the box. The passenger got out and started to walk forwards towards the back of the truck receiving the shotgun charge, accidently according to the driver, in the head. Reconstructing the event indicates the victim would, if walking as claimed (forwards), have been shot in the right side of the head. The embedded lead shot shows that the victim was shot in the left side of the face. The evidence indicates that the manner of death might have been homicide rather than an accident. The accused evidently thought so too, for when presented with the contradiction in his story, he pleaded guilty to a more serious charge.

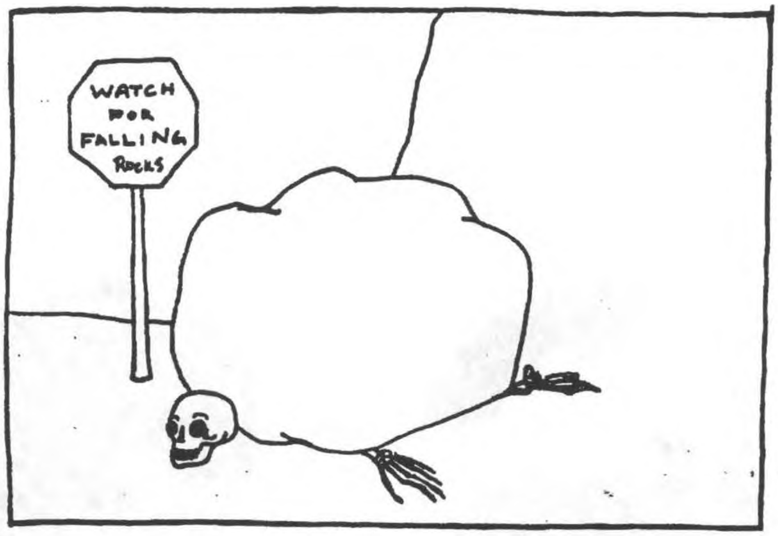
Pathologists rarely need to obtain a clear picture of what trauma to bone looks like. Examination of the soft tissues is usually sufficient to indicate the cause of death. Certain causes of death, however, will tend more frequently to confront the forensic anthropologist, for example, cremations and drownings. In the latter case, it may be possible to determine when the body was deposited on the shore by reference to annual flood records (Wilson 1980).

Murderers often attempt to hide or destroy their victim's body. Some suicides retreat to secluded spots. Outdoor deaths due to accident or exposure are not uncommon. In all these cases the bodies are not likely to be discovered until skeletonization has occurred, in which event the forensic anthropologist should become involved in the identification process.

One case will suffice to illustrate the quality of detail regarding cause and manner of death which may be available to the forensic anthropologist.

Fig. 20 diagrams the manner of skull breakage in a suicide mouth shot using a 20 gauge Cooey shotgun carrying slug shells. The lower jaw (and neck, not illustrated) were unbroken while there were two main damaged areas on the cranium: mid-face and top of the skull. The crucial evidence is not the complete cracks but the incomplete cracks, both shown as dotted lines in the figure. Observe their symmetry and that seven of eight incomplete cracks commence inferiorly in the mid-facial region, propagate upwards and peter out (observations by J. McKendry). These cracks indicate that the initial impact by the slug was the mid-face, not the top of the skull.

A final example of how cause of death can be recorded on the bones is afforded by cases of child battering (Kerley 1978). Happily, we have not encountered one of these but the forensic anthropologist should be able to recognize the characteristic pattern of trauma recorded on the skeleton of the battered child. In one study (Akbarnia et al. 1974) of 231 battered children in Philadelphia only 34 percent showed fractures, the most common sites of which were ribs, long bones, and crania. Of critical importance to the forensic anthropologist confronted with a skeleton containing broken bones (which could be due to one of a number of causes) would be the recognition of healed and partially healed premortem fractures in such sites and incidence as to arouse suspicion of battering (Kempe et al. 1962).



"Context is an important clue to cause of death."

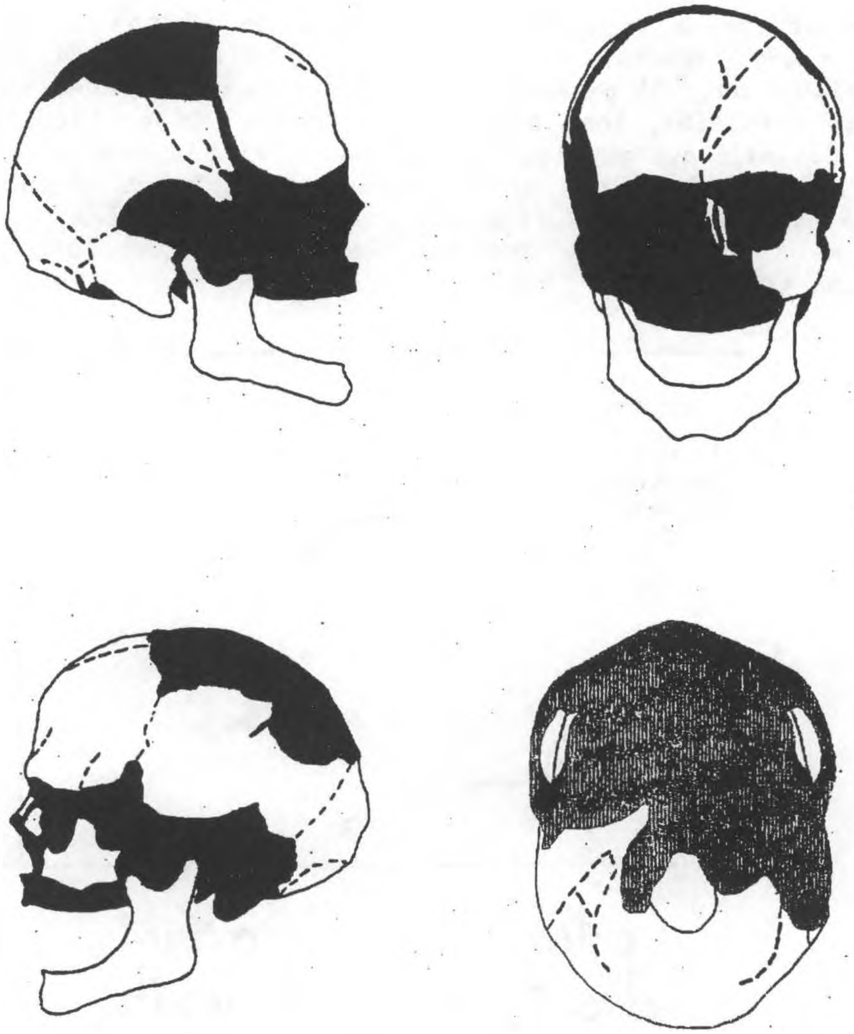


Figure 20. Firearms trauma to skull (20 gauge Cooey shotgun slug shell fired into roof of the mouth); blackened areas were not recovered, dotted lines signify complete and incomplete cracks.

CHAPTER V

Elapsed Time Since Death: Contextual Evidence for Interpretation of Postmortem Events

V. A. General Considerations

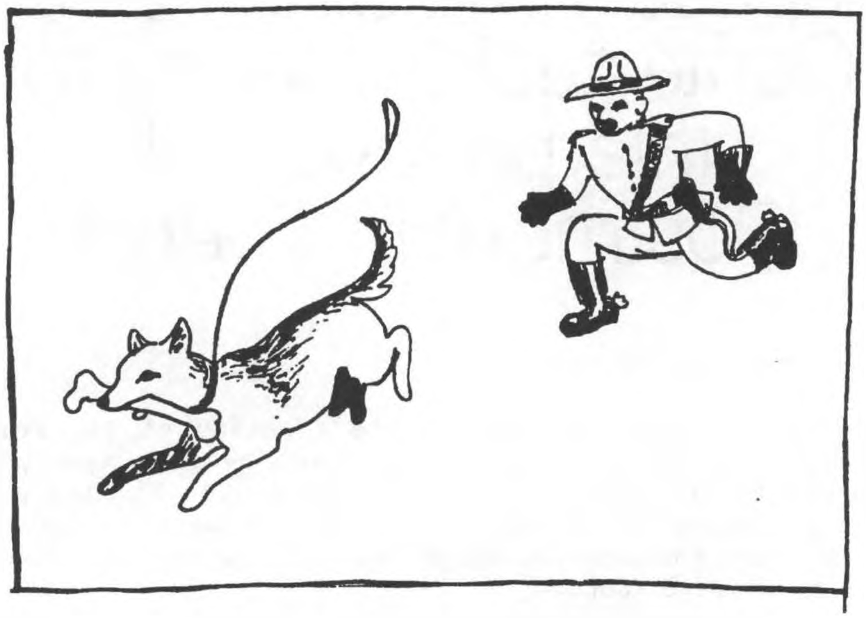
Not only are we interested in the identity of the remains, we wish to know when and where death occurred, by what agent, and what has happened to the remains subsequent to death; knowledge of which will help interpret the former questions. Answers to some of these can be had from the remains alone but the essential evidence lies where the bones were found.

The distribution of skeletal material can often suggest the kinds of variables which have acted on the body since death. Much surface skeletal material has been transported from the immediate locale of death by such agents as gravity, snow melt, water flow, and animal activity. Impediments to transport, such as heavy brush, must also be considered.

Generally speaking, observations should be made of slope, terrain, type and extent of vegetation or other cover, flood zone, river or creek flow rate throughout the year, prevailing temperature and moisture (for example, snowfall) conditions, annual temperature and precipitation ranges, altitude and freezing levels, leaf litter and shade.

Further observations should be made of bone "scatter" as some bone shapes are more easily moved (skull) than others (shoulder blades). Also one should look for evidence of animals (paths, tracks, SCATS, burrows, nests, gnawings, scratching, and rubbing) which could disturb or partially destroy the remains. Such evidence might be found in, or near, trees (porcupine, eagle) or in the ground (gopher, coyote).

Recent experience has shown that at least in our area (British Columbia) animals play a more significant role in events leading to death or, more usually, subsequent to death than previously suspected. Two cases illustrate this.



A male suicide whose death occurred more than a year prior to discovery in the bush had had in his possession a red handkerchief with a floral design. This was recovered from an animal (likely bear) scat, which had been dyed a colourful red from the dye seeping into the scat in which the handkerchief was incredibly wadded. The question arose as to when during the previous year the handkerchief had been swallowed. How long can a scat last and what kind of animal was involved? Interestingly, there were what appeared to be perforations from bear claws in one boot. The tearing pattern in the leather suggested this event occurred when the leather was soft and slightly rotted from moisture; i.e., significantly after death. Presumably then this animal activity, which was not recorded on the bones in any way, occurred at the same time as the eating of the handkerchief.

The second case involved a very elderly lady who wandered away and whose clothes, including an identifiable hearing aid, were found three and a half months later. The only human bone recovered was a small fragment of tibia, consistent in its microstructural characteristics with being from an aged human, likely female. This was found in a scat identified by the investigating officer as probably from a "big cat". If it had been possible to photograph and collect the scat without deforming it, then the species of animal might have been determined. It seems unlikely that cougars or bob cats would scavenge a dead body but there are documented instances of cougars attacking humans. Thus, if the animal scat could have been identified, it might have been possible to determine the manner of death.

Both cases illustrate well that all scats, whether known to contain evidence or not, should be carefully recorded and collected without cleaning for forwarding to a luckless specialist for examination.

The forensic anthropologist can, but should not always have to, infer the presence of animals in the recovery area from chew marks on the bones. We recall one case in which a skull was diagnosed as having been peppered with buckshot from at least two directions. This conclusion was derived from observation of numerous partial or completely penetrating similar-sized holes in the bone. Closer examination revealed these to be puncture marks from the canine teeth of a bear, nibbling on the head of the (presumably) dead individual (Fig. 21).

Environmental variables explain not only the current disposition of the remains, but also, most importantly, they may aid in interpreting the rate of DECOMPOSITION, as a clue to elapsed time since death.

The context of buried remains which, if not archaeological strongly suggest criminal activity, should be documented as carefully as surface material. For recent burials a fairly close approximation of the elapsed time since death may be possible (up to about three years in such a 'closed' environment) if observations are made of soil type, compaction, root penetration, overlying vegetation type and degree of cover, surface features such as hollows, depth of burial and so on.

The most useful indicators of season and elapsed time since death in both surface and buried remains are insect, POLLEN, and plant remains. Consequently we have dealt with these in greater detail below.

a

b

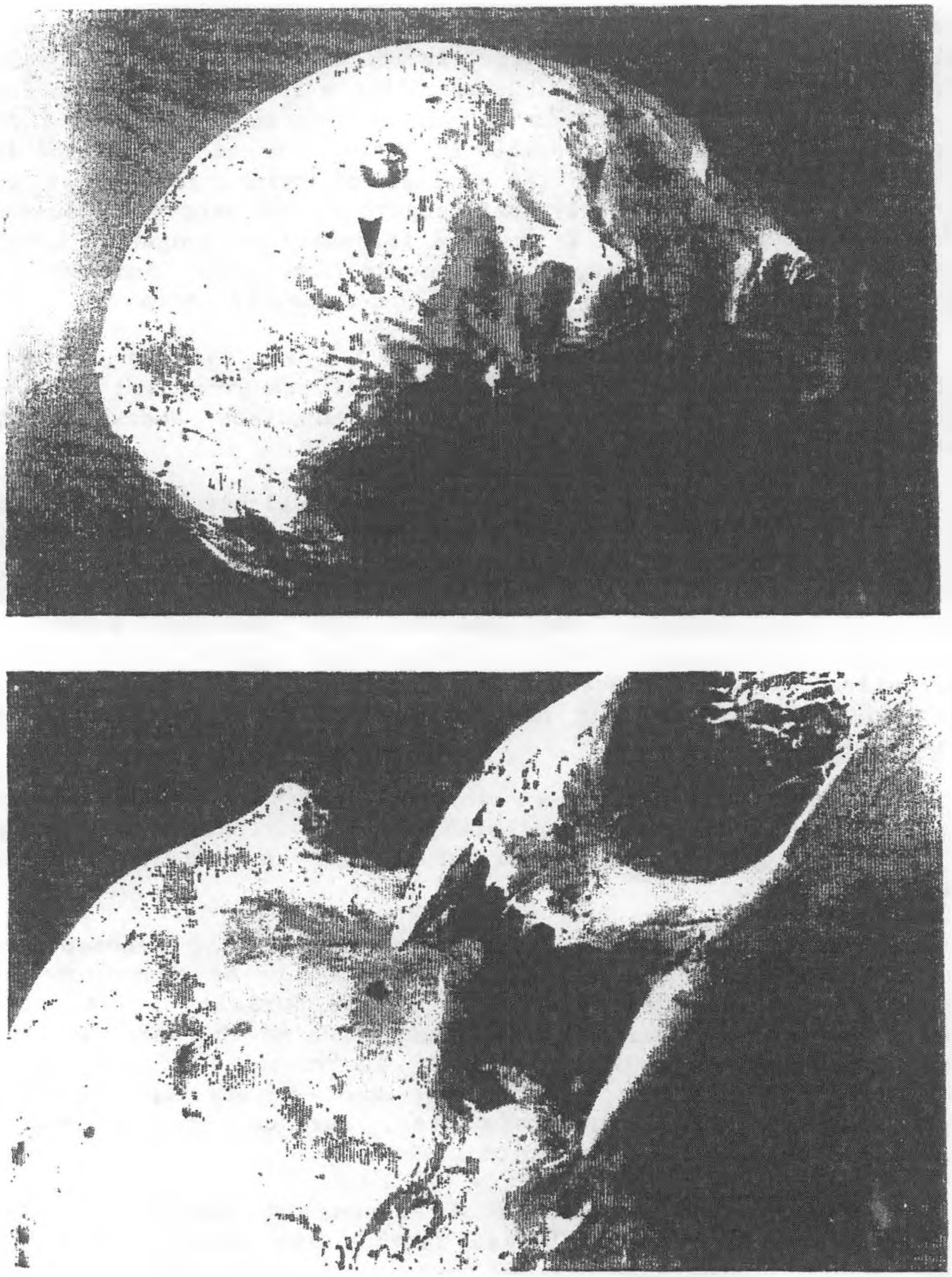


Figure 21. a) Arrows indicate penetrating impressions in the right temple and behind the right ear. b) The likely cause -- upper canines from bear.

V. B. Insect Remains

V. B. 1. *Rationale*

Insects often play a primary role in decomposition. In forensic investigation, the association of certain insect groups with decomposing human remains can provide reasonably accurate and valuable clues to the duration of the postmortem interval (Rodriguez and Bass 1983).

The life cycle of most insects is seasonally specific; that is, the stages through which an insect matures reflect an adaptation to specific seasons or environmental conditions. Drawing this correlation between an insect and its environment requires that the insect be identified **TAXONOMICALLY** as precisely as possible. It is of extreme importance therefore that anatomical parts characteristic of a species not be lost or distorted through poor recovery techniques.

Generally speaking, two Orders of insects are most often associated with decaying organic matter. These are **COLEOPTERA** (beetles) and **DIPTERA** (flies). Approximately 7,000 species of each are known in Canada with a considerable number yet to be identified. Furthermore, only a small proportion of the immature stages of these species has been described. Although most species will not normally be encountered in forensic contexts, it is evident that for purposes of identification, the collection of insects and their remains requires careful attention.

It is necessary that the state of decomposition of the human remains at the time of discovery be described in detail (for example, fresh, **PUTREFIED**, **DEHYDRATED**, **SAPONIFIED**, **SKELETONIZED**) as this both reflects and determines the kinds of insects present. Some insects are not **SAPROPHAGOUS** (**CARRION** feeders) themselves, but feed upon the carrion feeders, their eggs and **LARVAE**. In that either group can provide an estimate of minimum elapsed time since depth it follows that samples should be taken of all insects found associated with decaying human remains.

Both Coleoptera and Diptera are **HOLOMETABOLOUS**; that is, they **METAMORPHOSE** through four stages during the life cycle: egg-larva(e)-**PUPA**-adult. Any or all of these may be associated with decomposing animal matter. Thus one may find living insects at any of these growth stages (for example, **MAGGOTS** (larvae of Diptera) or **GRUBS** (larvae of Coleoptera)), quite possibly in association with the remnants of previous generations and their life stages, for example, dead or empty pupae, and cast larval skins.

The precision of taxonomic identification is of great importance. This precision increases with the stage of development of the insect, and with completeness of the remains. Certain body parts are more diagnostic than others: in Diptera, wing **VENATION** and hair-like **SETAE**; in Coleoptera, **TARSAE** (terminal segments of the legs) and antennae are important in this respect (Fig. 22). Accordingly when handling specimens care must be taken to avoid losing or damaging these parts. In the event that live maggots or grubs are encountered, it is preferable, from the point of view of identification, that they be reared to the adult stage (Peterson 1962). This requires special attention in their collection, preservation and transport. One of us (M.F.S.) must confess to killing live maggots inside the largely decayed cranial contents of one individual by immersing the skull in defleshing chemicals. Species identification was not possible since the larvae could not be raised to maturity.

V. B. 2. *Collecting techniques*

For forensic purposes the collection of insects and their remains assumes the possibility of subsequent precise taxonomic identification. Techniques of collection are directed therefore to finding all associated insects and doing minimum damage to specimens.

Adult insects are usually mobile, and in many cases short-lived (exceptions can be found in many Coleoptera). When live specimens are found with human remains these should be carefully collected and killed as soon as possible in a killing bottle (see Appendix 4), so as to minimize damage to diagnostic parts. The immature forms of saprophagous insects are perhaps more likely to be found in forensic work. The larvae of Coleoptera and Diptera, if discovered alive upon decomposing remains, are probably not yet ready to pupate, as in most instances larvae will leave the food source when they have finished feeding, and prior to **PUPATION**. Therefore, when collecting live larvae, an alternate suitable food source must be provided for as long as necessary for the adult stage to be reached (days or weeks). Preferably, an adequate sample of the decomposing soft tissue could be removed and placed in the rearing container (Appendix 4). Failing this, a meat substitute will do (not hamburger as preservatives are harmful to the insect). If the larvae are feeding upon decaying vegetable matter associated with the remains, this should be placed into the rearing container. All larvae found should be collected, if possible, as rearing is a difficult procedure, and a high mortality is to be expected. Where morphological dissimilarity in larval forms is obvious, these should be kept separate. In Appendix 4 can be found a description of

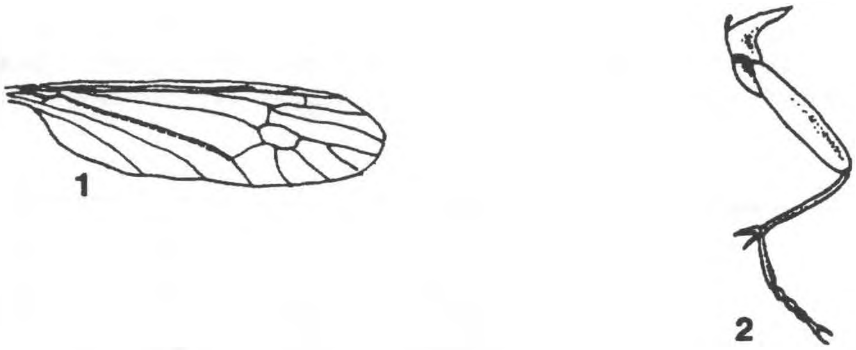


Figure 22. Diagnostic portions of insects. 1) Venation of Dipteran wing. 2) Tarsal segment of Coleopteran leg.

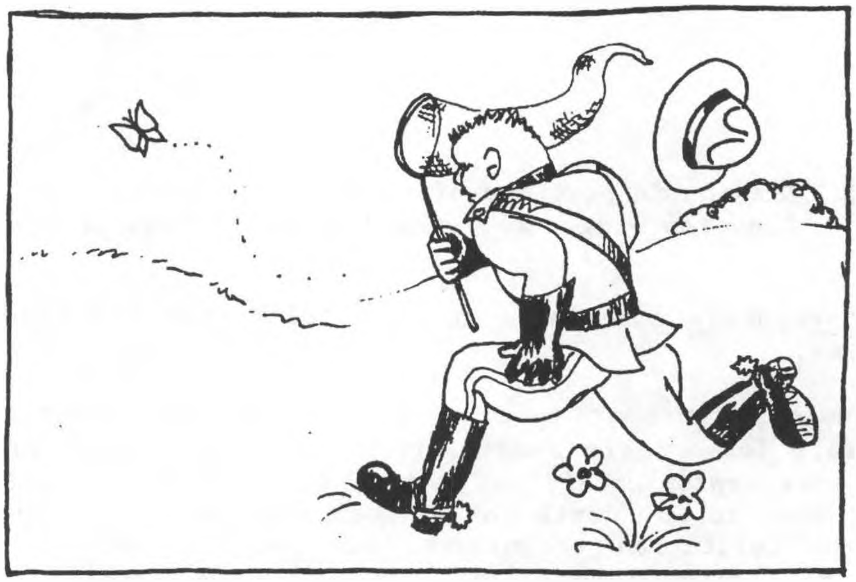
suitable temporary containers for the collection and transport of live larvae.

As noted, for most species, larvae that are ready to pupate will usually leave their food source. It is therefore recommended that an area approximately 0.5 meters around the periphery of the remains, and to a depth of 5 centimeters, be subjected to appropriate collection techniques (see below). In the case of burials, all screened material from above the remains should be searched thoroughly for insect remains, noting the depth from which the soil was taken. The earth beneath the remains can also be examined when it is certain that all other evidence has been found.

In the event that all insects recovered are dead (regardless of stage of development), or that only remains of previous stages or portions of insects are observed, it is sufficient that these be placed separately in suitable containers (for example, glass or plastic vials with screw-type or childproof caps) with 75 percent ethyl (grain) alcohol. These should be labelled appropriately and forwarded to the proper specialist for identification. If doubt exists as to whether the insect is in fact dead, treat it as if it were alive.

Where insects occur in direct association with decomposing flesh they will in most cases be seen readily. (An exception will be those which have made their way into the skull.) In these instances, direct hand collection, perhaps with the aid of delicate tools (for example, small soft hair brushes), is the most effective and simple method. Live adult forms should be placed in killing bottles, and pinned when dead, or put into alcohol. To collect specimens from the peripheral soil matrix the technique of

FLOTATION is recommended. This entails placing samples of the soil into a basin of water, and with gentle agitation allowing freed insects to float to the surface. In most cases the **PUPARIA** of insects are water-tight, and this technique should not result in death of the insects.



The following is suggested as the minimum information required for an adequate interpretation of the recovered insect sample:

1) Precise site location.

2) Site description -- describe in detail the nature of the terrain, vegetation, proximity of water, and weather conditions.

3) Note whether a surface find or burial; if the latter, be sure to indicate approximate depth from which insects were taken.

4) State of decomposition -- fresh, putrefied, dehydrated, saponified, or (semi-) skeletonized.

5) Nature of sample -- eggs, larvae, pupae and/or adults. Record the obvious presence of more than one species.

6) Nature of association -- note if insects were found directly associated with the remains, where they were found, and the degree of infestation. If recovered through hand sorting or flotation note the association of the matrix to the body.

7) Method of recovery -- for example, hand collection, flotation, sieving.

8) Method of preservation -- note methods used to kill adults and preserve them (for example, ethyl alcohol). Describe rearing container and any alternate food source.

9) Ancillary records (for example, photographs) -- note their existence.

V. C. Plant Remains

V. C. 1. *Rationale*

The utility of plant remains in forensic investigation should not be underestimated. Plants can provide information on geography, seasonality, and even the specific year of a significant event. Caréful notation of the types and nature of vegetation present but not collected should be made as this may affect the interpretation of the samples recovered.

Plant identification is based on external, internal and microscopic features depending in part on the species involved. Surface features include such things as leaves and needles, bark, buds and seeds. As in most groups of living organisms, some parts are more diagnostic than others; for instance, some plants can be identified accurately to species by parts of leaves while others might require the whole leaf simply to place the item at the generic or higher level. Internal features include gross wood structure and colour. Microscopic features include finer aspects of internal plant and wood structure as well as very small items like pollen and spores. Tree rings, whose growth has been affected by an event associated with a person's death or disposal, can be examined microscopically to determine elapsed time since death, possibly to within a season of a particular year.

It should be noted that it is not always necessary to identify the plant remains to obtain some significant information. Examples would be inferring season of death from the flowering stage of plants trapped beneath a fallen body, or degree to which vegetation beneath the body has died, estimating the age of a burial by the depth and state of decomposition of the surface litter layer, or from disturbed plant roots growing back into the soil above a burial.

In cases where human remains occur on the surface, leaves, needles, seeds and the like may accumulate on the body or even within the skull where they might subsequently be protected from the external environment. Recovered plant remains should be placed in plastic bags, sealed and labelled accordingly. It is also suggested that these kinds of remains be collected from beneath the body (or those skeletal parts in contact with the ground, for example, skull), since these areas, which were last exposed prior to deposition of the body, may reveal plant remains whose characteristic pattern of growth was affected at that moment in time.

If clothing is present it should be removed as soon as possible, labelled and sealed in sterile plastic bags for transport to a facility where a systematic search for local or exotic seeds and pollen can be undertaken. Any dirt adhering to clothing, shoes, etc. must be saved. In the event that removal of the clothing in the field is not possible, precautions should be taken to insure against loss of these kinds of information. This might entail placing plastic bags over likely areas of seed and pollen accumulation when the person was alive, such as pant cuffs, shirt collars and pockets. It must be stressed that the bags containing or protecting these materials should not be opened or removed prior to their arrival at a sterile facility for examination. This is to avoid contamination of older pollen with current 'POLLEN RAIN'.

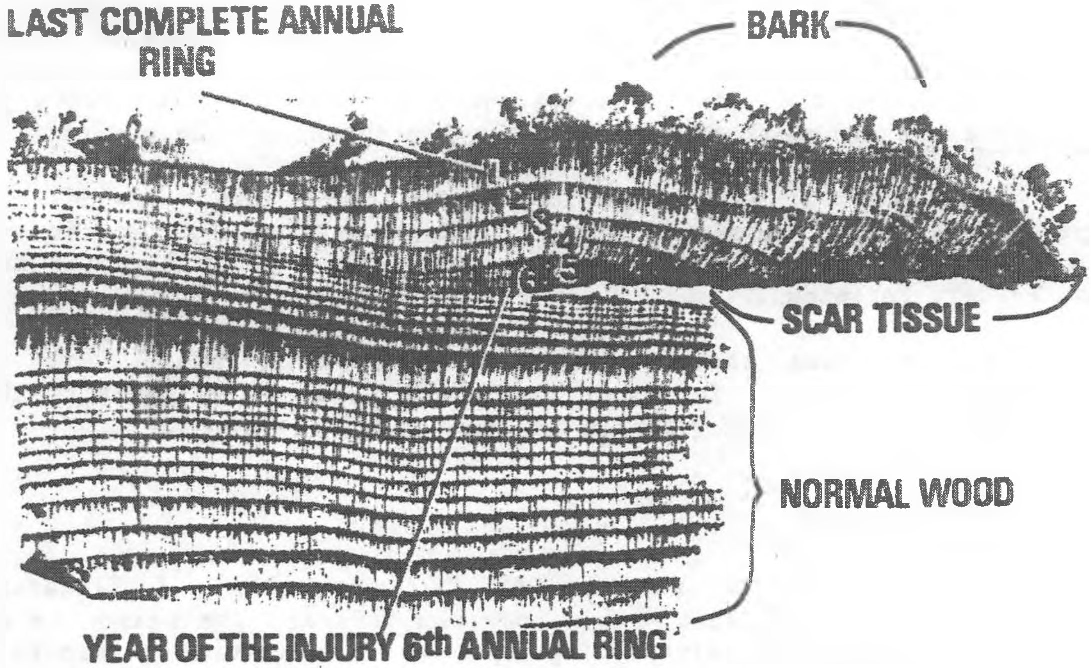
V. C. 2. *Tree rings*

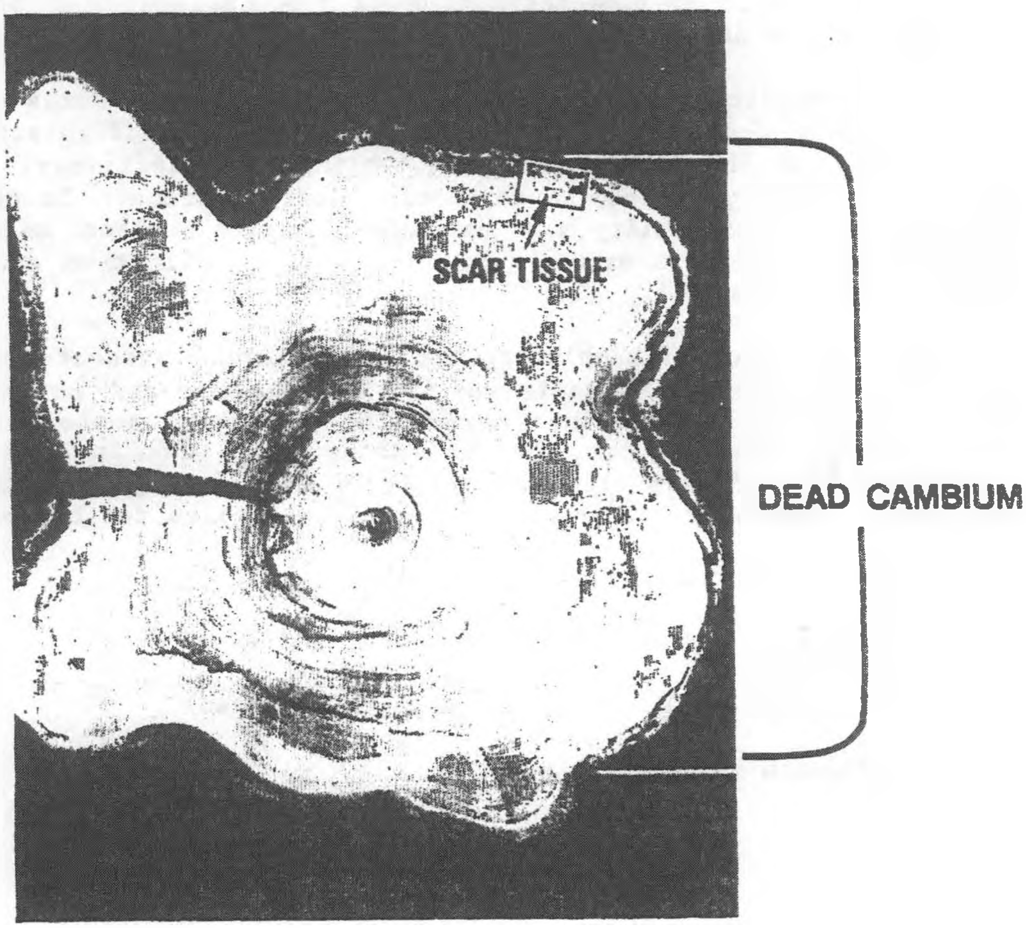
The analysis of annually-occurring tree rings ("dendrochronology") can indicate when a forensically significant event happened (Jozsa 1982). There are basically two reasons for this. First, tree rings grow with a certain rhythm which permits their calibration within the yearly cycle. In many species (especially conifers) a particular growth season can be determined from difference in width, density or colour patterns of the tree ring corresponding to that year's growth (i.e., "early" and "late" wood, denoting the beginning and end of the growing season, respectively).

Second, the criteria of ring width and density are independently susceptible to local effects of the environment. In the case of human burials, soil disturbance, nutrient enrichment through body decomposition, and shovel trauma can produce changes in the growth of tree roots which are observable through microscopic or densitometric (x-ray) examination of the subsequent growth rings (Denne 1977) (Fig. 23).

It is necessary to show that the observed effects on the tree rings, postulated to be the result of a criminal act, are not attrib-

Figure 23. Determination of elapsed time since death from tree ring analysis (upper figure -- magnified cross-section of scar tissue, from rectangular area marked in lower figure).


LAST COMPLETE ANNUAL RING
BARK
1
2
3
4
5
6
SCAR TISSUE
NORMAL WOOD
YEAR OF THE INJURY 6th ANNUAL RING


SCAR TISSUE
DEAD CAMBIUM

utable to natural phenomena. This requires obtaining unaffected plant material which is not in direct association with the human remains. If pieces of root which enter a grave are being recovered, it is suggested that similar sized roots be obtained from trees <u>of the same species</u> which are growing at a distance from the burial.

In one case of human cremation, nearby trees were scorched. It proved possible to determine when the body was burned to within two months of the date alleged by an informant (analysis by L. Jozsa and M. Parker, Forintek).

As tree ring characteristics vary between species, it is advisable to collect a few leaves and seeds in order to identify the species. A colour photograph of the tree would be useful.

V. C. 3. *Pollen*

Pollen grains are the male **GAMETES** (sex cells) of flowering plants and when associated with a body can indicate the season of an individual's death. Analysis of pollen can also provide information as to the movements or geographic location of the deceased prior to death. This would be especially true if the decedent had been in the proximity of an exotic or rare species (Erdtman 1969).

The identification of pollen is based on three features of the outer covering or **EXINE** (Fig. 24). These are the configuration of apertures, the shape, and the sculpturing. Collectively, these criteria provide very precise taxonomic identification. In certain circumstances, seasonality may be inferred from pollen analysis. For inferences of this nature, extreme care in collection and note taking is essential.

The collection of samples for pollen analysis presents special problems and therefore demands special precautions and procedures. This is particularly critical during the flowering season typical for the region in question, as the intensity of the 'pollen rain' significantly increases at these times. The following is a list of possible reservoirs of pollen which should be sampled for collection:

1) Dirt under nails

2) Clothing and adhering dirt

3) Hair and soil immediately beneath the head

4) Stomach and bowel regions

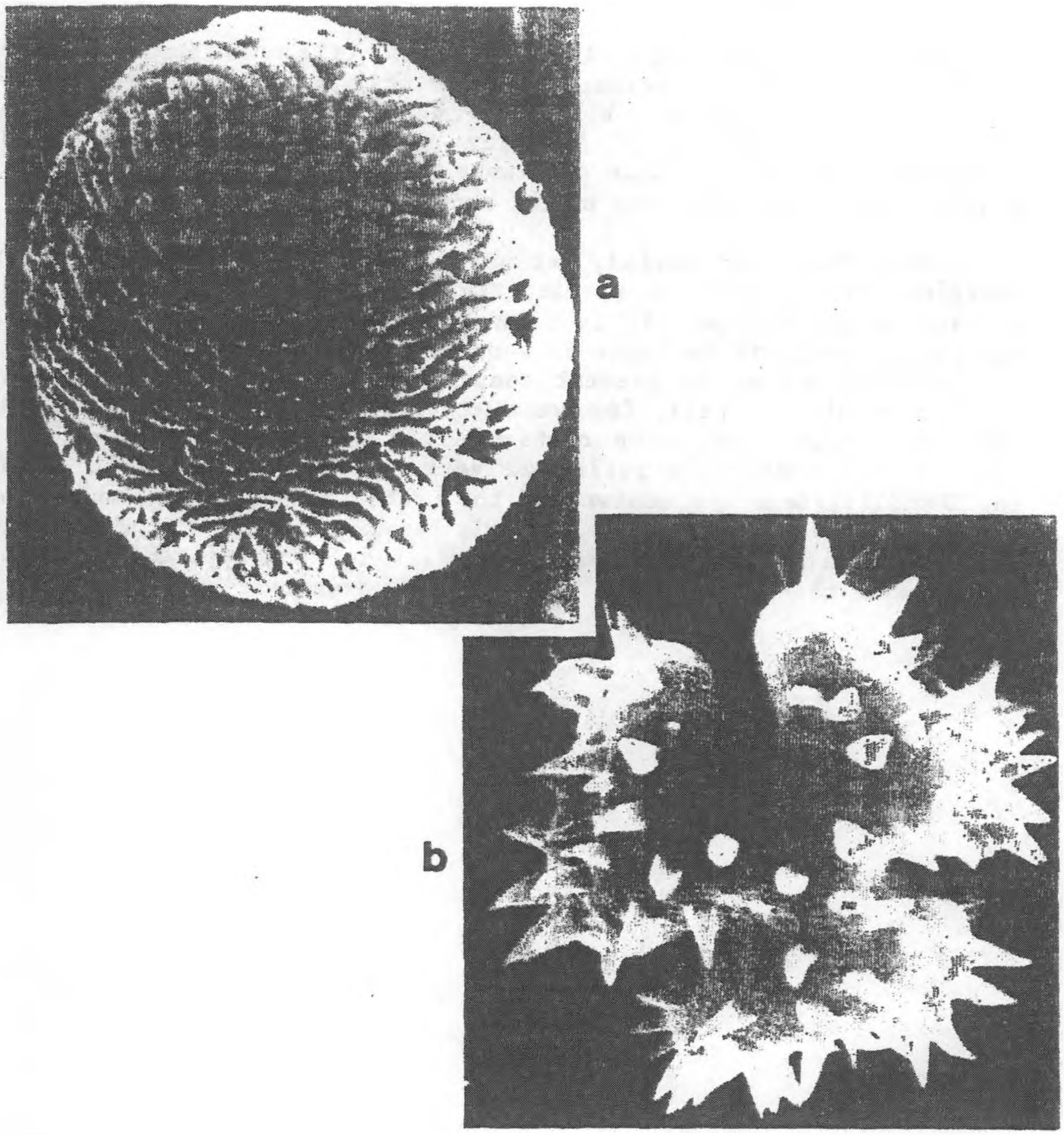


Figure 24. External surface features (exine) of pollen grains. Note variation in apertures, shape and sculpturing -- the basic characteristics used in species identification. a) *Polemonium corneum* (Jacob's Ladder), b) *Arceuthobium californium* (Dwarf Mistletoe). (Dr. Rolf Mathewes, palynologist with the Biosciences Department, Simon Fraser University, kindly supplied these scanning electron microscope photographs.)

5) Tracheal (lung) region

The first three apply to more recent (fleshed) human remains, the latter two pertain primarily to skeletal material recovered from a burial or protected by some means from continuous pollen deposition. As pollen is, in many cases, wind-borne, it can be expected to be found within our lungs and ear wax as well as within the food and fecal contents of the abdomen.

After death and burial, but prior to decomposition, the pollen contained in the body is static; that is, the kinds and quantities present do not change. It is imperative therefore that soil samples for pollen analysis be taken as soon as possible after uncovering of the remains, so as to prevent contamination from the ever-present 'pollen rain'. As well, for comparative purposes, samples should be taken from the earth at a distance from the burial. An adequate size of soil sample for pollen analysis would be on the order of 10 to 20 milliliters -- equivalent to a shot glass or egg cup. As always the samples must be properly labelled. If a considerable time between collection and analysis is anticipated, it is recommended that the samples be frozen for preservation.

CHAPTER VI

The Investigative Role of the Forensic Anthropologist and Archaeologist

VI. A. Rationale

The purpose of this section is to show that there exist a number of scientific disciplines whose members, usually to be found in universities, possess skills which may be of direct use to forensic investigators. Collectively, scientists investigate a wide range of phenomena using procedures designed to provide answers which are as accurate and reliable as possible. This emphasis on new and contributory research results in a body of knowledge on a particular topic which, in its recency and reliability, can ensure that the quality of interpretation of evidence in courts of law is of the highest calibre. Since evidence can be of any and all kinds, virtually any academic pursuit may be useful to the forensic investigator. Here, only that expertise pertaining to forensic anthropology, archaeology, and bones in particular, will be discussed in any detail.

VI. B. Comments on Analytical Methods

How do physical anthropologists get information from bones? No attempt will be made here to describe techniques in detail. Rather, our aim is to outline the types of analysis undertaken so that the investigating officer can evaluate the reports submitted by the forensic anthropologist.

Most of our work is simply observational, looking at the external features of the bones and teeth, in the light of experience. This reliable but subjective approach is usually supplemented by metrical (measuring) procedures (to determine age, sex, race and stature) using calipers, **OSTEOMETRIC BOARDS**, and the like, in conjunction with suitable biometrical formulae descriptive of these variables in known samples of people.

To these techniques we may add the use of an x-ray machine with which we ascertain tooth formation in children, or internal features of bone indicating physiological stress or trauma. We also employ slow speed wafering saws to produce thin sections of adult bones and teeth for microscopic examination.

As the occasion demands we may utilize more ambitious analyses. We have used x-ray emission spectroscopy to demonstrate the presence of lead in remains suspected to be historic, not prehistoric, in age.[1] Currently we are using video equipment[2] to superimpose separate images of a skull and photograph, both of which show evidence of facial scarring in similar positions when superimposed (technique suggested by Hillsdon-Smith 1979).

What do archaeologists do? In a nutshell, they dig sites of former human activity, recovering evidence produced by that activity. Consequently archaeologists are equipped to recover and interpret all manner of evidence; for example, soils, articles of human manufacture ranging from stone tools to historic artifacts like glass or nails, plant and animal remains reflecting what the people ate or used as materials for manufacture. They also of course study human skeletal remains, and try to date a site by developing knowledge of such techniques as tree ring dating and trace element analysis. These activities are of direct relevance to forensic cases. Naturally the equipment for recovery and analysis of such evidence is to be found somewhere in the university. Archaeologists and anthropologists, who have taken on the broad task of studying all of human kind through time, are great borrowers of ideas and tools of other more specialized disciplines. So, often, if an archaeologist cannot help, he can usually recommend someone who can. Here, however, we shall restrict ourselves to mentioning special problems of forensic investigation in which archaeologists and physical anthropologists have expert knowledge.

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1. Recent living bone incorporates atmospheric lead isotopes derived from the combustion of leaded fuels. This work was started at Simon Fraser University by Dr. O. Beattie and analysis in this case was undertaken by A. Cormie.

2. We thank Frank Campbell, Production Technician, Simon Fraser University Instructional Media Centre, for his kind assistance.

VI. C. Special Techniques

VI. C. 1. *Animal remains*

All manner of animal remains are found in archaeological sites and require study. For example, at the present time there are in the Department of Archaeology at Simon Fraser University students and faculty studying life forms ranging from land snails through fresh and marine water bivalves to large mammals like deer and domesticated species.

Recently we learned of a case of suspected substitution by a restaurant owner of poached deer for beef. A conviction could not be obtained due to the inability of the analyst to show by chemical means the species involved, since the evidence consisted of cooked, and therefore denatured, cuts of flesh and bone. Here an expert in animal bone morphology, particularly the incomplete portions usually seen by zooarchaeologists, should have been able at least to discern reliably that the bone was not from a cow, if not also identifying the precise species involved. Either way a case for fraud could be substantiated. We have also been involved at the request of Fish and Wildlife officers in demonstrating that a butchered leg bone seized from a suspect's freezer belonged without question to the remains of an abandoned deer carcass obviously shot out of season. This finding was based on physical matching of two adjoining bone segments: the **RADIUS** lacking the distal epiphysis (the "freezer" specimen), with the distal epiphysis and rest of the deer's foot found in the field.

Most identification officers will probably have difficulty distinguishing the bones of young children from animal bones. This is particularly so with fetal bones which commonly are dismissed as small animal bones, even by archaeologists who should know better. One of us (M.F.S.) must confess to finding recently, during a burial excavation, two small bones outside the pelvis of a backlying female. These were not recognized immediatedly for what they were -- skull portions of a fetus -- but were cheerfully labelled U.F.O.'s -- Unidentified Foot Objects.

VI. C. 2. *Cremations and fragmented bodies*

The burning of a body, whether intentional or accidental, and violent trauma (e.g., an aircraft accident, perhaps accompanied by burning), can result in extreme fragmentation of the body and the bones.

For purposes of reconstructing a criminal event, for identification, or for providing surviving relatives with the assurance that the body portions recovered for burial belong only to one individual, it is often necessary to employ the services of personnel experienced in identification and reconstruction of small hard tissue fragments. It is the nature of the archaeological record that bones are seldom intact. Physical anthropologists naturally have more experience with reconstructing fragmented bones than do forensic pathologists or medical practitioners. The lack of soft tissues, or soft tissues that are charred beyond recognition, may signal to these latter experts the end of useful investigation of such items; but to the physical anthropologist this is just the familiar beginning in his study to derive information about the individual concerned.

Apart from the role of physical anthropologists in assisting with the task of identification in mass disasters, there are two related problem areas in which he or she can be very useful: recognition of the human nature of burned and highly fragmented bone and teeth, and their controlled recovery.

Cremated bone and the effects of burning on human hard tissues may be familiar to some physical anthropologists because cremation has been practised by many cultures in the past for disposing of their dead. It is usually possible to show that bone was burned in a green (that is, fleshed) state. Burned flesh may be deposited on bone as a black, shiny substance. Higher temperatures and prolonged burning of bone produce colour changes characteristic of firing temperatures involved, as well as structural changes (for example, **VITRIFICATION**) and characteristic fracture patterns of bone shafts and teeth (Stewart 1979). Knowledge of these effects will assist in reconstructing not only the bone fragments but also some aspects of the nature of the fire (for example, temperature, hot spots, and gradients). Tooth crowns tend to explode when heated due to water in the pulp of the tooth turning to steam. These fragments are nevertheless recognizable, sometimes even to having come from a particular tooth. Furthermore, dental "fillings" (restorations), which even if lost through the effects of the heat or through fragmentation, may leave evidence of their previous presence on a tooth in the form of metal oxides driven from the **AMALGAM** and redeposited on the tooth's surface. Also, dental restorations will differentially transmit heat to the tooth's tissues during burning, producing marked, differentially burned, margins on the tooth surrounding the restorations. **PROSTHESES** can resist a fire remarkably well and are of course invaluable in identification. These should be examined by a forensic odontologist who is a specialist in the identification of persons from teeth and dental work. A typical severe cremation yields bone fragments 1 to 15 centimeters in length, numbering in the hundreds or thousands and weighing, in total, less than 1500 grams.

Armed with such knowledge, the forensic anthropologist can be very helpful in the initial task of finding evidence of a burnt victim in severe fires. Finding such, the next task is to recover the evidence. Precision recovery serves two functions, both based on spatial relationships amongst bone fragments. Obviously it is easier to start trying to reconstruct bones and teeth from fragments close to each other than from starting with a whole mess of fragments recovered as a unit (for example, a plastic garbage bag into which everything has been shovelled).

The second aspect is the relationship between the bones of the body and external features, such as the structure and temperature gradients within the fire, or physical features like the ground, floors, walls and doors. Mapping the identifiable bone fragments even without reconstruction can indicate orientation of the head and limbs or body as a whole, information which can be vital for reconstructing events prior to cremation. On a larger scale, mapping of the body area relative to structures (for example the location of a door in a now destroyed wall) may be very important in terms of later claims about fire safety procedures or criminal negligence.

Appropriate methods for the collection of cremated remains will be dictated by the degree of fragmentation that has occurred. Where the elements are largely intact and identifiable, previously described methods (II.B.3.) will suffice.

From our experience, however, it seems more likely that in a cremation the investigating officer will be faced with an area of poorly delimited extent known to contain more or less fragmented human bone within a matrix (of variable depth) composed of ash, burnt wood and extraneous materials. Bone in such situations is extremely fragile and would take days to excavate. Succumbing to the temptation to shovel the whole mess into bags (for some unfortunate forensic anthropologist to deal with) results in loss of valuable information. We recommend the following procedure which has been field tested.

The object is simply to establish a delimiting grid system of sufficient areal extent as previously described. Each square meter is then subdivided into much smaller grid squares, say 10 to 20 centimeters on a side, each of which is recovered intact down to the appropriate depth. A trowel or table knife will do to cut away each designated block of bone-bearing matrix which can then be bagged separately in labelled containers.

Inevitably, with this method, there will be damage to bone fragments spanning two block perimeters, but these can be anticipated and sometimes removed separately. This disadvantage is more than balanced by maintaining relatively precise horizontal spatial data for the fragments and by the speed with which the matrix can be recovered.

The laborious freeing of the fragile pieces can then be accomplished in the laboratory setting. In the previously mentioned case, we air dried each block of matrix and then used dissecting needles to tease apart the blocks. Only in this way can very small dental fragments be recovered without further breakage. Sieving of ash and charcoal for bone and tooth fragments is not recommended except for the final stage of examination when thoroughly-searched matrix (which has apparently yielded all it has to offer) can be gently wet screened through a series of nested sieves. Small but significant items like dental fillings may be recovered this way.

It should be noted that the recovery and analysis of such cremated material is extremely slow. Nine hundred hours were spent in one case just recovering 10000 bone and tooth fragments from one skeleton recovered in fifty-six 15 centimeter blocks of matrix. Admittedly in this case fragmentation was so severe that most of the bone sample was unanalyzable except for mapping the distribution of bone by weight, but even this helped in determining the general orientation of the body as a check against the accuracy of an informant's account of how the body was burned.

VI. C. 3. *Anatomic reconstruction*

Those physical anthropologists of most use to law enforcement agencies have experience in deriving information from archaeological (and possibly fossil) human bone. Consequently they have developed the descriptive and interpretive levels of morphological analysis of bones and teeth to a fine degree.

Three cases come to mind. The first involved a multiple gunshot slaying where three bodies had been recovered and a fourth possible victim was missing. Also recovered were six tiny fragments of bone suspected to be from one of the four, possibly the missing individual. Prolonged study of these indicated some were from the delicate bony structures comprising the base of the skull behind the face. This finding could then be checked for a corresponding damaged area in one of the three known victims as recorded in the autopsy report. Negative findings in such an instance would indicate the missing individual was likely also dead.

The second of these cases involved the study of a badly damaged cranial vault of a young male. In many areas the skull was so badly fragmented as to be held together only by soft tissue. After taking delivery of the autopsied specimen, it was defleshed using suitable chemicals, degreased and bleached. Study and partial reconstruction of over 50 dried cranial vault fragments yielded clear evidence of wounding from two implements -- a knife (Fig. 2) and a hatchet (Fig. 3), with the edge of the latter having left a unique pattern of striations on the skull from a glancing blow. In this case and the next one, the role of the forensic anthropologist was to provide knowledge of normal variability in the appearance of bone.

A problem of interpretation arose when in the process of chemically defleshing the partially decomposed skull of a homicide victim, a small hole was revealed which perforated one of the facial bones below the eye. The *modus operandi* of the suspected killer had on a previous occasion included the driving of a nail into a victim's head. Our examination of the questioned hole revealed that the margins of the defect were rounded and the hole appeared to have been closing up for some considerable time. Thus the hole was not coincident in time with death.

VI. C. 4. *Facial reconstruction*

Recent years have seen the revival of a technique for reconstructing facial features on a skull; stimulated in part by new standards of soft tissue thickness for different racial groups (Snow, Gatliff and McWilliams 1970; Rhine and Campbell 1980).

Typically medical sculptors assume this role. Preferably, however, a specialist in facial reconstruction should be found, who also has a thorough grounding in forensic anthropology. Such a background would allow him or her to determine race, sex, age at death and individualizing characteristics from the skull; variables which if correctly diagnosed will ensure the quality of the reconstruction. The address of one such specialist in Canada is supplied in the Appendix.

The basic technique is outlined below; followed by guidelines, directed particularly at the investigating officer, for procedures which will enhance the information yield of the reconstruction.

Upon receipt of a skull, including lower jaw, the specialist makes a thorough study, checking any previous diagnoses of race, sex, and age at death. The specialist may request the rest of the skeleton and any clothing or jewelry, if such can indicate stature, body build, or appearance. Individualizing characteristics such as facial bone scars, dentures, or unusual front teeth, will also be checked. Most importantly, a thorough search will be made for any adhering facial or head hairs (which are not uncommonly found) since inclusion of their characteristics (colour, length, curl, and so on) will greatly enhance the reconstruction.

With these important preliminaries accomplished, the next step will be to make a cast of the skull on which to build the reconstruction. The cast is used so that the original need not suffer undue handling during the reconstruction, but is available for re-checking particular features when necessary. Also, if demanded, the skull can be made available to other specialists for their examination or can be returned for burial.

The first step in the actual reconstruction is to glue rubber posts, representing average tissue thickness, onto specific anatomical landmarks of the cast. These posts are then joined by plasticene strips laid over the facial region, contouring the depth of the strips to match that of the posts they connect. Bare areas are then filled in with a view to reflecting accurately the age and body build of the individual. Glass eyes of the appropriate colour (e.g., native -- brown eyes) are added. Size and shape of the nose are largely determined from the skull but the mouth and lips are sculpted, necessarily, more with talented imagination than with science. Addition of a wig and a shirt or scarf usually complete the reconstruction, which can now be photographed for inclusion in a poster describing what is known of the remains.

From the above description of the technique it should be obvious that, apart from the skill of the specialist in facial reconstruction, the likeness produced is only as good as the quality of the recovered evidence. Thus the investigating officer should attempt to accomplish the following:

a) Recover all skeletal and dental elements, especially the front teeth which, while often very individualizing, fall easily from the skull.

b) Search for facial and head hair. Hair is a dead tissue and may accompany bones of even several years exposure. If hair has been submitted to a hair and fibre specialist, arrange for a sample, and the report, to be sent to the specialist in facial reconstruction for consideration.

c) Recover all clothing, eye glasses, and jewelry as these can indicate not only body build and personal appearance but may also suggest socio-economic status (which could be reflected in the reconstruction).

d) Ensure that the facial bones of the skull are protected at all times, since the degree of projection of these often very delicate processes is of utmost importance in the reconstruction.

e) If the remains are to be autopsied, try to make sure that the jaws are not sawn from the skull.

f) If there is pressure to dispose of the unidentified remains, try to retain the head for storage and later analysis.

The task of the identification officer to try to identify the remains does not end with receipt of the photograph of the reconstruction. It is his job to ensure that *all* the relevant information which could help identify the individual is recorded on the descriptive poster to be circulated. Too often we have seen such posters where, basically, only the reconstruction is illustrated while important information (such as the fact the person was diagnosed from the skull as native) was left off. Finally, the descriptive poster should be circulated as widely as possible.

In conclusion, we would like to observe that, whether simple or complex, analytical techniques are only as good as the quality of the recovery procedures and the remains themselves. Positive results are more likely to be forthcoming from a forensic anthropologist armed only with experience and presented with a complete skeleton from a documented and thorough recovery procedure than from a lab full of apparatus applied to a few scraps of bone of questionable context.

CHAPTER VII

Protocol for the Transfer of Human Remains

The legal code protecting unidentified human remains varies among provinces and states. In British Columbia, for example, such material is covered by the Anatomy Act as administered through the authority of the Office of Chief Coroner, while in Alberta all such cases are administered by the Office of the Chief Medical Examiner under the terms of the Provincial Human Fatalities Enquiry Act. At any rate, the investigating officer has the initial responsibility of ensuring that approval has been obtained from those in authority in accordance with policies and the law, before passing the material on to a specialist for expert analysis.

The working arrangement for all R.C.M.P. detachments in British Columbia is that, with approval from the local coroner or from the Chief Coroner, all unidentified skeletal remains and associated relevant evidence are delivered, usually in person, to the R.C.M.P. Crime Detection Laboratory (Vancouver) who then re-allocate some materials. The contributing officer may then bring the remains to us.

Most forensic anthropologists are fully aware of the rigorous demands of maintaining **continuity of evidence**. However, when an archaeologist, anatomist or physical anthropologist has only occasional involvement in forensic cases it may be necessary for the law enforcement officer to remind the recipient of the need for continuity of evidence. This includes signing for the material, keeping it in secure storage at all times, being able to account for keys and persons with access to the remains, and signing for its release at the end of his investigation.

APPENDIX 1

Resource Personnel in Human Remains Recovery and Identification

The following professionals have kindly offered to have their names included in this manual as experts willing to assist law enforcement agencies in their area with the recovery and/or analysis of human remains. A complete listing of certified forensic anthropologists can be found in the Directory of Forensic Science Diplomates, available from the Forensic Sciences Foundation, 225 S. Academy Blvd., Colorado Springs, Colorado, 80910, U.S.A., (303) 596-6006.

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APPENDIX 2

Equipment and Materials for the Recovery of Human Remains

Mapping and Measuring Instruments:

surveying instruments (transit, alidade, plane table, engineer's rod), plumb bob, line level, cloth tape (2.5 meters minimum), two 50 meter steel tapes, metric ruler, non-stretchable nylon string, engineer's spikes, North arrow, centimeter scale, site board, flagging tape, compass, meter grid.

Recording Equipment:

camera, colour and black and white film, filters, tripod, light meter, pencils, pens, grease pencils, labels, cassette recorder, video tape recorder.

Record Keeping:

human remains field recovery form, notebooks, metric graph paper.

Excavation Instruments:

trowels, brushes (stiff whisk and soft), small dust pan, spoons, knitting needles, pen knife, nesting sieves, fine nylon mesh screening, flashlight, shovels, lean screen, tweezers.

Containers:

plastic and paper bags of various sizes, stapler and staples, air-tight structurally strong containers (glass or plastic vials), insect killing and rearing bottles, ethyl acetate, 75 percent ethyl alcohol.

Packing and Construction Materials:

newspaper, toilet paper, cotton wool, masking tape, claw hammer, nails, hatchet.

A field manual of human osteology (e.g., Bass 1971).

APPENDIX 3

Notes on use of Human Remains Field Recovery Form

The purpose of the following detailed form is to remind the investigator of the sorts of evidence which are useful to collect. It is not anticipated that the investigating police officer will have the background to fill in the entire form. However, experience has shown that during the initial phases of observation and recovery of the remains it is not uncommon for local medical, dental and even archaeological personnel to be consulted on the remains. Such persons do have the expertise to help the investigator catalogue and describe the human skeletal material recovered. This form, if made available by the investigating officer to the relevant specialists, provides a uniform data recording mechanism for maximum information retrieval. A copy of the completed form can then accompany the remains when they are submitted to a forensic anthropologist for thorough analysis.

One further note is required on the method of recording the teeth recovered (p. 8 of form). The system used here, known as the F.D.I. nomenclature (Féderation Dentaire Internationale), is becoming widely adopted for its suitability in naming teeth in a form that can be sent by telex and used in computer search of dental records (Leatherman 1971). It is a two digit system where the first digit identifies the quadrant of the mouth in the following manner (dentition viewed from the front, as though looking at the subject's face):

	Permanent (Adult) Teeth		Deciduous (Milk) Teeth		
UPPER RIGHT	1	2	5	6	UPPER LEFT
LOWER RIGHT	4	3	8	7	LOWER LEFT

The second digit identifies the tooth's position along the dental arch starting at the mid-line (mesial) with '1' and proceeding away from the mid-line along the dental arch (distal) to '8' in the permanent dentition (to '5' in the deciduous dentition).

Thus the fifth tooth from the front on the left side of the upper jaw would have the designation 2-5, if permanent, and 6-5, if deciduous. Note there is normally a maximum of 20 deciduous (milk) teeth (5 in each quadrant) and 32 permanent teeth (8 in each quadrant).

A system for numbering teeth which may be more familiar to most dentists, particularly in the United States, is known as the "Universal" system. With this system, one imagines the subject's mouth opened very wide with the chewing surfaces of the teeth facing the examiner. The permanent teeth are designated, starting with 1, from the upper right third molar (wisdom tooth), numbering clockwise to 32 for the lower right third molar.

Human Remains Field Recovery Form

Detachment ______________________ Date (M/D/Y) ________
Investigator ______________________ Case No. ________
Signature ______________________

SUMMARY OBSERVATIONS

1. Unknown/known/suspected identity: (Circle which)
   Name ______________________
   Date of birth (M/D/Y) ______________________
   Sex ________ Race ______________________

2. Discovery location of remains ______________________
   ____

3. Date remains discovered (M/D/Y) ________ By whom ________

4. Date(s) remains recovered (M/D/Y) ________ By whom ________

5. Repository of evidence: (Specify for each)
   Skeletal ______________________
   Artifactual (Personal effects, foreign objects) ________
   ____
   Soil samples ______________________
   Insect remains ______________________
   Plant remains ______________________
   Photographs ______________________
   Field notes ______________________
   Other ______________________

6. Remarks ______________________
   ____

Case No. ______________________

CONTEXTUAL OBSERVATIONS (Describe in Detail)

1. Search Area:
   a) location ______________________
   b) access to locale ______________________
   ____
   c) physiography/(micro)climate: terrain ______________________
   ____
   altitude ______________________
   adjacent bodies of water (note creek, lake, swamp, ditch, etc., or flood zone) ______________________
   exposure to sunlight ______________________
   d) vegetation zone: general (e.g., forest, bush, prairie, rural, urban) ______________________
   recovery locale; major vegetation type (e.g., fir) ______________________
   degree and type of ground cover ______________________
   e) animal activity (e.g., scats, trails, burrows) ______________________
   ____
   f) important nearby features (e.g., buildings, roads) ______________________
   ____

2. Recovery Area:
   a) surface/buried remains (circle, and describe situation ______________________
   ____
   b) nature of indication of human remains (e.g., bones, informant, disturbed soil) ______________________
   c) nature of ground cover (e.g., regenerating plants, leaf litter) ______________________
   d) mapped terrain (note trees, large boulders, hollows, slope, etc.) ______________________

3. Remarks ______________________

Case No. ______________________

SPATIAL CONTROL AND LOCATIONAL DATA

1. Describe basic mapping design and permanent reference points ___
____
____

2. On accompanying graph paper, draw a scaled metric plan view of the mapped area designating datum point(s) and corner posts, numbering grid squares, and noting compass direction.

3. Specify datum point(s): ______________________________
depth of surface below datum ____________________________

4. Locational data:
   a) approximate areal extent of remains: L ________ W ________
   b) description/size of any container or cover ______________
   ____
   c) dimensions of grave: L _________ W _________ D _________
   d) mapping data for specific objects: SEE PAGE 6 OF FORM.

NATURE OF REMAINS

1. Mode of deposition: surface exposed/covered/partial burial/ buried? (circle which)

2. Was deposition: accidental/intentional/unknown? (circle which)

3. If cremation, did it occur *in situ*/elsewhere? Carbonized vegetable matter present __________, recovered __________? Container evident _________?

Case No. ______________________

4. Integrity of remains: disturbed, yes/no? If yes, note degree of disarticulation ____________________________
degree of discovery disturbance ____________________________
previous disturbance (e.g., animal activity) ____________

5. State of decomposition (describe soft tissue preservation, if any, in detail) ____________________________
____

6. Associated biological materials (e.g., plant/insect remains). Describe nature of these, relating control and specimen samples taken to mapped area, methods of preservation, and noting sample item numbers ____________________________
____
____
____
____

7. Associated artifactual materials (describe as for "6" above) ___
____
____

8. Burial data:
a) nature of grave fill ____________________________
b) degree of compaction ____________________________
c) plant regeneration ____________________________
d) root penetration ____________________________
e) evidence of mode of digging ____________________________
f) shape of grave ____________________________
g) maximum depth ____________________________

Case No. ____________________

SPATIAL CONTROL AND LOCATIONAL DATA - MAPPING DATA FOR SPECIFIC OBJECTS

				Triangulation Method					Grid Sub-Square Method
Object	Item No.	Square	Depth Below Datum	Co-Ordinates Used X	Co-Ordinates Used Y	Direction	Distance to Co-Ordinates X	Distance to Co-Ordinates Y	Sub-Square No.

Case No. ____________________

9. Disposition of remains:

a) no pattern apparent ____________________

b) orientation (long axis): head end of skeleton __________
direction in which face pointing ____________________

c) position of remains: flexed, yes/no? Lying on side, yes/no?
which side? __________, degree of flexion __________
extended, yes/no? Face-lying, side-lying (state which), or
back-lying ____________________

d) orientation of limbs:

		left	right
arms:	straight?	______	______
	flexed (on to where?)	______	______
hands:	pronated or supinated?	______	______
	clenched?	______	______
legs:	parallel?	______	______
	crossed (where and which)	______	______

10. Remarks ____________________
____
____
____

Case No. ______________________

OSTEOLOGICAL AND ASSOCIATED MATERIAL INVENTORY

Missing elements (detail only if most of skeleton present):
a) premortem loss:
b) postmortem loss - preburial loss:
- discovery loss:
- recovery loss:

Elements present (indicate presence by item number):

Element	Item No.	Element	Item No.
cranium	______	malleus	L ______ R ______
mandible	______	incus	L ______ R ______
hyoid	______	stapes	L ______ R ______

Dentition (circle if recovered)

Upper Right	(deciduous) 5-5 5-4 5-3 5-2 5-1	UR	UL	6-1 6-2 6-3 6-4 6-5 (deciduous)	Upper Left
(Permanent)	1-8 1-7 1-6 1-5 1-4 1-3 1-2 1-1			2-1 2-2 2-3 2-4 2-5 2-6 2-7 2-8	(Permanant)
(Permanent)	4-8 4-7 4-6 4-5 4-4 4-3 4-2 4-1			3-1 3-2 3-3 3-4 3-5 3-6 3-7 3-8	(Permanent)
Lower Right	(deciduous) 8-5 8-4 8-3 8-2 8-1	LR	LL	7-1 7-2 7-3 7-4 7-5 (deciduous)	Lower Left

Vertebrae (cervical = C, thoracic = T, lumbar = L)

Element	Item No.	Element	Item No.
C1	______	T6	______
C2	______	T7	______
C3	______	T8	______
C4	______	T9	______
C5	______	T10	______
C6	______	T11	______
C7	______	T12	______
T1	______	L1	______
T2	______	L2	______
T3	______	L3	______
T4	______	L4	______
T5	______	L5	______
sacrum	______	manubrium	______
coccyx	______	sternal body	______
		xiphoid	______

Case No. ____________________

Ribs:	Left	Right
1	______	______
2	______	______
3	______	______
4	______	______
5	______	______
6	______	______
7	______	______
8	______	______
9	______	______
10	______	______
11	______	______
12	______	______
Clavicle	______	______
Scapula	______	______
Humerus	______	______
Radius	______	______
Ulna	______	______

Hand:

Carpus:					
Scaphoid	L	______	Trapezium	L	______
	R	______		R	______
Lunate	L	______	Trapezoid	L	______
	R	______		R	______
Triquetrum	L	______	Capitate	L	______
	R	______		R	______
Pisiform	L	______	Hamate	L	______
	R	______		R	______

Metacarpus:								
1st	L	______	Phalanges: proximal	L1	______	R1	______
	R	______		2	______	2	______
2nd	L	______		3	______	3	______
	R	______		4	______	4	______
3rd	L	______		5	______	5	______
	R	______	middle	2	______	2	______
4th	L	______		3	______	3	______
	R	______		4	______	4	______
5th	L	______		5	______	5	______
	R	______					
1st Sesamoids	L	______	distal	L1	______	R1	______
	R	______		2	______	2	______
				3	______	3	______
				4	______	4	______
				5	______	5	______

Case No. ______________________

Element:	Left	Right
Innominate	______	______
Femur	______	______
Patella	______	______
Tibia	______	______
Fibula	______	______

Foot:

Tarsus:	Talus	L	______	2nd Cuneiform		L	______
		R	______			R	______
	Calcaneus	L	______	3rd Cuneiform		L	______
		R	______			R	______
	Navicular	L	______	Cuboid		L	______
		R	______			R	______
	1st Cuneiform	L	______				
		R	______				

Metatarsus:	1st	L	______	Phalanges:	proximal	L1	______	R1	______
		R	______			2	______	2	______
	2nd	L	______			3	______	3	______
		R	______			4	______	4	______
	3rd	L	______			5	______	5	______
		R	______		middle	2	______	2	______
	4th	L	______			3	______	3	______
		R	______			4	______	4	______
	5th	L	______			5	______	5	______
		R	______		distal	1	______	1	______
						2	______	2	______
1st Sesamoids		L	______			3	______	3	______
		R	______			4	______	4	______
						5	______	5	______

Further observations (add pages as needed):

APPENDIX 4

Killing Bottle and Rearing Container for Insect Samples

The Killing Bottle (Fig. 25):

The ideal killing bottle or agent kills rapidly, and does not affect such identifying features as colour and shape. For forensic purposes a liquid killing agent is satisfactory. Ethyl acetate is recommended. This agent is highly flammable and caution must be used.

A killing bottle can be constructed as follows: with an unbreakable glass (pyrex) jar, sealed with a tight lid or stopper, apply a layer of absorbent material to the bottom. This may be either plaster of paris (1.5 to 2.0 centimeters thick) which must be allowed to dry thoroughly before use, or a layer of felt (0.5 to 1.0 centimeters deep) covered with a layer of cotton wool. To this add a few drops of the killing agent, over which are placed a few sheets of blotting paper. When using the killing bottle, the following should be remembered: do not overcrowd, do not mix large and small, or soft and hard bodied insects, clean the bottle regularly with dampened cloth or cotton. If a killing bottle is not available, and cannot be constructed, live adult insects can be placed directly into 75 percent ethyl alcohol for preservation.

The Rearing Container (Fig. 25):

Successful rearing of insects requires that the natural environment be artificially approximated as closely as possible. Regulation of humidity and temperature is desirable. An adequate food supply is necessary for larval feeding, and pupation sites should be provided. Restrictions imposed by field procedures and conditions may prohibit the construction and maintenance of optimal habitats for rearing and temporary methods must be employed. These conditions will probably be less than ideal, and transfer of the insects to more suitable cages should be made as soon as possible. The following are recommended as temporary measures.

To a small box or glass vial add the insects and a small piece of moistened blotting paper. Adequate food for larvae should be provided. If pupae are recovered from the leaf litter or soil, this should be included. Seal with cotton or similar material to allow air circulation without rapid loss of moisture. Avoid extremes of temperature and direct sunlight. Be very careful when adding or removing material not to damage the eggs, larvae or pupae.

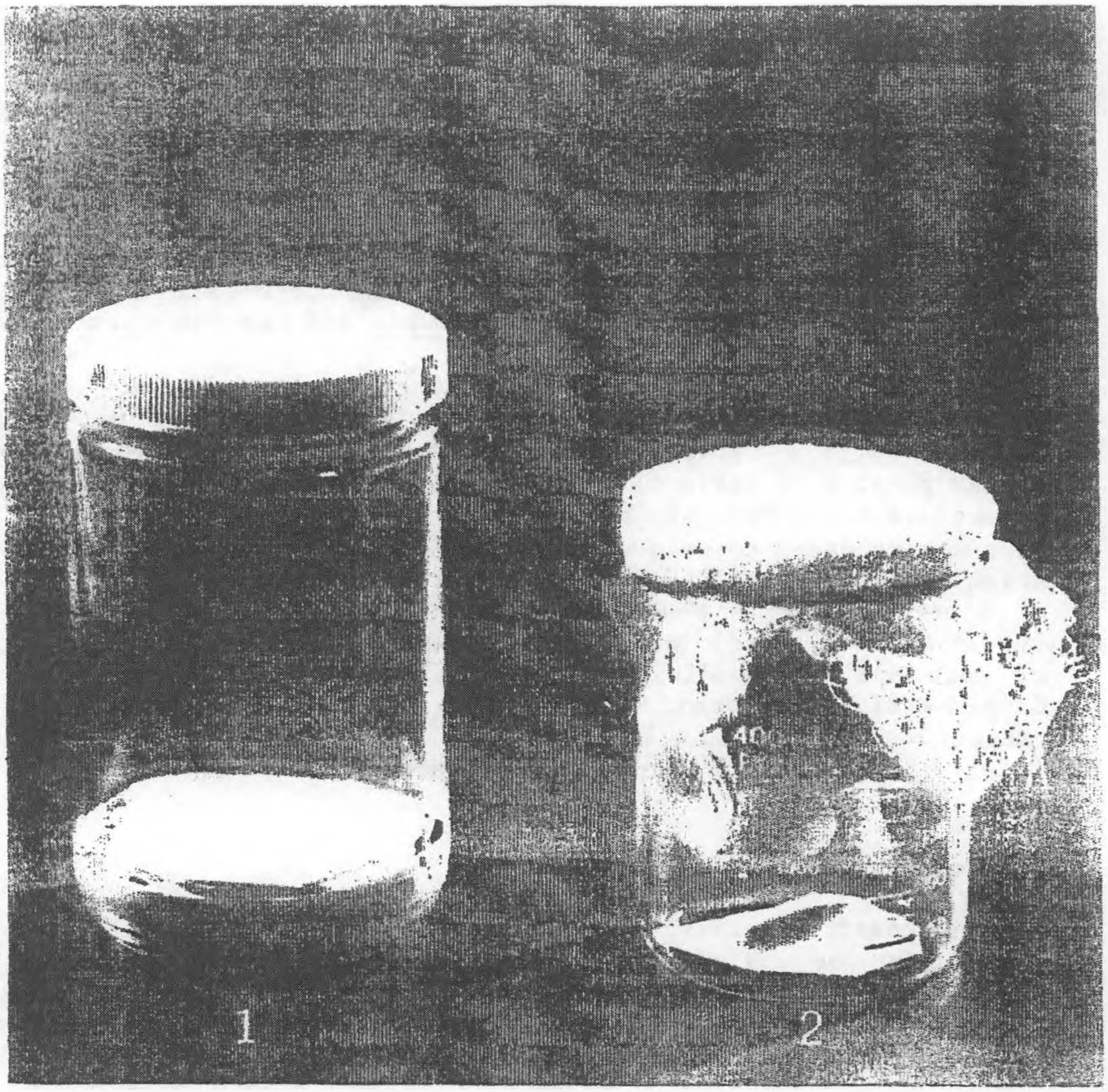

Figure 25. **Simply-constructed examples of 1) insect-killing bottle and 2) rearing container.**

Glossary

This Glossary provides common definitions for terms used in the manual.

Pl. = Plural
Adj. = Adjective

Terms in **Bold Face** are defined elsewhere in the Glossary.

GLOSSARY

A

ACROMION
A **PROCESS** of bone of the **SCAPULA**, overhanging the head of the **HUMERUS**; occasionally persists as a separate bone in the adult.

ADIPOCERE
A greasy, soapy transformation of body fat which has partially decomposed in a warm, moist, oxygen-poor environment. Forms in well-nourished subjects in a matter of weeks or months and may persist for two or more years in exceptional circumstances.

ADULT TEETH
Refers to those teeth which replace **DECIDUOUS** teeth, or erupt behind them in the jaw. The first adult tooth erupts around six years of age, and optimistically all will last a person's lifetime; also known as **PERMANENT** teeth.

ALIDADE
An optical surveying instrument commonly used by archaeologists in combination with a **PLANE TABLE** and **STADIA ROD** for mapping the topography of the **RECOVERY AREA**.

ALISPHENOID
Paired **PROCESSES** of bone from the **BASISPHENOID** forming a small portion of the inferior **NEUROCRANIAL VAULT**. Also known as the greater wing, it exists as a separate **CENTRE OF OSSIFICATION** in the very immature **SKELETON**.

AMALGAM
Otherwise known as silver dental fillings, this is an alloy of silver and tin mixed with mercury; used primarily as restorations on posterior teeth. These restorations are highly resistant to decay and heat.

ANNULUS
A circular, almost complete, ring of bone forming the support for the outer ear drum. After **FUSION** to the **PETROUS** bone (around birth), the annulus grows out as a tube known as the external auditory meatus, the shape of which may be racially diagnostic; also known as the **TYMPANIC RING** (pl. annuli).

ARTICULATED

Refers to a **SKELETON** in which the joints are still somewhat intact with **SOFT TISSUE** holding the bones in place; or bones which despite loss of soft tissue have not moved from their approximate anatomical position.

ARTIFACT

Any non-biological product of human activity associated with remains; for example, personal effects, surgical appliances, projectiles and foot prints.

ATLAS

First **CERVICAL VERTEBRA**, located at top of the spinal column, articulating with the **CRANIUM**.

AXIS

Second **CERVICAL VERTEBRA**, articulates superiorly with the atlas.

B

BASIOCCIPITAL

A separate **CENTRE OF OSSIFICATION** in the **OCCIPITAL** bone of the **FETAL CRANIUM** forming the anterior margin of the **FORAMEN MAGNUM**.

BASISPHENOID

A separate **CENTRE OF OSSIFICATION** in the **SPHENOID** bone of the **FETAL CRANIUM** forming the base of the pituitary fossa and articulating posteriorly with the **BASIOCCIPITAL.** The fibrous junction of the basioccipital and basisphenoid portions, known as the basal synchondrosis, obliterates through **FUSION** in young adulthood, serving as a useful indicator of skeletal maturity.

BIOLOGICAL IDENTITY

Expresses the basic biological characteristics of all persons in terms of age, sex, race and stature. This partial identification is usually determined from skeletal remains prior to attempts to determine personal identity.

BIOMETRICAL

Refers simply to measurements, of biological organisms, taken in a rigorous fashion between anatomically defined landmarks. This allows standardized comparisons between individuals or populations to show differences or similarities in size and shape.

BOSS
A marked accentuation in the curvature of the **FRONTAL** and **PARIETAL** bones. 'Bossing' is more pronounced, as a rule, in juvenile and female crania.

C

CALCANEUS
The largest of the **TARSAL** (ankle) bones; forms the heel.

CANINE
Also known commonly as the eye tooth or cuspid, the canine is the third tooth from the front (mid-line) in both the **DECIDUOUS** and **PERMANENT DENTITIONS**. It is characterized by having a sharpish, pointed crown and long root.

CAPITATE
The largest of the eight **CARPAL** (wrist) bones. From the thumb side, the third bone in the **DISTAL** row of the **CARPUS**.

CARBONIZED
The result of a fire or cremation where **SOFT TISSUES** of the body, or whole portions of insects and plant materials are preserved as blackened, relatively crusty, resistent specimens from which the contained moisture has been driven off.

CARPAL/CARPUS
Refers to the wrist and wrist bones as a whole. The eight morphologically dissimilar bones of the wrist, found as two rows of four each.

CARRION
Dead, putrefying **SOFT TISSUE**; a food source for **SAPROPHAGOUS** insects.

CAUCASOID
A major racial stock of humankind, mostly of European ancestry, sharing an inherited complex of physical features. The term is usually considered synonymous with 'white' individuals characterized by light skin. Police usually speak of 'class' differences rather than 'racial' differences.

CENTRE OF OSSIFICATION
The areas within a body or within a **SOFT TISSUE** precursor of a skeletal element where bone initially forms. There are separate centres of ossification for individual bones, many of their **PROCESSES**, and either or both ends.

CENTRUM

This is the heart or kidney shaped weight-bearing portion of the **VERTEBRAE** to which the **NEURAL ARCH** fuses during growth. All vertebrae and sacral vertebrae, except the first **CERVICAL** vertebra, have a centrum (pl. centra).

CERVICAL

In this context refers to the neck region, specifically the seven vertebrae of the neck.

CHRONOLOGIC AGE

This is the 'true' or calendrical age usually measured from date of birth (see **PHYSIOLOGIC AGE**).

CLAVICLE

Commonly known as the collar bone, the clavicle articulates with the **MANUBRIUM** and **ACROMION PROCESS** of the **SCAPULA**. It is a common site of fracture and often bears evidence of **PREMORTEM** trauma.

COCCYX

The 'tail bone' located at the end of the **SACRUM**, consisting of 3 to 5 bones.

COLEOPTERA

An **ORDER** of insects characterized by biting mouth parts, membranous hind wings beneath a thick, tough, outer wing, and complete **METAMORPHOSIS**; commonly known as beetles.

CONCHAE

Also known as turbinates, the conchae are delicate, scroll-like bones, inside the nasal aperture, lined with mucous membrane. Only the inferior conchae tend to separate from the **CRANIUM** after prolonged **DECOMPOSITION**.

CONTINUITY OF EVIDENCE

This vital aspect of **FORENSIC** procedure concerns the necessity for maintaining an unbroken chain of custody as evidence is collected, submitted through various investigators and specialists, to appear ultimately in court. It is essential that it be demonstrated that at no time did unauthorized persons have access to the evidence, or have opportunity to add, remove, or otherwise alter the evidence; also known as 'evidentiary escort'.

CORACOID PROCESS

A small finger-like **PROCESS** of bone on the **SCAPULA**.

CORNU

Small projection on the **HYOID** forming the arms of the 'U' from which ligaments attach the hyoid to the base of the skull (pl. cornua).

CORONOID PROCESS

Bony projection of bone on the **MANDIBLE** to which the **TEMPORAL** muscle attaches.

COSTAL

Refers to ribs (adj.).

CRANIUM

Considered to be that portion of the **SKULL** excluding the lower jaw and HYOID.

CRATERING

Describes the effect of a projectile on bone where the exit hole is larger than the entry hole due to an expanding bevel (cone of percussion) travelling through the bone from the point of impact. An example of this effect is seen in glass impacted by BB shot.

CREMATION

A fire in which a body is burned so severely as to affect the **HARD TISSUES**.

CUBOID

One of the seven **TARSAL** (ankle) bones located on the 'little toe' side of the foot.

CUNEIFORM

There are three of these roughly wedge-shaped bones in the ankle located between the 'big toe' side of the foot and the **CUBOID**.

D

DECIDUOUS

Those teeth which are replaced by the **PERMANENT DENTITION**; also known as **MILK TEETH**.

DECOMPOSITION

The process of body decay after death caused by the **PUTREFACTIVE** qualities of intestinal bacteria, and by environmental effects such as insect infestation and temperature.

DEHYDRATED

Bodies which lose their fluids rapidly in a warm dry locale tend to dry out and, under certain circumstances (for example, in an attic or behind a heat register), the **SOFT TISSUES** may actually mummify.

DENTAL FORMATION

The process of tooth growth starting at the top of the crown and proceeding to the tip of the root. The majority of a tooth's formation occurs prior to **ERUPTION** of the tooth but may be seen radiographically; i.e., with x-rays. Dental formation can be an accurate indicator of age in immature individuals, particularly children.

DENTAL RESTORATION

Refers to the materials involved in reconstructing the portion of a tooth removed to repair a cavity; may be **AMALGAM**, gold, silica, or plastic resin.

DENTITION

refers simply to the set of natural teeth in a mouth.

DEPTH BELOW DATUM (D.B.D.)

The vertical distance below a previously established arbitrary horizontal datum plane.

DIPTERA

An **ORDER** of insects characterized by a single pair of functional wings, sucking mouth parts and complete **METAMORPHOSIS**; commonly known as flies.

DISARTICULATED

A body which, through natural or purposeful agency, has the various joints no longer intact; usually signifies more or less scattered and often incomplete skeletal remains.

DISMEMBERMENT

Deliberate separation of the body into several parts (usually at the joints for the limbs and trunk); unless very skilfully done, cut or sawmarks will be preserved on the bone.

DISTAL

The extremity of an **ARTICULATED** anatomical element which is furthest from the trunk of the body. All long bones of the body have two extremities, one distal and one **PROXIMAL**.

DORSAL
The posterior or backwards facing surface of an anatomical structure from a subject in the normal anatomical position standing erect, face front with palms forward. Thus, one's back and the back of the hand are dorsal surfaces, regardless of the position of the body or its parts when observed.

E

EPIPHYSIS
A SECONDARY CENTRE OF OSSIFICATION at the end of growing bones separated from the **PRIMARY CENTRE** by a tough fibrous band of **SOFT TISSUE**. With prolonged **DECOMPOSITION** the fibrous union will decay yielding a loose epiphysis which can be easily overlooked in the recovery of immature skeletal remains (pl. epiphyses).

ERUPTION
The process of emergence of a tooth through the gum into the mouth.

ETHMOID
A delicate bone in the midline of the **SKULL** behind the nose forming a portion of the inner side of each bony **ORBIT**.

EVERSION
Describes the degree of outward flare at the angle of the lower jaw; more pronounced in males and heavy chewers.

EXINE
The outer covering of **POLLEN** grains.

EXOCCIPTAL
A separate **CENTRE OF OSSIFICATION** in the **OCCIPITAL** bone of the **FETAL CRANIUM** forming the sides of the **FORAMEN MAGNUM** .

EXPOSURE CRACKING
Seen on most bones, but particularly the **CRANIUM**, where repeated bouts of moisture and high temperature produce stress cracks in the outer surface of the bone.

EXTENDED BURIAL
Describes a body in which the lower limbs are straight in line with the trunk; position of the arms may vary.

EXTERNAL OCCIPITAL PROTUBERANCE
A bony projection on the **OCCIPITAL** in the midline forming the attachment for a major ligament which balances the weight of the **SKULL** on the spinal column; more pronounced in males because of the greater weight of the face.

F

FECES
Excrement or stool, which prior to evacuation of the bowels is described as fecal matter. Fecal matter should be collected for analysis of foods or drugs taken before death. Animal feces are called **SCATS**.

FEMORAL
Referring to the **FEMUR** (adj.).

FEMUR
The largest limb bone, forming the upper leg; also known as the thigh bone.

FETAL
Describes a developing human between four months **INTRAUTERINE** and full term (adj.).

FIBULA
The long, thin outer (lateral) of the two bones in the lower leg.

FIXED DATUM
A permanent reference point to which a mapped area is tied; for example, a tagged tree or marked stake. All mapping measurements must be referable to the fixed datum in order to relocate, with confidence, the spatial distribution of the site and its contents.

FLAGGING TAPE
Wide, non-sticky tape used by surveyors, forestry personnel and archaeologists to mark location or direction; usually bright orange or blue.

FLEXED BURIAL
A body, usually lying on its side, with the limbs drawn up into a contracted position. Such a position would normally indicate deliberate positioning of the limbs by someone else, except in the case of new-born infants.

FLOTATION
A process for recovering small items such as insect and plant materials by immersing **MATRIX** in a container of water. Both the floating residue and bottom sediment should be recovered, air dried and examined.

FORAMEN
A passage or hole in a bone through which nerves and blood **VESSELS** pass (pl. foramina).

FORAMEN MAGNUM
The large foramen in the **OCCIPITAL** at the base of the human **CRANIUM** through which protrudes the brain stem passing into the spinal column.

FORENSIC
Relating to the courts of law; commonly used to indicate matters of police or legal significance.

FORENSIC ANTHROPOLOGY
The study of human bones and teeth with associated evidence to assist various representatives of the legal system in the identification of human remains and interpretation of circumstances affecting death and decomposition.

FRONTAL
An element of the anterior **CRANIUM** forming the forehead and upper margin of the **ORBITS**. In **FETAL** and infant human remains (seldom in adults) the frontal is composed of left and right halves.

FUSION
The replacement of **SOFT TISSUE** between two bony elements by bone resulting in a solid union. Maturation of the human skeleton is characterized by progressive fusion reducing the number of discrete elements considerably. Trauma and old age can produce pathological fusion of elements.

G

GAMETE
A general term for the male or female reproductive cell. Here the term refers to **POLLEN** grains of flowering plants which are analogous to human male sperm.

GLABELLA
An anatomical landmark denoting the (usually) bald spot between the eyebrows or, in the **SKULL**, the most projecting point on the brow in the midline.

GROWTH ARREST LINE
Also known as Harris' Lines, these are relatively dense 'bands' of bone near the extremity of a skeletal element marking the former end of the growing bone when growth temporarily stopped, due to illness or malnutrition. These can be seen radiographically, and can assist in **INDIVIDUALIZING** the remains.

GRUB
LARVAL form of **COLEOPTERAN** insects.

H

HAMATE
A large wrist bone exhibiting a pronounced hook-like projection. From the thumb, the hamate is the fourth bone in the **DISTAL** row of the **CARPUS**.

HARD TISSUES
An inclusive term for the bones and teeth.

HAVERSIAN
Name applied to bone remodeled through the removal and redeposition of bone, in the form of secondary **OSTEONS**. Osteons are circular when the bone is thin-sectioned transversely for viewing under a microscope. Progressive changes in the incidence and form of osteons are used as an age indicator in adult skeletal remains.

HOLOMETABOLOUS
Describes insects, such as flies and beetles, which exhibit dramatic growth transformations from egg to **LARVA** to **PUPA** to adult; i.e., they undergo a marked change (**METAMORPHOSIS**) in body form, for example, growing wings and legs on a **MAGGOT**-like body during the pupal stage.

HUMAN REMAINS
An inclusive term for the dead human body regardless of the stage of **DECOMPOSITION**.

HUMERUS
The bone of the upper arm.

HYOID
A U-shaped bone in the floor of the mouth supporting the tongue and swallowing musculature. The fractured hyoid can be evidence of manual strangulation.

I

IDENTIFICATION
Broadly speaking, this implies determining who specifically is represented by some remains. However, the term is used by some **FORENSIC ANTHROPOLOGISTS** to mean only the preliminary diagnosis of the basic biological features of age, sex, race and stature (see **INDIVIDUALIZATION**).

ILIUM
The major portion of the **INNOMINATE** bone contributing to the pelvic basin which supports the abdominal contents. Around puberty the ilium fuses to the **ISCHIUM** and **PUBIS** in the region of the hip socket.

INCISOR
At the front of both the upper and lower jaws are four incisor teeth characterized by a crown with a chisel-like working edge and a single, short root.

INCUS
One of three very small bones from the middle ear inside the **TEMPORAL** bone of the **SKULL**; also known as the anvil.

INDIVIDUALIZATION
The process of determining the specific identity of a person from a comparison between idiosyncratic features of the bones and teeth and **PREMORTEM** records such as medical/dental records, x-rays and photographs.

INNOMINATE
The hip bone, or pelvis, forming a portion of the pelvic girdle. It forms through **FUSION** of the **ILIUM**, **ISCHIUM** and **PUBIS** at puberty.

IN SITU
Means 'in place'. The implication is that an object whose location is of importance must not be moved by the investigator prior to recording all relevant locational data, including photographs.

INSTRUMENT
An inclusive term for any object which produces a wound on the body; for example, bullets, shovels, hat pins, rings and so on. The term is deliberately broad so as to embrace many more objects of violence than merely the commonly recognized "weapons".

IN UTERO
In the womb or uterus; the age of a **FETUS** is usually expressed in weeks or months since conception, i.e. 32 weeks in utero (i.u.).

INTRAUTERINE
Synonymous with **IN UTERO**.

ISCHIOPUBIC RAMUS
The portion of bone which joins the **ISCHIUM** and **PUBIS**; **FUSION** occurs around age eight.

ISCHIUM
A portion of the **INNOMINATE**; fuses with the **ILIUM** and **PUBIS** to form the **INNOMINATE**.

L

LACRIMAL
A small bone of the inner margin of the **ORBIT**, bearing a channel through which tears are passed into the nose.

LAMELLAR
Describes the layered structure of bone seen microscopically (particularly in cross-section). It is deposited during growth and throughout adulthood as sheets upon external and internal surfaces of bones, and within **OSTEONS** as concentric rings. The layered sheets are characteristic of immature bone, while concentric layered rings typify adult bone as a result of osteonal remodeling (see **HAVERSIAN**).

LARVA
A pre-adult growth stage derived from an insect egg prior to **METAMORPHOSIS**. The larva of flies is the **MAGGOT**, and of beetles is the **GRUB**. There may be several larval stages prior to adulthood (pl. larvae).

LINE LEVEL
Similar to a carpenter's bubble level, except it is designed to be hung from a horizontal string. Allows the determination of vertical depth measurements below the horizontal datum plane (see **DEPTH BELOW DATUM**).

LINGUAL
Indicates the surface of oral structures, particularly teeth, which face toward the tongue.

LUMBAR
Describes the five vertebrae in the lower back (waist) region which do not bear ribs.

LUNATE
A small crescentic bone of the wrist; from the thumb, the second bone in the **PROXIMAL** row of the **CARPUS**.

M

MAGGOT
The **LARVAL** form of **DIPTERAN** insects.

MALLEUS
One of three very small bones of the middle ear located in the **TEMPORAL** bone; also known as the hammer.

MANDIBLE
The lower jaw which, in the newborn, is separated at the chin into left and right halves.

MANDIBULAR CORPUS
The body of the mandible including the chin, base and tooth-bearing region but excluding the **MANDIBULAR RAMUS**.

MANDIBULAR RAMUS
A roughly vertical bony link between the corpus and the **CRANIUM**. The majority of strong chewing muscles attach to the mandibular (ascending) ramus.

MANDIBULAR TORUS
A raised series of dense bony bumps, or a fairly continuous ridge of bone, along the **LINGUAL** side of the **MANDIBULAR CORPUS** below the teeth, which occurs more commonly in North American native peoples.

MANUBRIUM
The topmost portion of the breast bone, most often occurring as a discrete element, to which attach the collar bone and upper ribs.

MASTOID PROCESS
A bony projection from the **TEMPORAL** bone of the **CRANIUM** to which attach muscles for turning the head to either side. Usually larger in males, the mastoid process can be felt just behind the ear lobe.

MATRIX
The dirt, soil, gravel, sand, ash and so on, in which human remains are found and which often adheres to the bone surfaces. Samples of matrix should be recovered along with the remains. The removal of adhering matrix should be left to the specialist.

MAXILLA
The upper jaw (pl. maxillae, designating left and right halves, adj. maxillary).

MEDIAL
Designates the surface of an anatomical structure which faces towards the midline of the body, for example, the medial side (inside) of the thigh.

METACARPALS
The five bones forming the palm of the hand between the wrist and the finger bones (**PHALANGES**).

METACARPUS
Name for the general region of the hand around the **METACARPALS**; all five metacarpals considered together.

METAMORPHOSE
The act of undergoing an extreme change; for example, the marked changes in the **PUBIC SYMPHYSIS** during adult life. Also the transformation of an insect from **PUPA** to adult is described as a metamorphosis (pl. metamorphoses).

METATARSALS
The five bones of the foot between the ankle and the toe bones.

METER GRID
A square box frame one meter on a side, fitted with a grid of strings (usually at intervals of 10 centimeters) as an aid to sketching or locating a concentration of exposed objects or features during mapping.

METRICAL ANALYSIS

The process of measuring bones in a standardized fashion and comparing the size and shape of the specimen to a reference set of figures, usually by means of statistics. Most metrical analyses of human skeletal remains in **FORENSIC** cases are meant to determine sex, race and stature. Metrical analysis is considered to be less subjective than observational (non-metric) analysis but is by no means necessarily more reliable. Applicability of metric techniques diminishes with increased fragmentation of the remains.

MILK TEETH

These are the so-called baby teeth which **ERUPT** into the mouth between six months and two and one-half years of age. They are replaced by the **PERMANENT** teeth between approximately six and twelve years of age. Also known as the **DECIDUOUS** teeth, there are five milk teeth in each **QUADRANT** of the mouth, or twenty in total.

MOLAR

These are the **DECIDUOUS** and **PERMANENT** teeth located at the back of the tooth row which have two or three roots and a large crown with a complex chewing surface. There are normally two deciduous and three permanent molars in each **QUADRANT** of the jaw.

MONGOLOID

A major racial stock of humankind found in eastern Asia and in the New World sharing an inherited complex of physical features, particularly yellow to brown skin and straight black hair. In that New World natives are recently derived from Asian mongoloids, it is difficult on occasion to tell them apart skeletally.

MORPHOLOGY

The study of the form or appearance of an organism or its parts; basically a description of what something looks like.

MYLOHYOID

A skeletal variation more commonly seen in North American native Indians where a bridge of bone roofs the **MYLOHYOID** groove, along which pass the **MYLOHYOID** artery and nerve. It is located on the inner side of the vertical portion of the mandible behind the teeth.

N

NASAL ROOT

The depression beneath the brow and between the eyes where the top of the nose is located.

NASAL SILL

The bony lower margin of the nasal opening (aperture) on either side of the **NASAL SPINE**. The nasal sill tends to be more obvious and sharp in males.

NASAL SPINE

The bony projection from the lower margin of the nasal opening where the cartilage forming the nostrils attaches in the midline.

NAVICULAR

A medium-sized bone in the ankle which can be felt midway between the arch and the large bump (the **DISTAL** end of the **TIBIA**) on the inside of the ankle. The term is less commonly applied to the **SCAPHOID** bone of the wrist.

NEGROID

A major racial stock of humankind largely of African ancestry sharing an inherited complex of physical features notably kinked hair and dark skin; usually considered synonymous with "blacks".

NEURAL ARCH

The portion of a **VERTEBRA** on the posterior side which protects the spinal cord, and to which attach the deep back muscles. Each neural arch is initially ossified in a left and right half which fuse to each other before the neural arch fuses to the **CENTRUM**. Consequently, the spine of infants and young children can be quite difficult to excavate and collect because of the many separate elements.

NEUROCRANIAL VAULT

Describes the portion of the **CRANIUM** which houses and protects the brain; the cranium excluding the facial bones.

NORMATIVE STANDARD

A reference set of data on a particular aspect of the **MORPHOLOGY** of a large sample of persons whose important characteristics affecting the aspect in question have been fully documented. One example is the normal range of variation determined for male and female **STATURE** in different ethnic groups.

NUCHAL LINES
Ridges of raised bone on the lower part of the back of the **CRANIUM** where neck muscles attach; usually more pronounced in males.

O

OCCIPITAL
A bone at the back of the **CRANIUM** to which the neck muscles attach. The spinal cord passes (via **FORAMEN MAGNUM**) from the brain stem where the occipital curves forward to help form the base of the **SKULL**. Formed by the **FUSION** of the **BASIOCCIPITAL**, the **EXOCCIPITALS**, and **SQUAMA**.

OCCIPITAL CONDYLES
Two raised bumps on the **OCCIPITAL** bone, on either side of the **FORAMEN MAGNUM**, which help form the joint between the **SKULL** and spine; these tend to be larger in males.

OCCIPITAL PROFILE
Describes the evenness of curvature of the **OCCIPITAL** bone when the **CRANIUM** is viewed from the side. The occipital profile tends to be rounded in **CAUCASOIDS** and **NEGROIDS**, but more angulated in **MONGOLOIDS**.

OCCLUSAL
Describes the chewing, or working, surfaces of teeth; those surfaces of teeth, in upper and lower jaws, which contact each other.

ODONTOID
A tooth-like projection on the upper margin of the **CENTRUM** of the second **CERVICAL VERTEBRA (AXIS)** around which the **ATLAS**, and hence **SKULL**, pivot when the head is turned. Preserves well in severely cremated bodies.

ORBIT
In terms of the **SKULL**, refers to the opening which houses each eye; formed from the contributions of many bones in the **SKULL**.

ORBITOSPHENOID
Paired **PROCESSES** of bone from the **SPHENOID** forming the back of the **ORBIT** and through which passes the optic nerve to the eye; they exist as separate **CENTRES OF OSSIFICATION** in the **FETAL CRANIUM**.

ORDER
A large scale grouping of biological organisms all of which share a number of physical and behavioural features not shared with other Orders; for example, Order **DIPTERA** or Order Primates, which includes, amongst others, monkeys, apes and man.

OSSIFICATION
The process whereby **SOFT TISSUE** is replaced by bone, normally during growth.

OSTEOLOGY
The rigorous study of bone, bones and skeletons, stressing their evolution, growth and function in relation to the whole organism.

OSTEOMETRY
Referring to the standardized measurement of skeletal elements for descriptive and comparative purposes (see **METRICAL ANALYSIS**).

OSTEOMETRIC BOARD
A standard measuring device for limb bones, fitted with an upright and a longer base marked out in metric intervals for ease of measurements.

OSTEON
A characteristic, roughly circular, microscopic structural feature of bone viewed, for example, in thin cross-sections of long bones. An osteon is characteristic of adult bone which is remodeled throughout life; hence, osteon numbers have been used as age indicators in adult skeletal remains (see **HAVERSIAN**).

P

PALATE
The roof of the mouth formed in great part by inward projections from the left and right **MAXILLAE**; should be examined carefully for signs of corrective surgery in the case of cleft palate.

PALATINE
Separate bones forming the posterior quarter of the **PALATE**.

PALYNOLOGY
The analysis of **POLLEN** grains whose protective coating and distinctive sculpturing allow identification of the type of plant; useful for determining the season of death or if a body has been transported to a locale differing in plant types.

PARIETAL
Two bones meeting in the midline of the **CRANIUM** and forming the top and sides of the **NEUROCRANIAL VAULT.** The degree of parietal **BOSSING** and strength of the **TEMPORAL** line on the parietal are useful sex indicators.

PATELLA
The knee cap which functions as a large **SESAMOID** in the tendon of the front thigh muscles increasing the mechanical advantage of the pull of these muscles when straightening the leg (acting somewhat like the bridge on a violin); these bones are commonly overlooked during recovery.

PENETRATING WOUND
A wound which only enters an anatomical structure but does not pass through to the other side (see **PERFORATING WOUND**).

PERFORATING WOUND
A wound which enters and passes all the way through to the other side of an anatomical structure; the significance of perforating wounds is that the holes of entry and exit must not be confused with two separate woundings.

PERINATAL
Around birth; indicates events or a stage of growth coinciding with a degree of maturity consistent with birth (whether or not such occurred, or the event was a live or still birth).

PERMANENT
In this context, refers to the **ADULT TEETH**.

PETROUS
A dense bone in the base of the **CRANIUM** containing the ear ossicles (**INCUS**, **MALLEUS** and **STAPES**) which fuses to the **SQUAMOUS** and tympanic ring (**ANNULUS**) to form the **TEMPORAL** bone. The petrous bone is one of the first in the human skeleton to start to ossify, around the fifth month **IN UTERO**.

PHALANGES
The bones of the fingers and toes. The thumb and big toe have only two phalanges while the others all have three (singular 'phalange').

PHYSICAL ANTHROPOLOGY
The study of how and why human beings evolved into the physically and culturally varied populations we see today; a growing branch of physical anthropology is **FORENSIC ANTHROPOLOGY.**

PHYSIOGRAPHY
The description of variability in land forms relating to climate, vegetation, terrain and so on.

PHYSIOLOGIC AGE
Describes the physical maturity of an individual in comparison to the typical age at which the majority of the population reaches that degree of physical maturity. Since one cannot normally determine **CHRONOLOGIC AGE** from skeletal and dental remains, we are forced to express the age equivalent of the observed physical maturity with the stated assumption that the person is fairly average in that feature. For example, that **EPIPHYSEAL FUSION** is occurring indicates the attainment of puberty and an age of 'x' years, if he or she is not unusually advanced or retarded in this respect. The same problem is encountered in adult remains but becomes more acute with increasing age; for example, degenerative changes in the **SKELETON** can produce a senile appearance starting in middle age.

PISIFORM
A pea-sized wrist bone. From the thumb, the fourth bone in the **PROXIMAL** row of the **CARPUS**.

PLANE TABLE
An adjustable drawing table mounted on a tripod serving as the base for the **ALIDADE** in mapping.

POLLEN
Microspores of seed plants each containing the male **GAMETE**. Wind and insects carry the pollen to other plants containing the female egg cell where fertilization can occur.

POLLEN RAIN
The largely continuous load of pollen in the air which settles on the landscape throughout the year but which becomes much more intense during the flowering season. Thus, for example, a body deposited in the spring and covered since that time may bear a different variety of pollen types than that falling at the time of recovery.

POST-BREGMATIC DEPRESSION
Bregma is an anatomical landmark on the top of the **SKULL** where the two **PARIETALS** and the **FRONTAL** bone meet at a single point in the midline. A post-bregmatic depression, then, is a slight depression behind bregma on the parietals running from side to side.

POSTMORTEM
Refers to "after death"; observations made on features of the dead person which have not been altered by death or by subsequent postmortem events might be compared to descriptions of the same features made while the person was alive (see **PREMORTEM**).

PREMOLAR
Teeth of the adult **DENTITION** which replace the **DECIDUOUS MOLARS** and which are characterized by a crown with two cusps (peaks) on the **OCCLUSAL** surface and usually one root; two in each **QUADRANT**, they are situated between the **CANINE** and **MOLARS**.

PREMORTEM
Means "prior to death"; observations recorded on features of living individuals constitute premortem records and can be compared to **POSTMORTEM** observations in the process of **INDIVIDUALIZATION**.

PRIMARY OSSIFICATION CENTRE
The point where a future bone starts to **OSSIFY** prior to the appearance of **SECONDARY CENTRES OF OSSIFICATION** for the **EPIPHYSES**. Typically in a major limb bone the primary ossification centre grows to form the shaft while the epiphyses form either end.

PROCESS
A process constitutes any growth of bony substance which projects significantly from the main portion of the element, for example, **ACROMION**.

PROGNATHIC

Indicates the mouth region which projects somewhat beyond the facial profile; usually a consequence of large teeth, particularly front ones; as in **NEGROIDS**.

PRONATED

Describes the forearm, when the hand is rotated so as to be palm down, with the **RADIUS** crossed over the **ULNA**.

PROSTHESES

Artificial appliances which replace missing teeth; dental prostheses are bridges that attach to existing teeth or dentures (false teeth) which are removable. Prostheses are often highly individualistic and resist decay and fire.

PROXIMAL

The extremity of an anatomical element which, when articulated, is in a direction towards the trunk of the body, for example, the proximal (shoulder) end of the **HUMERUS**.

PUBIS

The portion of the **INNOMINATE** which, with its counterpart from the other side, forms the pubic mound at the front of the pelvis. The penis and clitoris attach to the front surface of the pubis; modifications related to childbearing make the pubis an excellent indicator of sex. The pubis fuses to the **ILIUM** and **ISCHIUM** in the region of the hip socket around puberty (adj. pubic).

PUBIC SYMPHYSIS

The joining surfaces of the pubic bones in the mid-line of the pelvis at the front. Between the two surfaces is a gristle-like substance. Throughout adult life the surface of the pubic symphysis undergoes a fairly regular process of bone remodeling (termed **METAMORPHOSIS**) which is useful as an age indicator. Normally an immovable joint, in females experiencing hormonal changes in preparation for childbirth, the fibrous joint relaxes and widens somewhat. This results in more variability in the age related changes of the female pubic symphysis (pl. symphyses).

PUPA

Growth stage between **LARVA** and adult of insects which undergo **METAMORPHOSIS**, where movement and feeding cease but development continues until the adult form is completed (pl. pupae).

PUPARIUM
The pupal case protecting the developing **PUPA**; the discarded pupal case after the adult has emerged (pl. puparia).

PUPATION
The process of becoming a **PUPA**; the **LARVA** to pupa transition requiring the formation of the **PUPARIUM**.

PUTREFACTION
Flesh which is becoming rotted, an early stage in the process of **DECOMPOSITION**.

Q

QUADRANT
The full **DENTITION** is considered to consist of four quarters; i.e., left and right halves of both upper and lower jaws. Each quarter is called a dental quadrant.

R

RADIOGRAPH
A record produced on photographic film by roentgen rays; specifically an x-ray photograph. Commonly known as an x-ray, radiographs may be very useful **PREMORTEM** records; however, they are seldom kept on file (hospital, dental, chiropractic, etc.) for very long. As soon as a person is reported missing, precautions must be taken to ensure that all manner of premortem records are saved until such time as human remains are found for comparison.

RADIUS
One of the two bones in the forearm; lying on the thumb side of the forearm. A common site of fracture from falling on the outstretched palm.

RECOVERY AREA
The locale in which evidence is observed, mapped and collected.

RODENT
The most widespread and numerous of all mammals, characterized by large ever-growing incisors adapted for gnawing. Rodents are commonly observed to gnaw on dried **SOFT TISSUE** adhering to bones and on the bones themselves; a significant factor in the scattering, loss and breakdown of the **SKELETON**.

S

SACRUM

Bone, forming the posterior portion of the pelvic girdle, which supports the spinal column and weight of the chest and head; consequently, the sacrum is a useful sex indicator.

SAGITTAL CONTOUR

The degree of curvature of the top of the **CRANIUM** when viewed from the side; a moderately useful criterion of race.

SAPONIFICATION

The process whereby subcutaneous fat of bodies decomposing in a warm moist, oxygen-poor environment changes its chemical structure to become a greasy soapy substance resistant to decay (see **ADIPOCERE**).

SAPROPHAGOUS

An organism, such as some insects, which feeds on rotting flesh or body fluids.

SCAPHOID

A bone of the wrist which **ARTICULATES** with the **DISTAL RADIUS** and, like the radius, is subject to fracture from falling on the palm. From the thumb, the first bone in the **PROXIMAL** row of the **CARPUS**.

SCAPULA

The shoulder blade, a triangular bone which is very thin in places and may preserve, rather faithfully, the shape of a **PERFORATING** instrument, such as a knife.

SCAT

Animal droppings or **FECES**; scats are often found in association with human skeletal remains and should always be collected as the evidence of animals in the locale may help explain the state of the remains. Not to be confused with bird pellets which are regurgitated bone, hair and feather bundles that have not passed through the digestive tract. Some birds, notably hawks, eagles and owls, feed on small animals and occasionally upon **CARRION**.

SEARCH AREA

The region around the discovery locale which is searched for further evidence of human remains, **ARTIFACTS** and the like; particularly approaches to the site, making observations on the environmental context of the remains.

SECONDARY OSSIFICATION CENTRE

EPIPHYSIS, a small bony centre which grows at the extremities of major bones and to which they ultimately fuse, causing the cessation of growth (see **PRIMARY OSSIFICATION CENTRE**).

SESAMOID

A nodule of bone, usually situated within a tendon of a muscle which serves the dual function of protecting the tendon from being crushed and enhancing the leverage of the muscle. Sesamoids in the human **SKELETON** are the two knee caps and the barley-grain sized, paired sesamoids at the base of the big toes and thumbs. The bear paw, which approximates in appearance the human hand after prolonged decomposition, can be distinguished grossly or radiographically by the presence of sesamoids at the root of all the **PHALANGES**.

SETA

Tiny hair-like bristles on the legs of some insects (for example, beetles) which are useful for identification (pl. setae).

SIBLING

An inclusive term for one's brother or sister.

SINUS

An air-filled cavity within a bone, which serves to lighten the bone without reducing structural strength. Important sinuses in the human **SKELETON** are found in the **FRONTAL** bone, **MAXILLA** and **MASTOID PROCESSES**; they may be useful as sex indicators.

SITE BOARD

A slate or plastic letter board, included in photgraphs, describing what is being recorded, where and when.

SKELETON

The bony support structure of the body, which also serves to protect organs and as a mineral reservoir. Since the skeleton is considered to include the teeth, it can be fairly stated that the teeth are the only part of a skeleton to contact the environment directly in living animals. Their susceptibility to modification makes the **DENTITION** so useful in the **IDENTIFICATION** of human remains.

SKELETONIZED

Being stripped of flesh; reduced to bare bones.

SKULL
That part of the human **SKELETON** forming the head which protects the brain and sense organs, and bears the teeth. The skull is composed of the **CRANIUM**, the **MANDIBLE**, and the **HYOID**.

SOFT TISSUE
A useful term for any residue of decomposing remains which is not bone or tooth.

SPHENOID
A complex bone in the base of the **CRANIUM** which is formed through **FUSION** of several **PROCESSES** (**ORBITOSPHENOID**, **ALISPHENOID**) to a central body (**BASISPHENOID**) by the end of the first year of life.

SQUAMA
The large, thin, curved, tabular portion of the **OCCIPITAL** at the back of the **CRANIUM**.

SQUAMOSAL
The thin, flat plate of bone attaching to the **PETROUS** which together help form the **TEMPORAL** bone located on the lower side of the **NEUROCRANIAL VAULT** in the ear region.

STADIA ROD
A calibrated surveyor's staff used for mapping elevations and distances in conjunction with an **ALIDADE** or **TRANSIT**.

STAPES
One of the three small ear bones, also known as the stirrup.

STATURE
An alternative term for height. A great deal of effort is expended by forensic anthropologists in determining stature from partial or complete limb bones, since height is a common attribute of a police blotter description of an individual.

STERNAL BODY
The lower part of the breast bone to which ribs attach (see **MANUBRIUM**).

STERNEBRAE
The **STERNUM** is composed of a number (usually five) of separate sternebrae which, in the young child, are rather like checkers. These finish fusing around puberty.

STERNUM
The breast bone, consisting of the **MANUBRIUM** and **STERNAL BODY**.

SUBPUBIC CONCAVITY
Describes the inferior margin of the pubic bone, useful as a sexing aid. In females, it appears in front view rather curved, but in males is straighter.

SUPINATED
Position of the hand with the palm facing forward so that the **RADIUS** and **ULNA** are parallel (see **PRONATED**).

SUPRAMASTOID CREST
A ridge of bone on the **CRANIUM** above the ear hole marking the attachment area for a major jaw muscle; often more pronounced in males.

SUPRAORBITAL MARGIN
The upper margin of the **ORBIT** which tends to be more rounded in males due to their heavier brows (see **SUPRAORBITAL RIDGES**).

SUPRAORBITAL RIDGES
A raised ridge of bone above each **ORBIT** contributing to the heavier brow of males.

SUTURE
The line of union at the immovable joints of the bones of the **NEUROCRANIAL VAULT**. Suture pattern is characteristically complex, almost like dove-tailing, for most cranial sutures. With increasing age, progressive **FUSION** leads to obliteration of the suture; hence suture 'closure' is a useful indicator of gross age categories, such as young or old adult.

T

TALUS
A major ankle bone between the heel and lower leg bones. The sizes of the talus and **CALCANEUS** (heel) are reasonably good indicators of sex since virtually the entire body weight of the (usually) heavier male is concentrated on the ankles.

TARSALS
The seven ankle bones of the human foot, considered as a group.

TARSAL SEGMENT
Many insect tarsae are divided into a characteristic number of tarsal segments (see **TARSUS**).

TARSUS
The portion of a typical insect's leg which is between the tibia and the claws. Variability in the structure of the tarsus as an adaptation for locomotion and feeding amongst different insects makes the tarsus a useful guide to identification of species (pl. tarsae).

TAXONOMY
The study of describing, naming and classifying organisms in terms of their similarities and differences in (primarily) **MORPHOLOGY**. Organisms classified together are considered to have had a relatively recent common ancestor from which they have diverged through evolution.

TEMPORAL - Definition 1
A major bone of the **CRANIUM** forming the lower side and part of the base; composed of the **SQUAMOSAL**, **PETROUS** and **ANNULUS** which finish fusing to each other shortly after birth.

Definition 2
Signifying time, that is, information about the relative timing of events.

TEMPORAL LINES
(See **TEMPORAL** Definition 1) A pair of lines, one of which is faint, on the side of the **NEUROCRANIAL VAULT**, marking the attachment of the temporal muscle which inserts on the **CORONOID PROCESS** of the **MANDIBLE** and acts to close the mouth. The temporal lines and the **SUPRAMASTOID CREST** are more pronounced in males because of their larger average lower jaw size.

THORACIC
Describes the rib-bearing **VERTEBRAE** (adj.).

TIBIA
The major bone of the two in the lower leg, on the big toe side; also known as the shin bone (see **FIBULA**).

TOOL MARK
An impression on relatively softer material by any tool, such that the individual characteristics of the tool are imparted to the contacted surface. These can be matched, linking a

particular tool (or weapon or **INSTRUMENT**) to a particular impression; for example, knife, saw or hatchet marks on bone. Because bone is fairly hard and brittle under heavy impact, tool marks on bone are rare; but if imparted should be fairly faithful reproductions with little distortion.

TRANSIT
A surveying instrument which is mounted directly on a tripod without an intervening **PLANE TABLE** (see **ALIDADE**).

TRANSVERSE PROCESS
Bony projections, each with its own **EPIPHYSIS**, from the sides of the **VERTEBRAE** to which attach back muscles.

TRAPEZIUM
A small wrist bone on which the thumb rotates across the palm. From the thumb, the first bone of the **DISTAL** row of the **CARPUS**.

TRAPEZOID
A small wrist bone. From the thumb, the second bone of the **DISTAL** row of the **CARPUS**.

TRIANGULATION
A method of recording the location of an object by measuring its distance from two other defined points a known distance apart.

TRIQUETRUM
A small wrist bone; from the thumb, the third bone of the **PROXIMAL** row of the **CARPUS**.

TROCHANTER
Major bumps on the **PROXIMAL** end of the **FEMUR** to which attach large hip muscles.

TYMPANIC DEHISCENCE
A hole in the inferior surface of the bony tube formed as an outgrowth of the **TYMPANIC RING**; more common in North American natives.

TYMPANIC RING
An alternative term for the **ANNULUS**, which supports the outer ear drum, and forms the outer wall of the middle ear. During childhood the tympanic ring grows outward to form a bony tube.

U

ULNA
One of the two bones of the forearm, located on the little finger side (see **RADIUS**).

V

VASCULAR
Pertaining to blood vessels.

VENATION
The system of veins in the wing of an insect which is an important characteristic for classification.

VENTRAL
Describes a surface facing towards the front of the human body.

VENTRAL ARC
A distinct ridge of bone on the **VENTRAL** surface of the **PUBIC** bone In the female the ventral arc sweeps widely to the side while in the male, the arc is more vertical and less distinct.

VERTEBRA
One of a series of bones in the back forming the spinal column, which serves to protect the spinal cord and as attachment areas for the trunk muscles (pl. vertebrae).

VITRIFICATION
The process where bone heated to temperatures in excess of 800°C acquires a hard porcelain-like quality with a distinct tonal sound when tapped against a hard surface.

VOMER
A small bone located behind the nose in the midline contributing to the bony nasal septum.

Z

ZYGOMA
The cheek bone, which in **MONGOLOID** peoples tends to be more projecting (pl. zygomae).

References and Recommended Reading

Adelson, A.
1974 *The Pathology of Homicide*. Charles C. Thomas, Springfield.

Akbarnia, B., J.S. Torg, J. Kirkpatrick, and S. Sussman
1974 Manifestations of the Battered Child Syndrome. *Journal of Bone and Joint Surgery* 56A:1159-1166.

Bass, W.M.
1971 *Human Osteology: A Laboratory and Field Manual of the Human Skeleton*. Missouri Archeological Society, Columbia.

Bass, W.M. and W.H. Birkby
1978 Exhumation: The Method Could Make the Difference. *F.B.I. Law Enforcement Bulletin* 47(7):6-11.

Binford, L.R.
1981 *Bones. Ancient Men and Modern Myths*. Academic Press, Toronto.

Boyd, R.M.
1979 Buried Body Cases. *F.B.I. Law Enforcement Bulletin* 48(2):1-7.

Cullason, A.D.
1969 Identification by Probabilities and Trial by Arithmetic (A Lesson for Beginners in How to be Wrong with Greater Precision). *Houston Law Review* 6:471-518.

Denne, M.P.
1977 Dating of Events From Tree Growth and Wood Structure. *Journal of the Forensic Science Society* 17:257-264.

Easton, A.M. and K.G.V. Smith
1970 The Entomology of the Cadaver. *Medical Scientific Law* 10:208-215.

Erdtman, G.
1969 *Handbook of Palynology*. Hafner Publishing Co., New York.

Facchini, F. and D. Pettener
1977 Chemical and Physical Methods in Dating Human Skeletal Remains. *American Journal of Physical Anthropology* 47:65-70.

Geberth, V.J.
1983 *Practical Homicide Investigation: Tactics, Procedures and Forensic Techniques*. Elsevier, New York.

Gejvall, N. Gustav
1963 Cremations, in D.R. Brothwell and E.H. Higgs (editors). *Science in Archaeology*. Prager, New York. pp. 379-390.

Gilbert, B.M. and W.M. Bass
1967 Seasonal Dating of Burials from the Presence of Fly Pupae. *American Antiquity* 32:534-535.

Giles, E. and O. Elliot
1962 Race Identification from Cranial Measurements. *Journal of Forensic Sciences* 7:147-157.

Gustafson, G.
1966 *Forensic Odontology*. Staples Press, London.

Hamilton, D.
1982 *A Survey of Bone Fractures*. Unpublished manuscript, 26 pp.

Hillsdon-Smith, J.
1979 Advanced Identification Techniques, in J. Hillsdon-Smith, *Forensic Pathology and the Identification Officer*. Ministry of the Solicitor General, Toronto. pp. 64-70.

Jozsa, L.A.
1982 *What can Dendrochronology do For You?* Forintek Canada Corp., Vancouver.

Keiser-Nielsen, S.
1980 *Person Identification by Means of the Teeth*. John Wright and Sons Ltd., Bristol.

Kempe, H.C., F.N. Silverman, B.F. Steele, W. Droegemueller and H.K. Silver
1962 The Battered Child Syndrome. *American Medical Association Journal* 181:17-24.

Kerley, E.R.
1978 The Identification of Battered Infant Skeletons. *Journal of Forensic Sciences* 23:163-168.

Knight, B. and J. Lauder
1969 Methods of Dating Skeletal Remains. *Human Biology* 41:322-341.

Krogman, W.M.
1962 *The Human Skeleton in Forensic Medicine*. Charles C. Thomas, Springfield.

Leatherman, G.
1971 Two-digit System of Designating Teeth--F.D.I. Submission. *Australian Dental Journal* 16:394.

MacLeod, D.G.
1979 The Archaeological Approach to Skeleton Recovery, in J. Hillsdon-Smith, *Forensic Pathology and the Identification Officer*. Ministry of Solicitor General, Toronto. pp. 155-168.

Maples, W.R.
1978 An Improved Technique Using Dental Histology for Estimation of Adult Age. *Journal of Forensic Sciences* 23:764-770.

Morse, D., D. Crusoe and H.G. Smith
1976 Forensic Archeology. *Journal of Forensic Sciences* 21:323-332.

Morse, D., J. Stoutamire and J. Duncan
1976 A Unique Course in Anthropology. *American Journal of Physical Anthropology* 45:743-748.

Peterson, A.
1962 *Larvae of Insects. An Introduction to Nearctic Species, Parts I and II*. Edwards Brothers, Inc., Ann Arbor.

Rhine, J.S. and H.R. Campbell
1980 Thickness of Facial Tissues in American Blacks. *Journal of Forensic Sciences* 25:847-858.

Rodriguez, W.C. and W. M. Bass
1983 Insect Activity and its Relationship to Decay Rates of Human Cadavers in East Tennessee. *Journal of Forensic Sciences* 28:423-432.

Skinner, M.F.
1983 *Old and New Approaches to Positive Identification of Human Skeletal Remains*. Manuscript in preparation.

Smyth, F.
1980 *Cause of Death. The Story of Forensic Science*. Van Nostrand Reinhold Company, Toronto.

Snow, C.C., B.P. Gatliff, and K.R. McWilliams
1970 Reconstruction of Facial Features from the Skull: An Evaluation of its Usefulness in Forensic Anthropology. *American Journal of Physical Anthropology* 33:221-227.

Snyder, L.
1977 *Homicide Investigation*. Charles C. Thomas, Springfield.

Sopher, I.M.
1976 *Forensic Dentistry*. Charles C. Thomas, Springfield.

Spitz, W.U. and R.S. Fisher
1980 *Medicolegal Investigation of Death* (second edition). Charles C. Thomas, Springfield.

Stewart, T.D. (editor)
1970 *Personal Identification in Mass Disasters*. Smithsonian Institution, Washington.

Stewart, T.D.
1979 *Essentials of Forensic Anthropology*. Charles C. Thomas, Springfield.

Thompson, D.D.
1979 The Core Technique in the Determination of Age at Death in Skeletons. *Journal of Forensic Sciences* 24:902-915.

Ubelaker, D.H.
1978 *Human Skeletal Remains: Excavation, Analysis, Interpretation*. Aldine, Chicago.

Wilson, M.
1980 *The Twin Bridges, Alberta Human Skeleton*. Forensic Report 80-1.

Workshop of European Anthropologists
1980 Recommendations for Age and Sex Diagnoses of Skeletons. *Journal of Human Evolution* 9:517-547.

Illustrations of the Human Skeleton

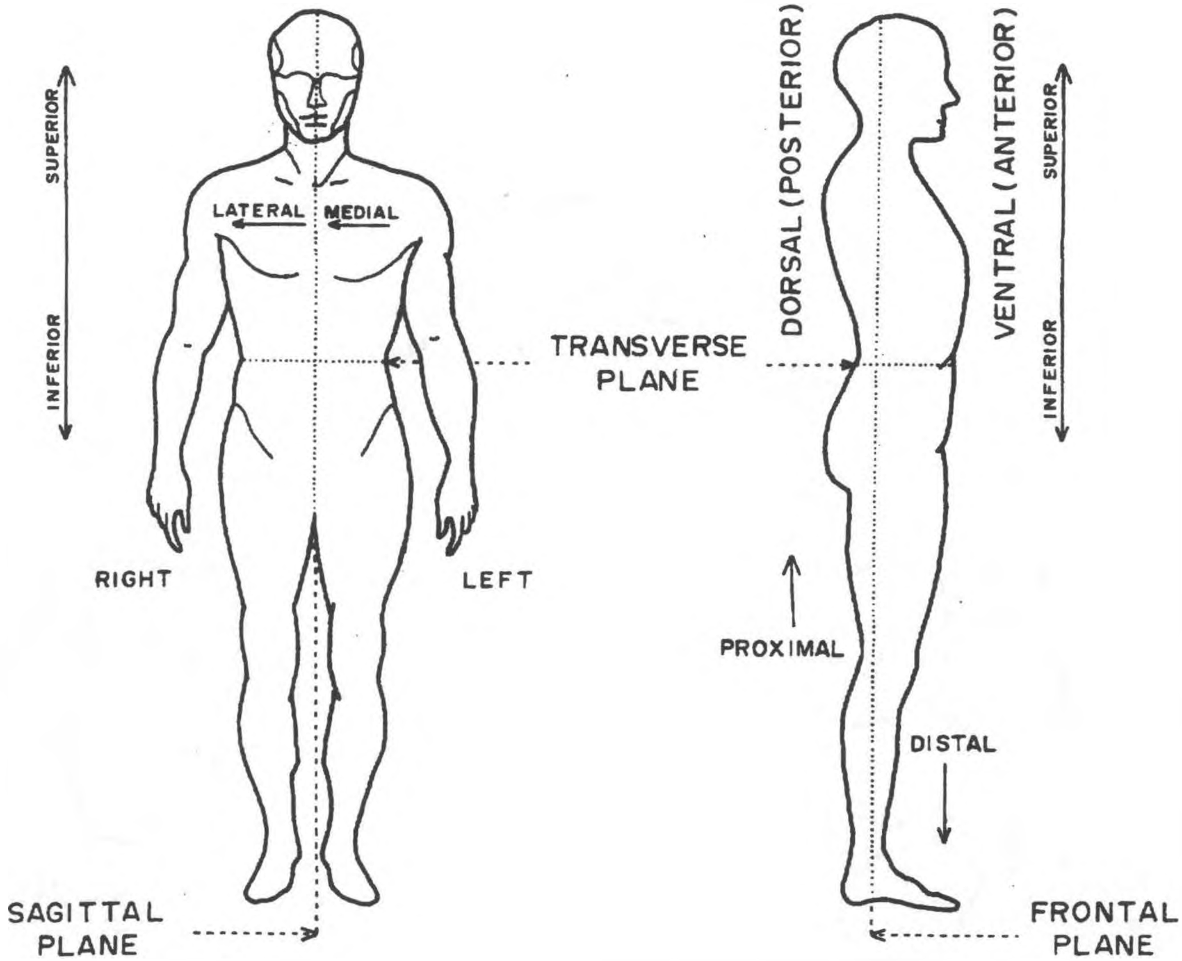

Figure 26. Anatomical surfaces and directions in the human body (from W.M. Bass (1971), *Human Osteology*. Missouri Archaeological Society, Columbia, Missouri, used with permission of the author and publisher).

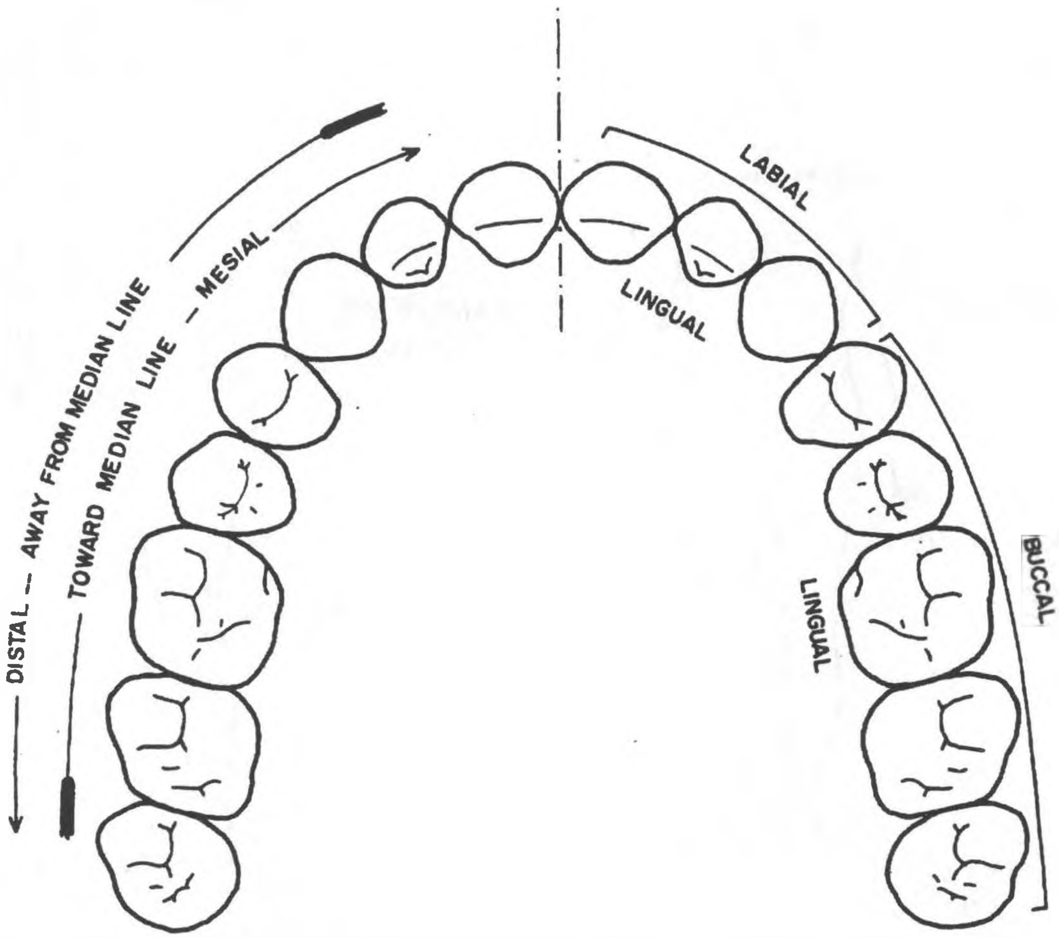

Figure 27. Anatomical surfaces and directions in the human dentition (from R.C. Wheeler (1974), *Dental Anatomy, Physiology, and Occlusion*. W.B. Saunders Co., used with permission of the publisher).

Figure 28. Illustrations of the Human Skeleton I (modified from Illustration by Carolina Biological supply Company, © 1968, used with permission).

Key to Numbered Bones (numbers in parentheses indicate quantity).

1. **CRANIUM** (skull)
2. **MANDIBLE** (Lower Jaw)
3. **HYOID**
6. **CERVICAL** (Neck) **VERTEBRAE** (7)
8. **LUMBAR** (Lower Back) **VERTEBRAE** (5)
9. **SACRUM**
10. **COCCYX** (3 to 5) Elements (Tail Bone)
11. **SCAPULA** (2) (Shoulder Blade)
12. **CLAVICLE** (2) (Collar Bone)
13. **MANUBRIUM**
14. **STERNAL BODY** (Breast Bone)
15. **RIBS** (12 Each Side = 24)
16. **HUMERUS** (2)
17. **RADIUS** (2)
18. **ULNA** (2)
19. **CARPALS** (8 Each Hand) (Wrist Bones)
20. **METACARPALS** (5 Each Hand) (Hand Bones)
21. **PHALANGES** (14 Each Hand/Foot) (Finger/Toe Bones)
22. **INNOMINATE** (2) (Hip/Pelvis)
23. **FEMUR** (2) (Thigh Bone)
24. **PATELLA** (2) (Knee Cap)
25. **TIBIA** (2) (Shin Bone)
26. **FIBULA** (2)
27. **TARSALS** (7 Each Foot) (Ankle Bones)
28. **METATARSALS** (5 Each Foot) (Foot Bones)

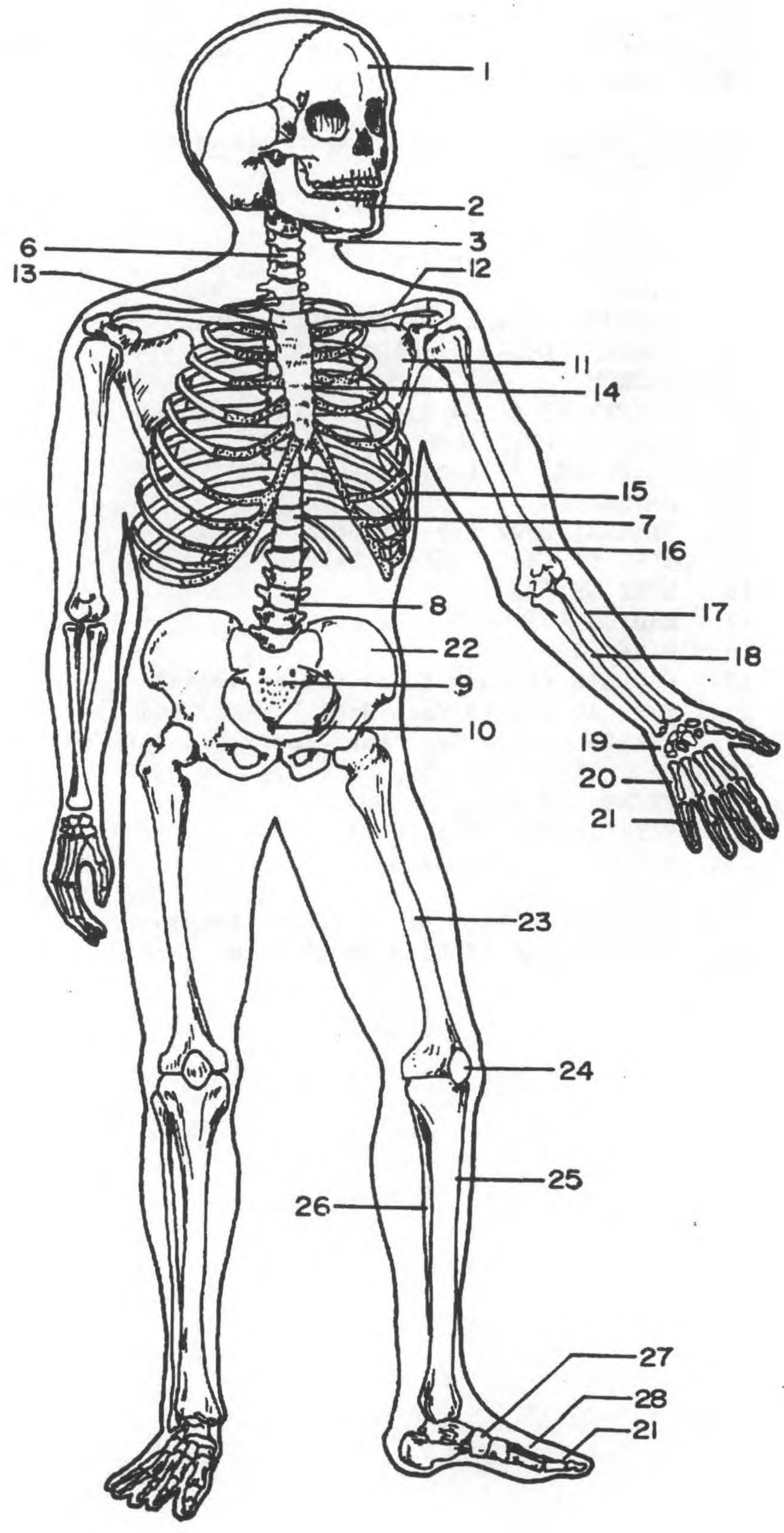
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Figure 29. Illustrations of the Human Skeleton II (modified from Illustration by Carolina Biological Supply Company, c 1968, used with permission).

Key to Numbered Bones (numbers in parentheses indicate quantity).

3. **HYOID**
4. **FIRST CERVICAL VERTEBRA** (Atlas)
5. **SECOND CERVICAL VERTEBRA** (Axis)
6. **CERVICAL VERTEBRAE** (7)
7. **THORACIC VERTEBRAE** (12)
8. **LUMBAR VERTEBRAE** (5)
9. **SACRUM**
10. **COCCYX**
11. **SCAPULA** (2) (Left)
12. **CLAVICLE** (2) (Left)
13. **MANUBRIUM**
14. **STERNAL BODY**
16. **HUMERUS** (2) (Left)
17. **RADIUS** (2) (Right)
18. **ULNA** (2) (Right)

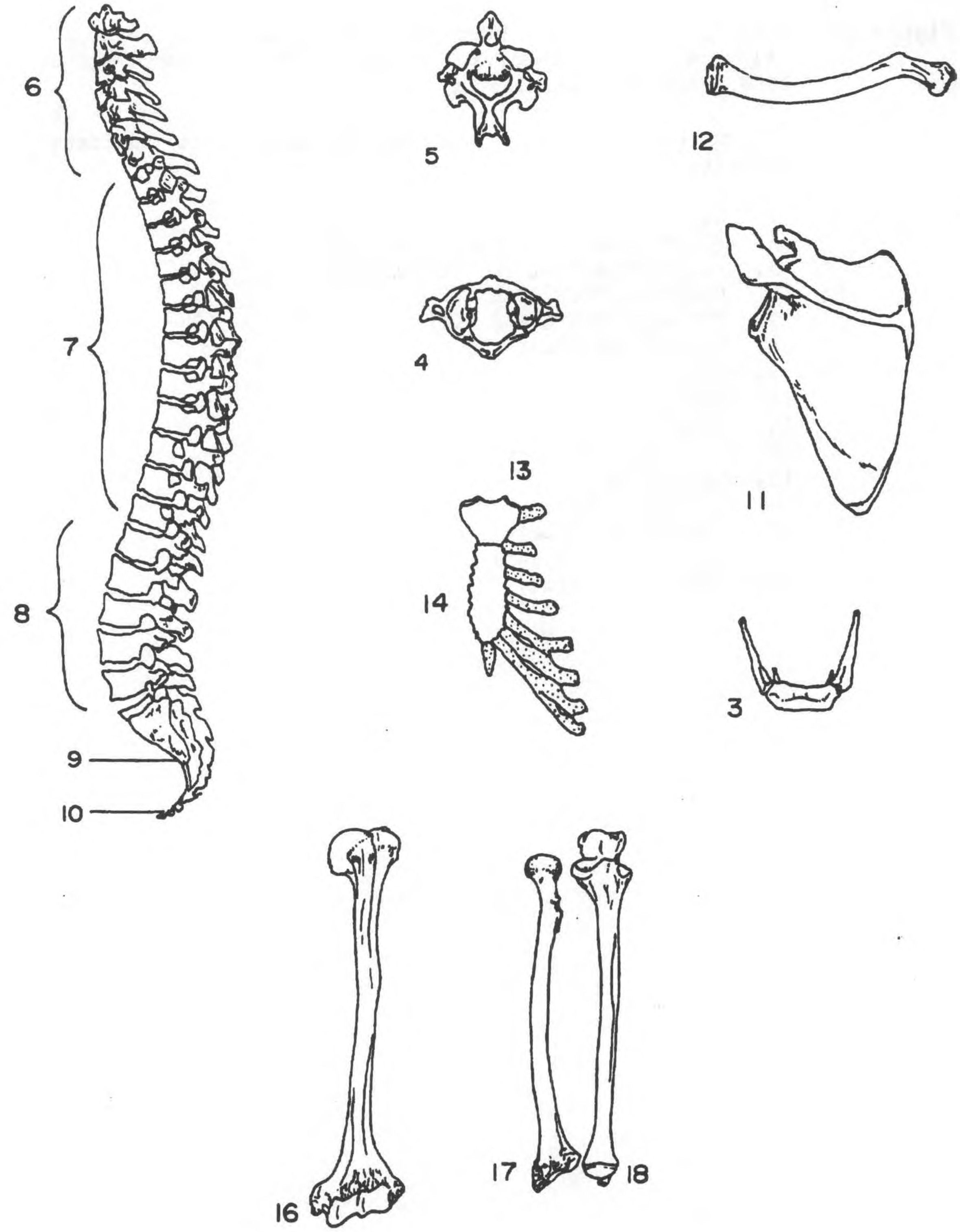
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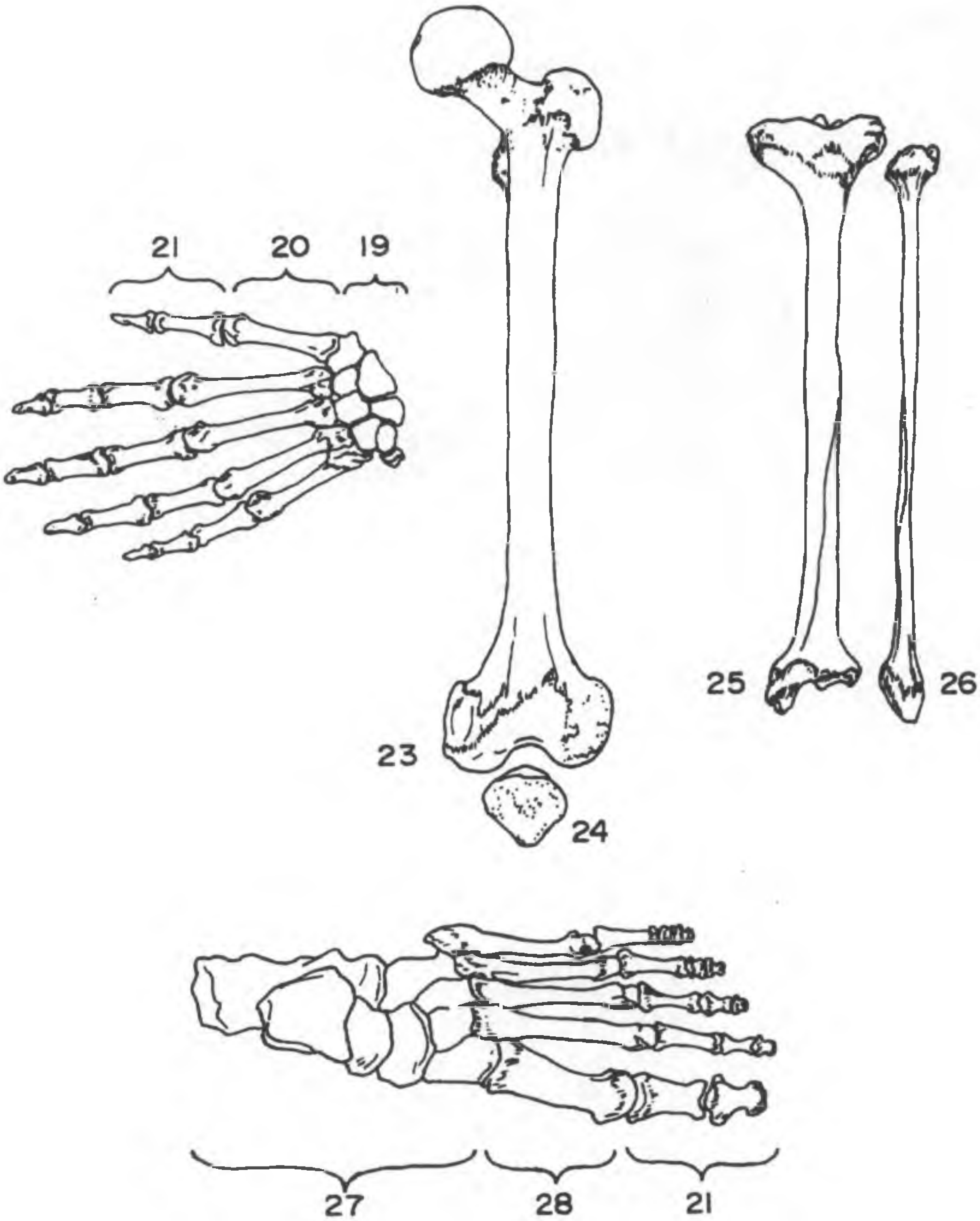
Figure 30. Illustrations of the Human Skeleton III (modified from Illustration by Carolina Biological Supply Company, © 1968, used with permission).

Key to Numbered Bones (numbers in parentheses indicate quantity).

19. **CARPALS** (8 Each hand)
20. **METACARPALS** (5 Each Hand)
21. **PHALANGES** (14 Each Hand/Foot)
23. **FEMUR** (2) (Left)
24. **PATELLA** (2)
25. **TIBIA** (2) (Left)
26. **FIBULA** (2) (Left)
27. **TARSALS** (7 Each Foot)
28. **METATARSALS** (7 Each Foot)



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Photographic Views of the Human Skeleton.

The size of each bone shown in the following figures can be found by comparison with the whole skeleton shown in Figure 28.

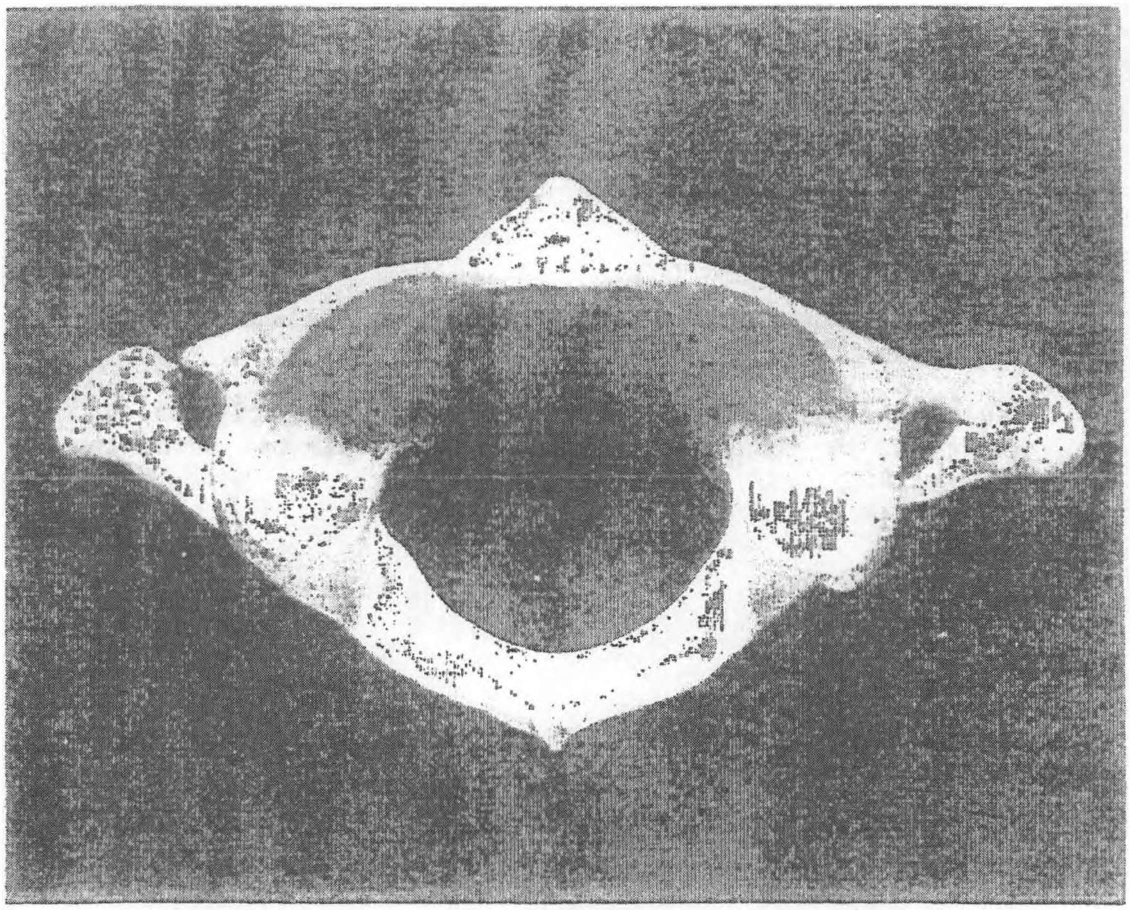


Figure 31. First cervical vertebra (atlas, superior view).

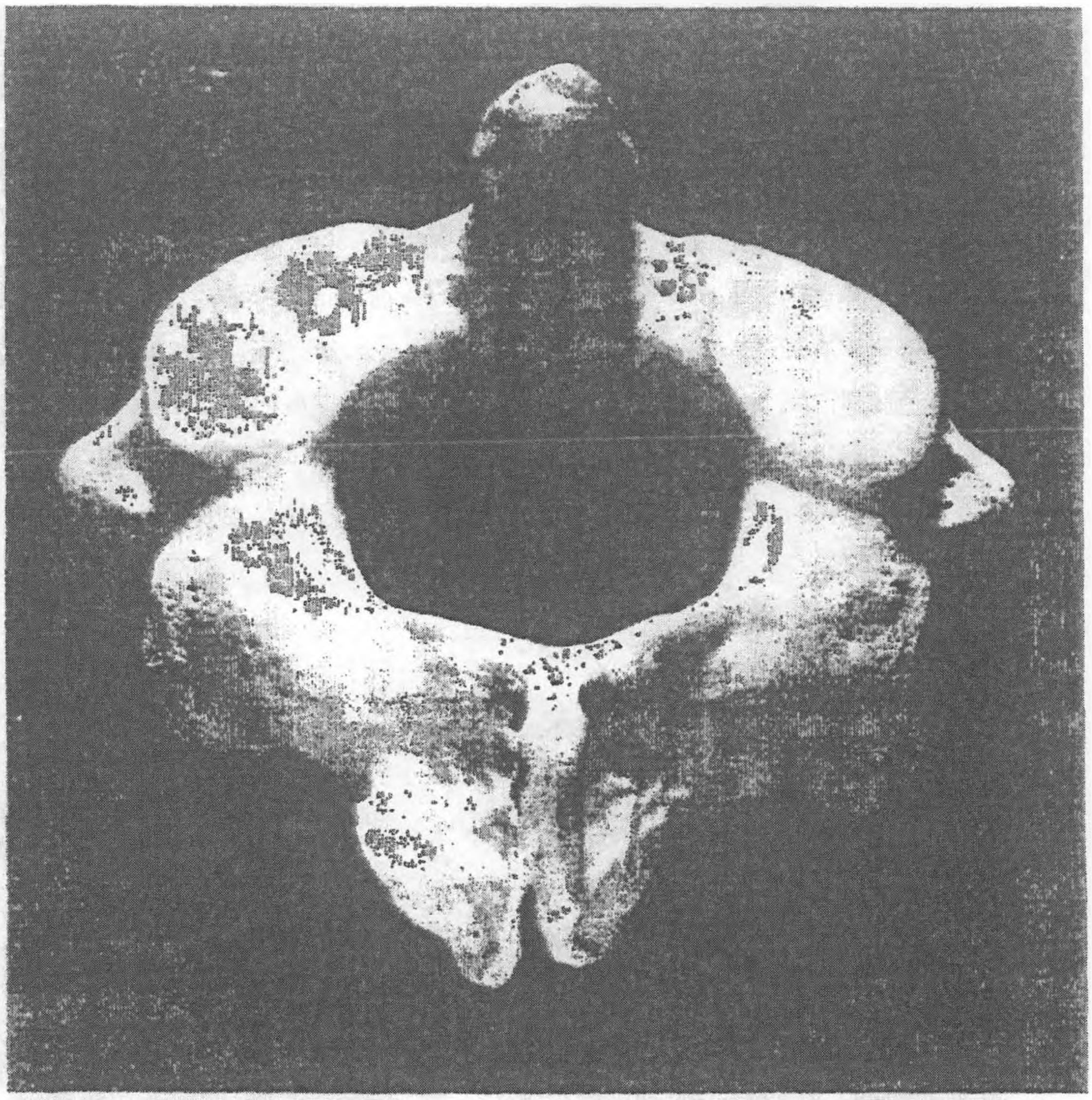
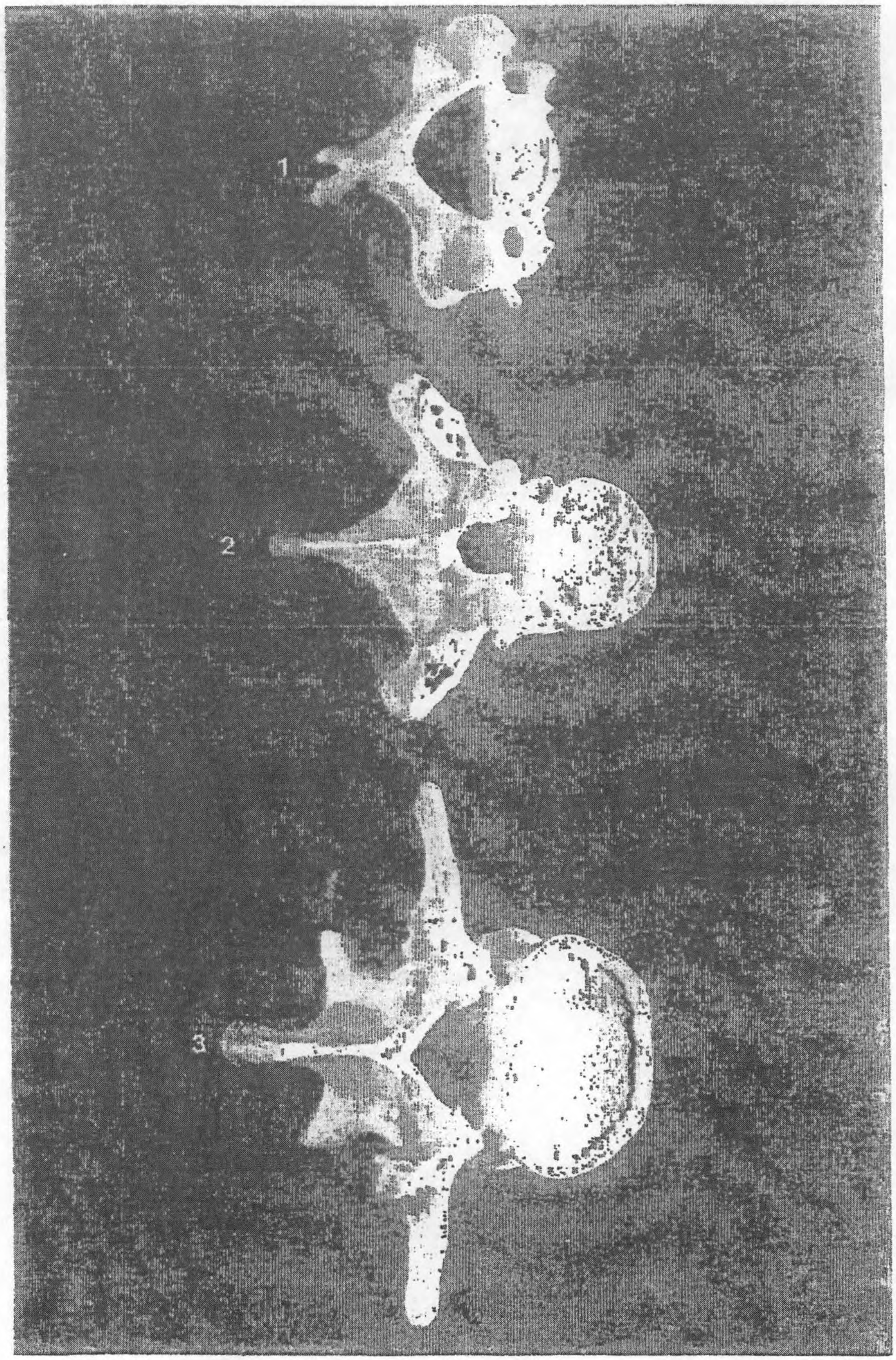


Figure 32. *Above:* Second cervical vertebra (axis, superior view).

Figure 33. *Next page:* Typical vertebrae: 1) cervical, 2) thoracic. 3) lumbar, all in superior view.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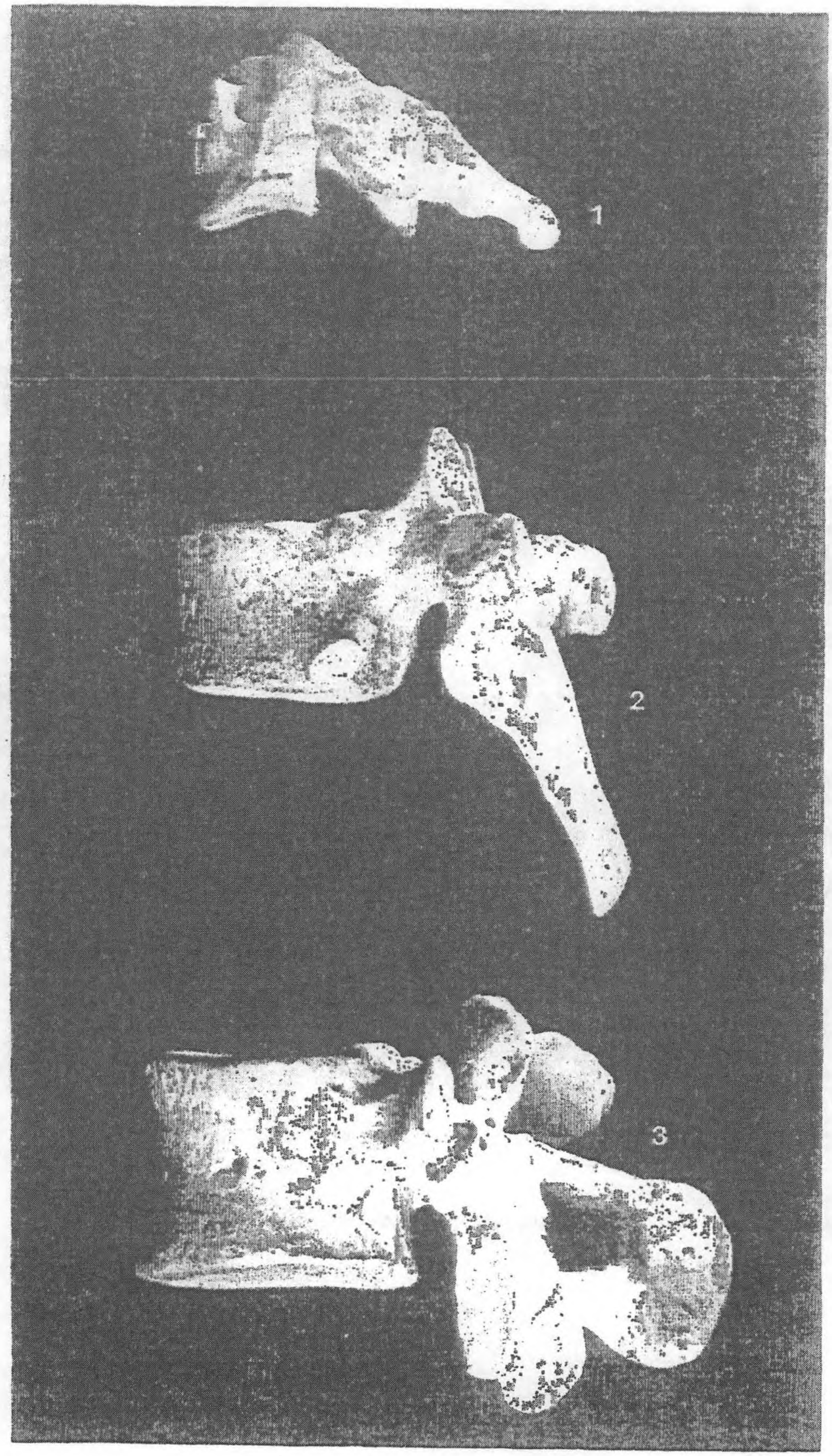
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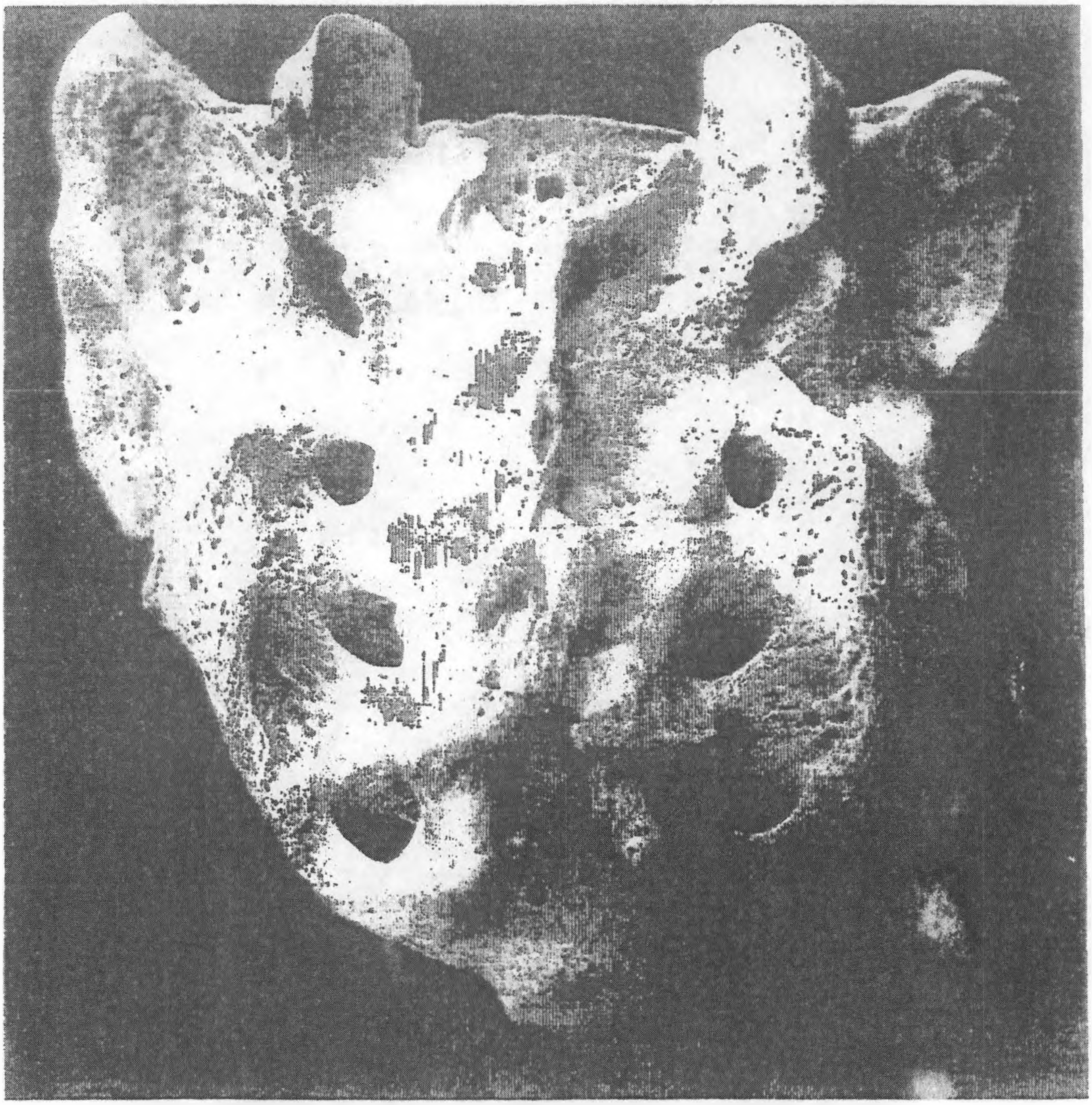


Figure 34. *Previous page:* Typical vertebrae: 1) cervical, 2) thoracic, 3) lumbar, side view.

Figure 35. *Above:* Sacrum (posterior view).

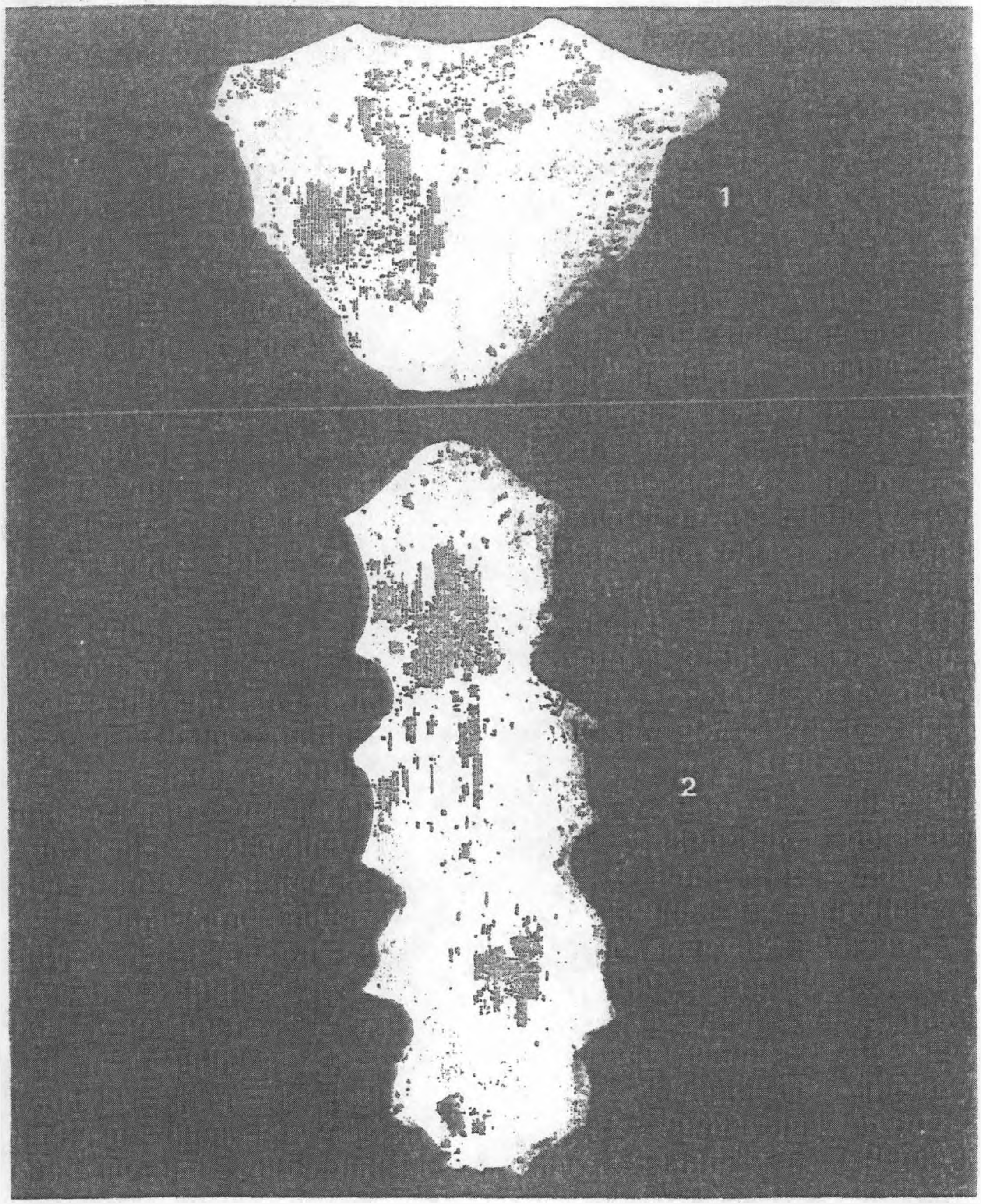
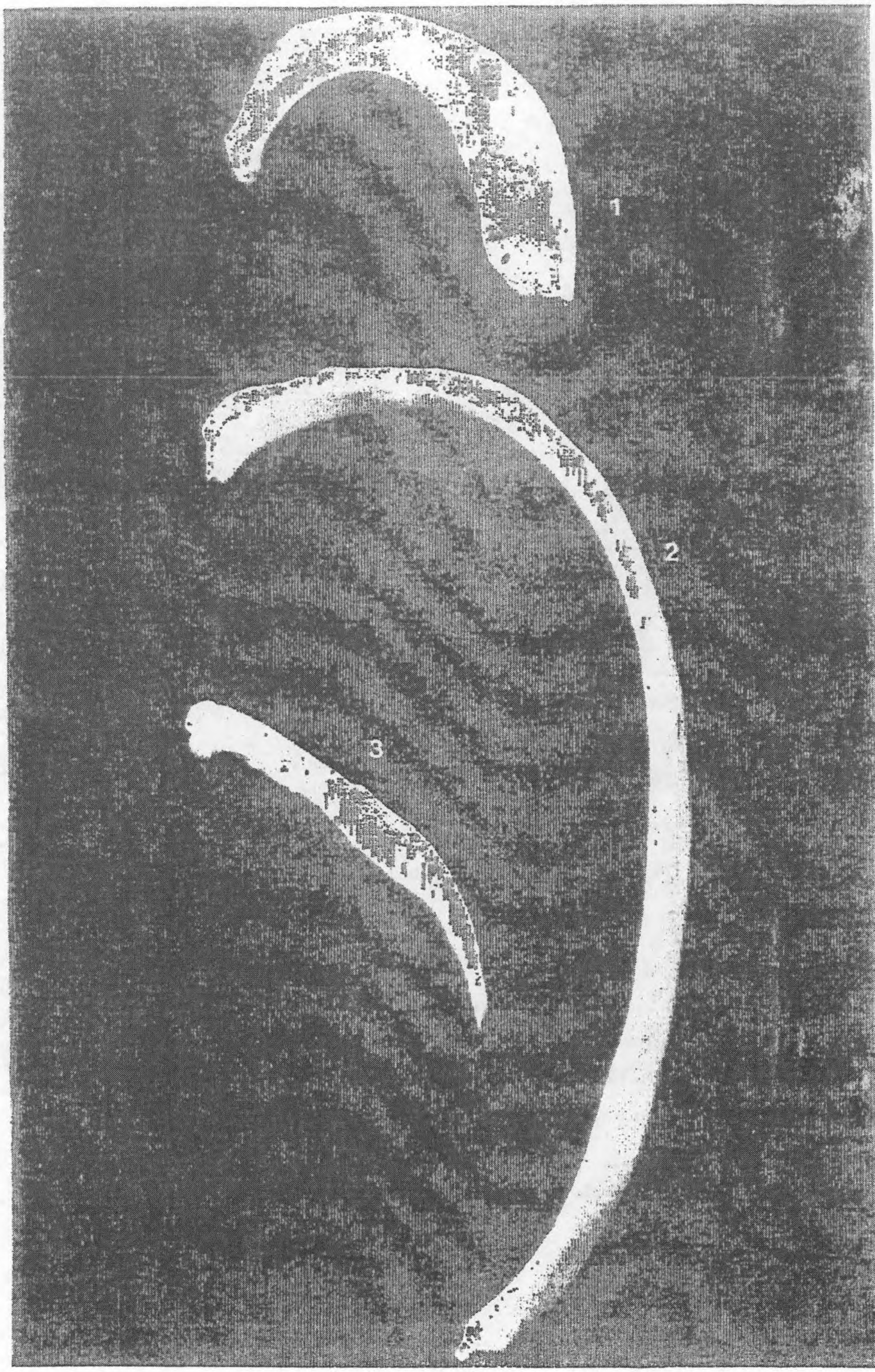


Figure 36. 1) Manubrium and 2) sternal body (front view).

Figure 37. *Next page:* Variation in rib shape: 1) left first rib, 2) left middle rib, 3) left twelfth rib.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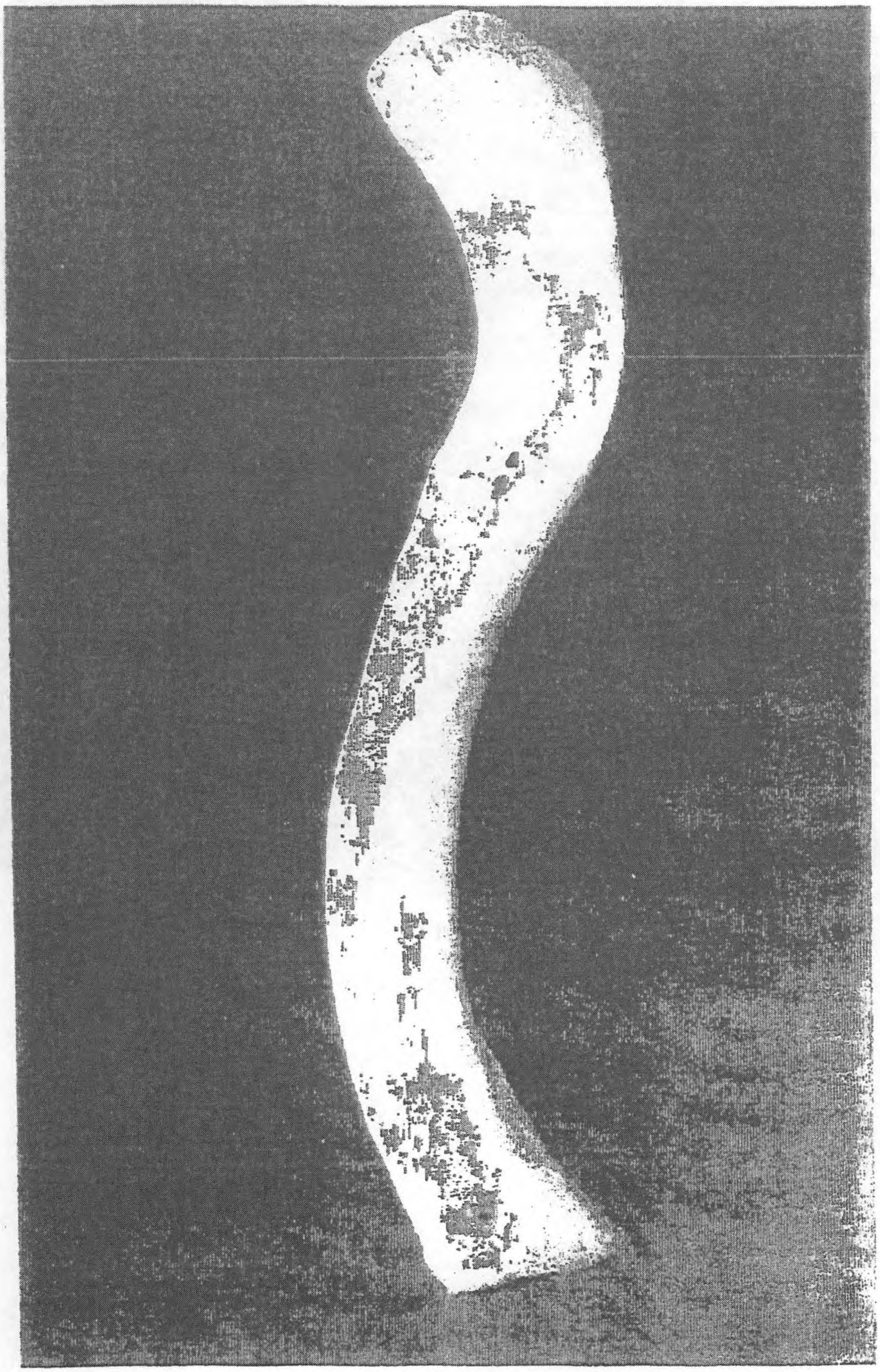

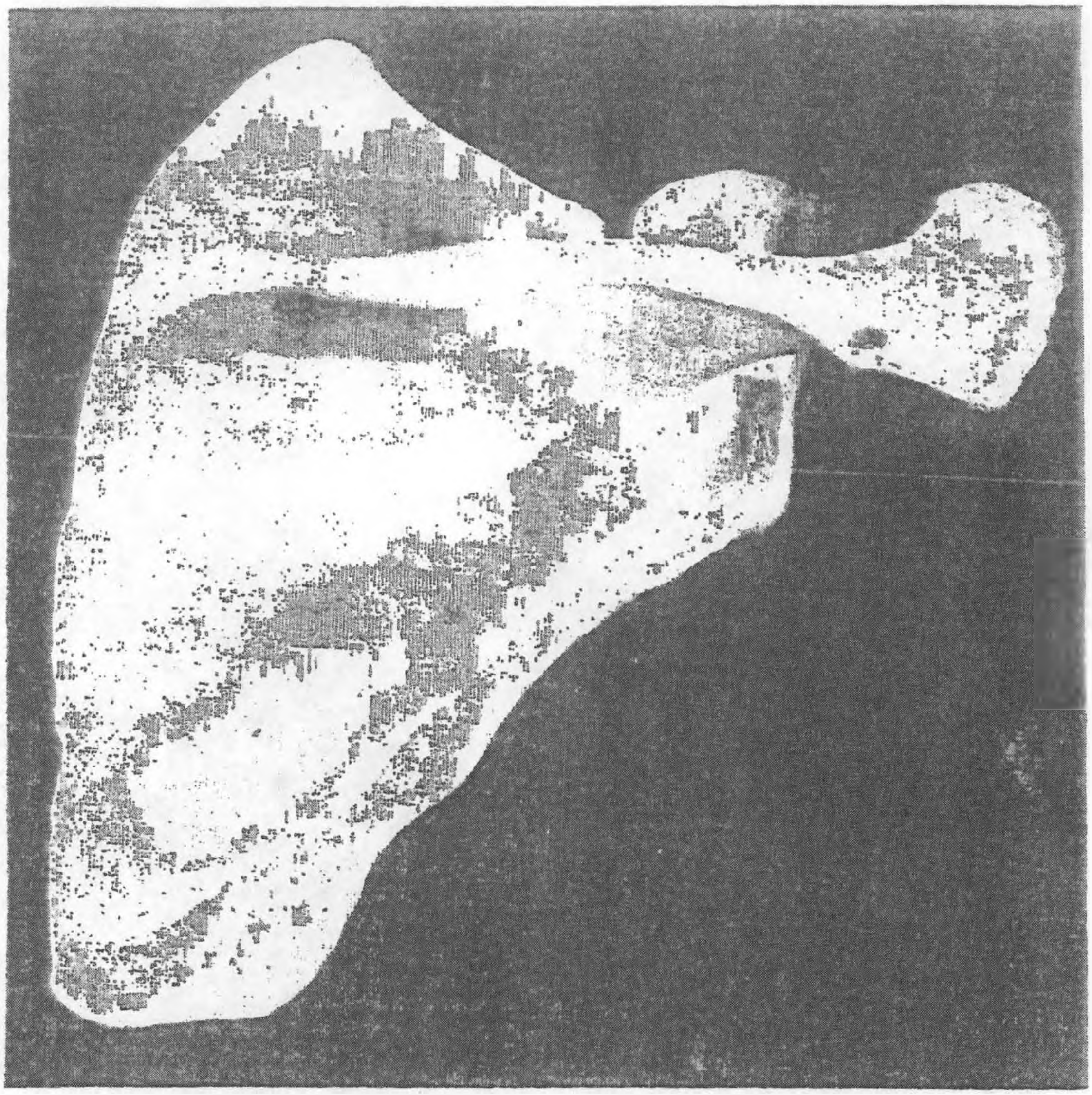

Figure 38. *Preceding page:* Clavicle (left, inferior view).

Figure 39. *Above:* Scapula (right, posterior view).

Figure 40. *Opposite:* Arm bones -- right: 1) radius (front view), 2) ulna (side view), 3) humerus (front view).

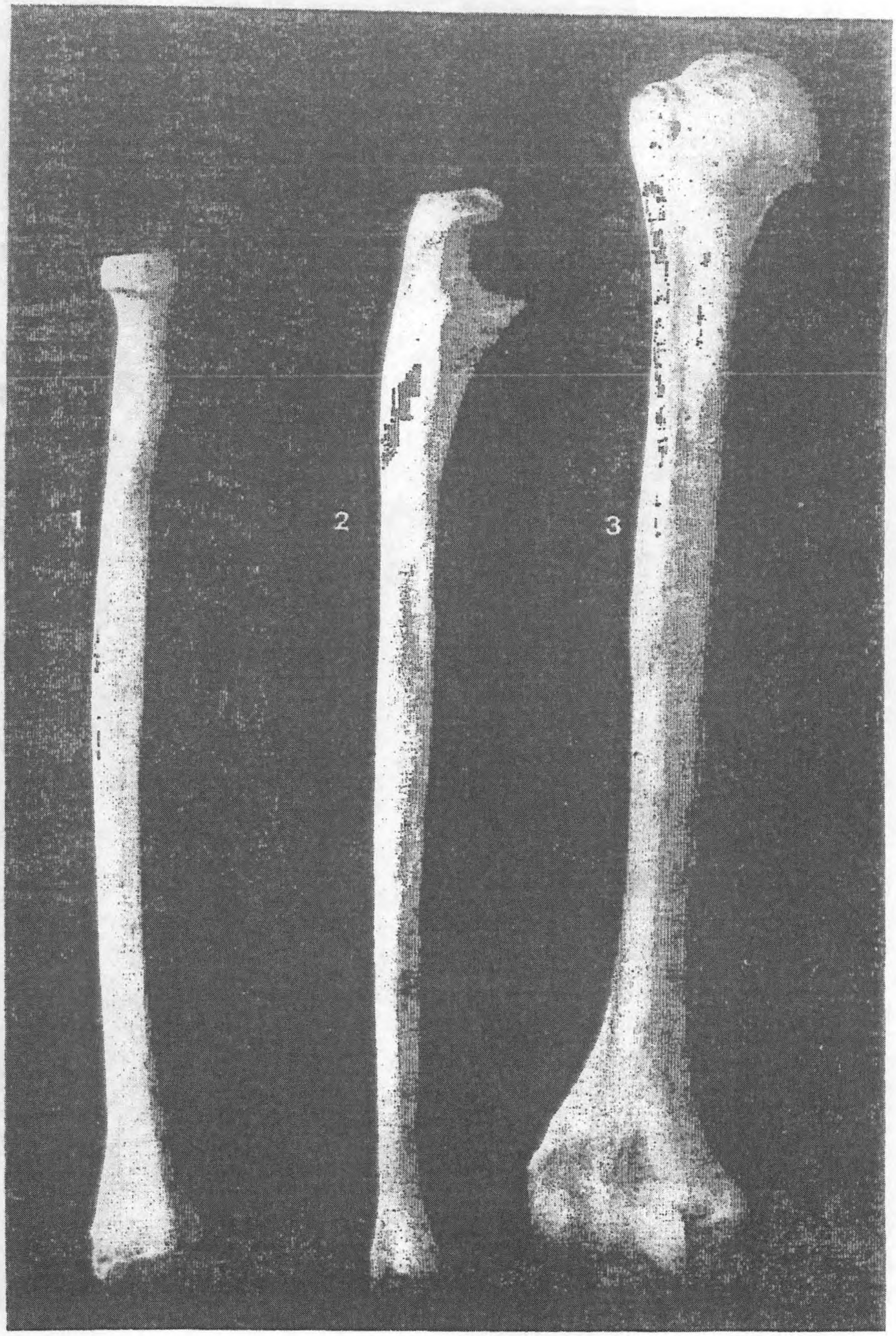
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Figure 41. Wrist and hand bones (left, palm).

Figure 42. Wrist and hand bones (left, back).

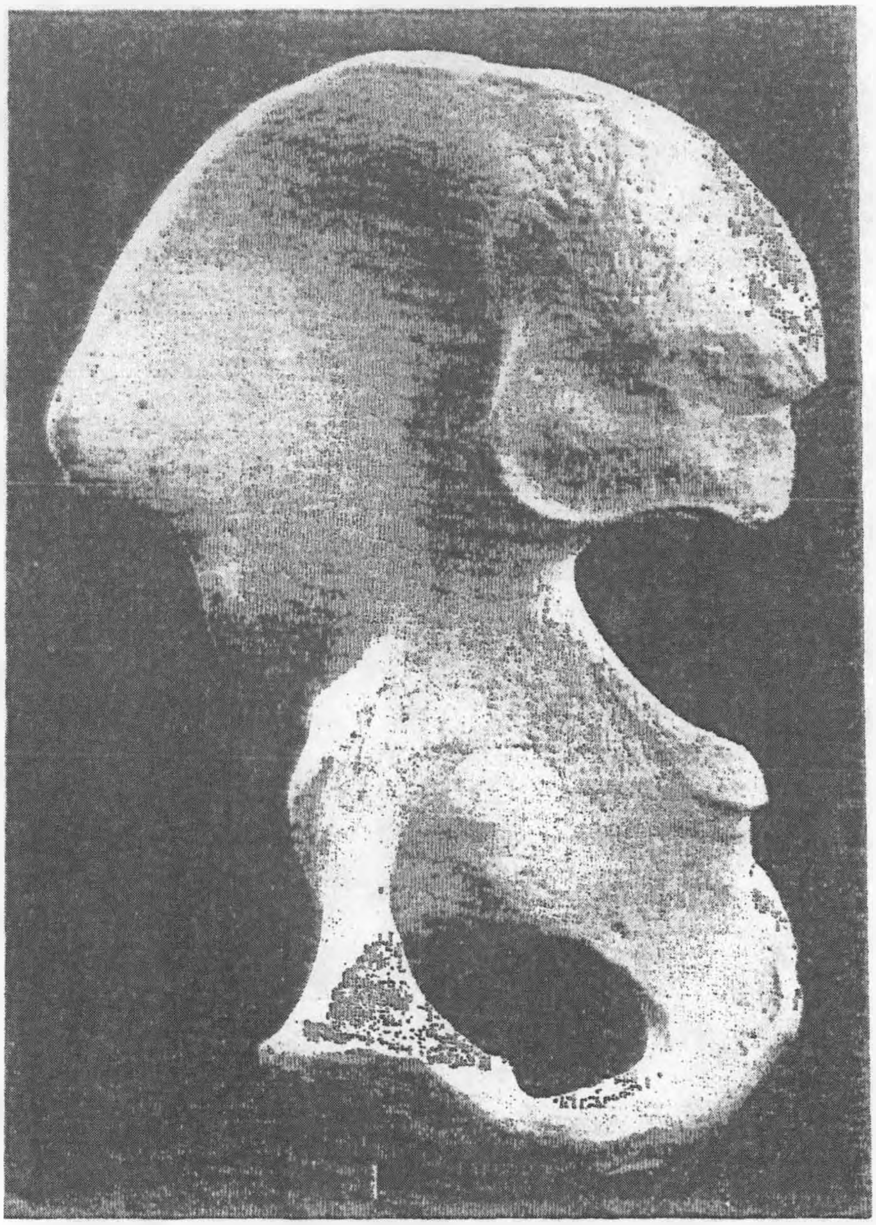
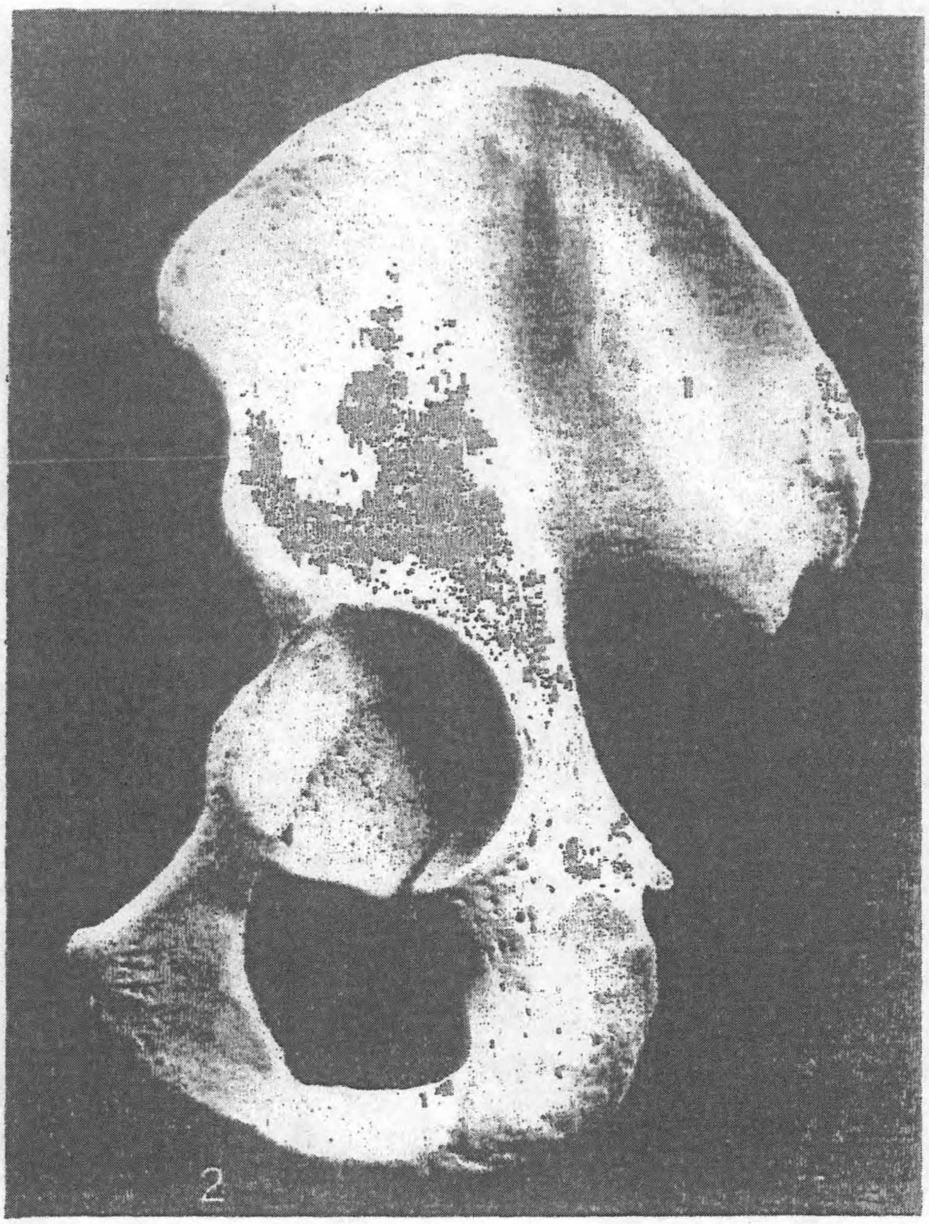


Figure 43. 1) Right innominate, internal view
2) Left innominate, external view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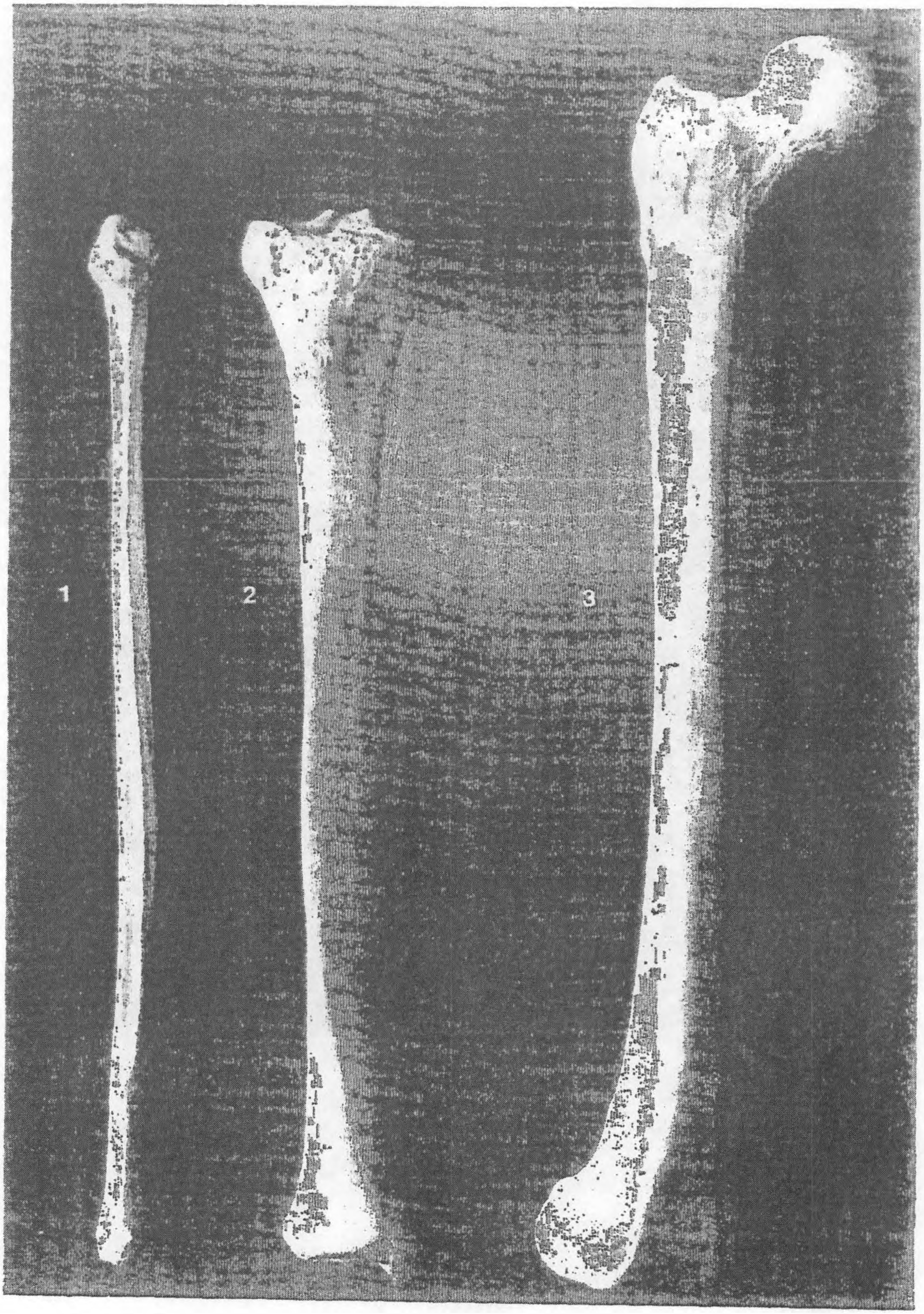


Figure 44. Leg bones: 1) fibula, 2) tibia, 3) femur (all front view).

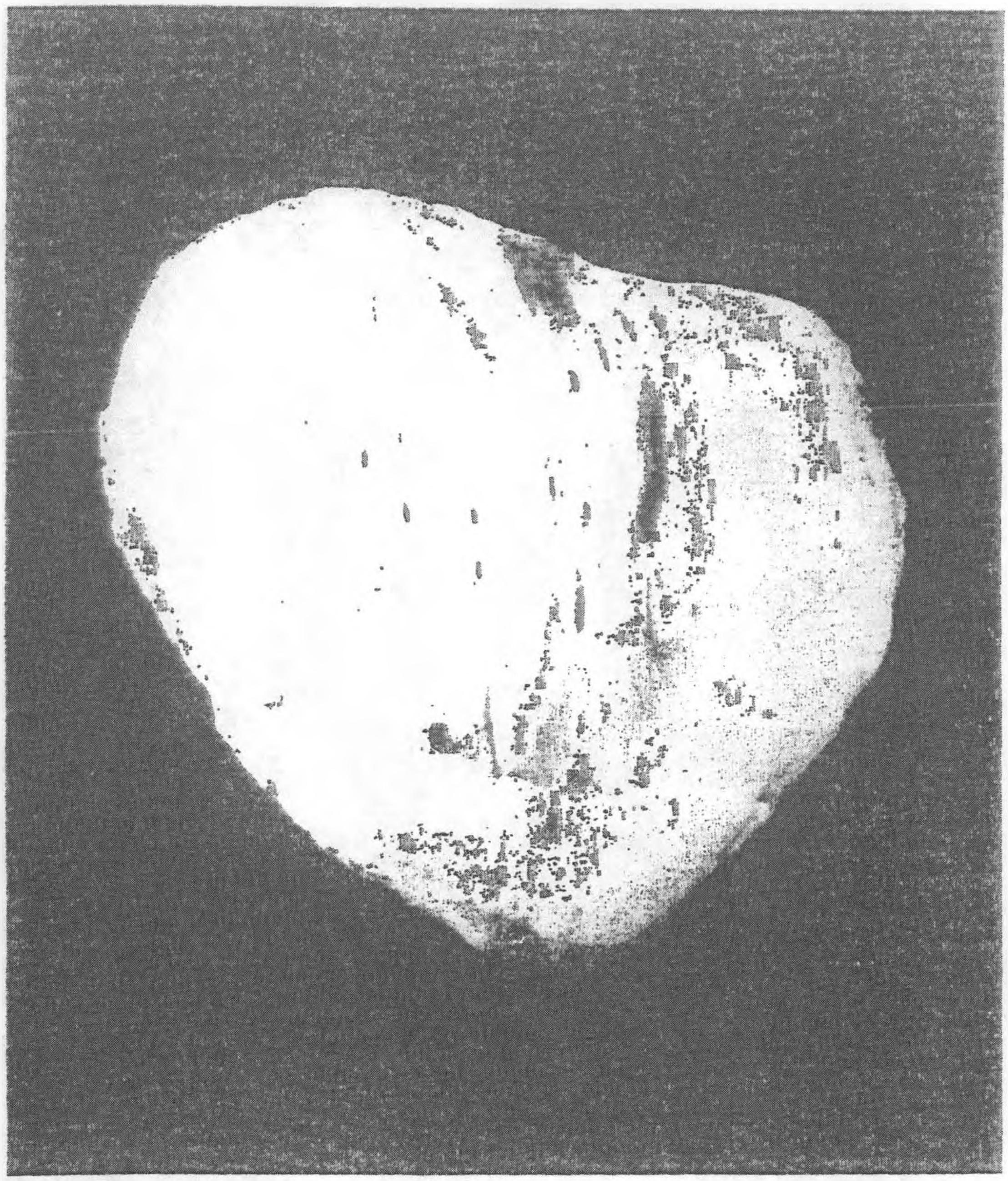
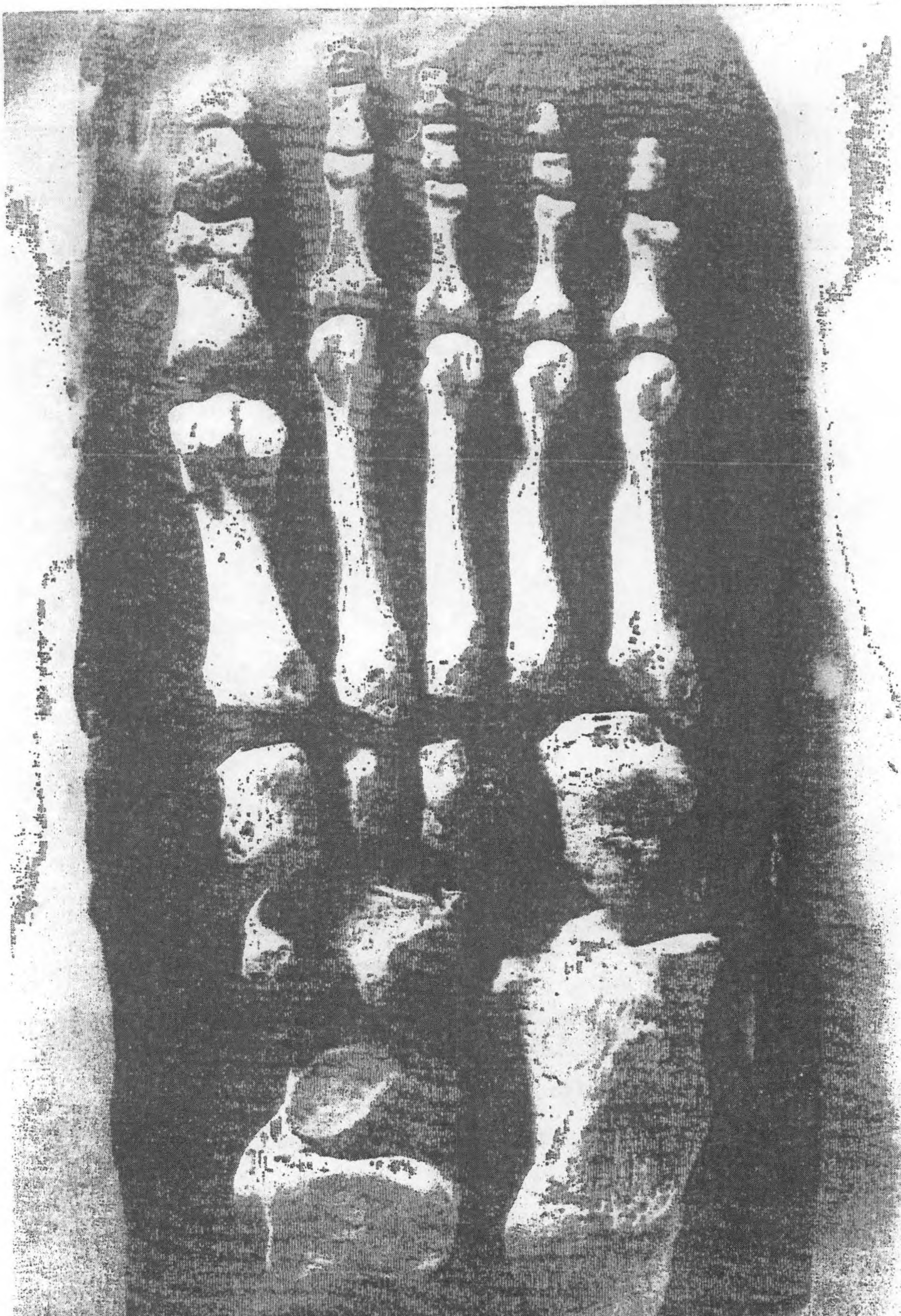


Figure 45. Patella (front view).

Figure 46. *Following page:* Ankle and foot bones (left, sole).



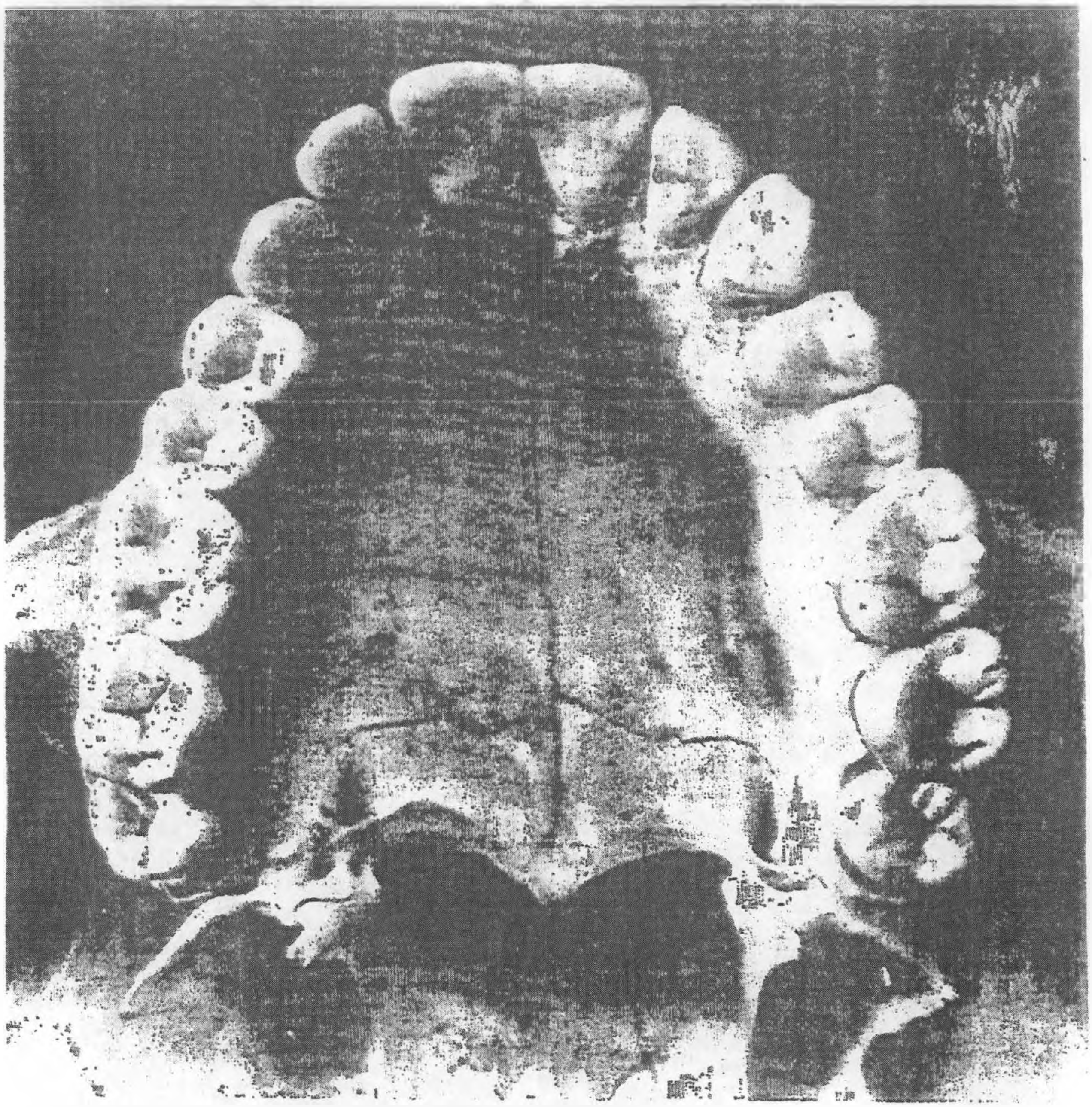


Figure 47. *Preceding page:* Ankle and foot bones (left, top).

Figure 48. *Above:* Maxillary adult dentition (occlusal view).

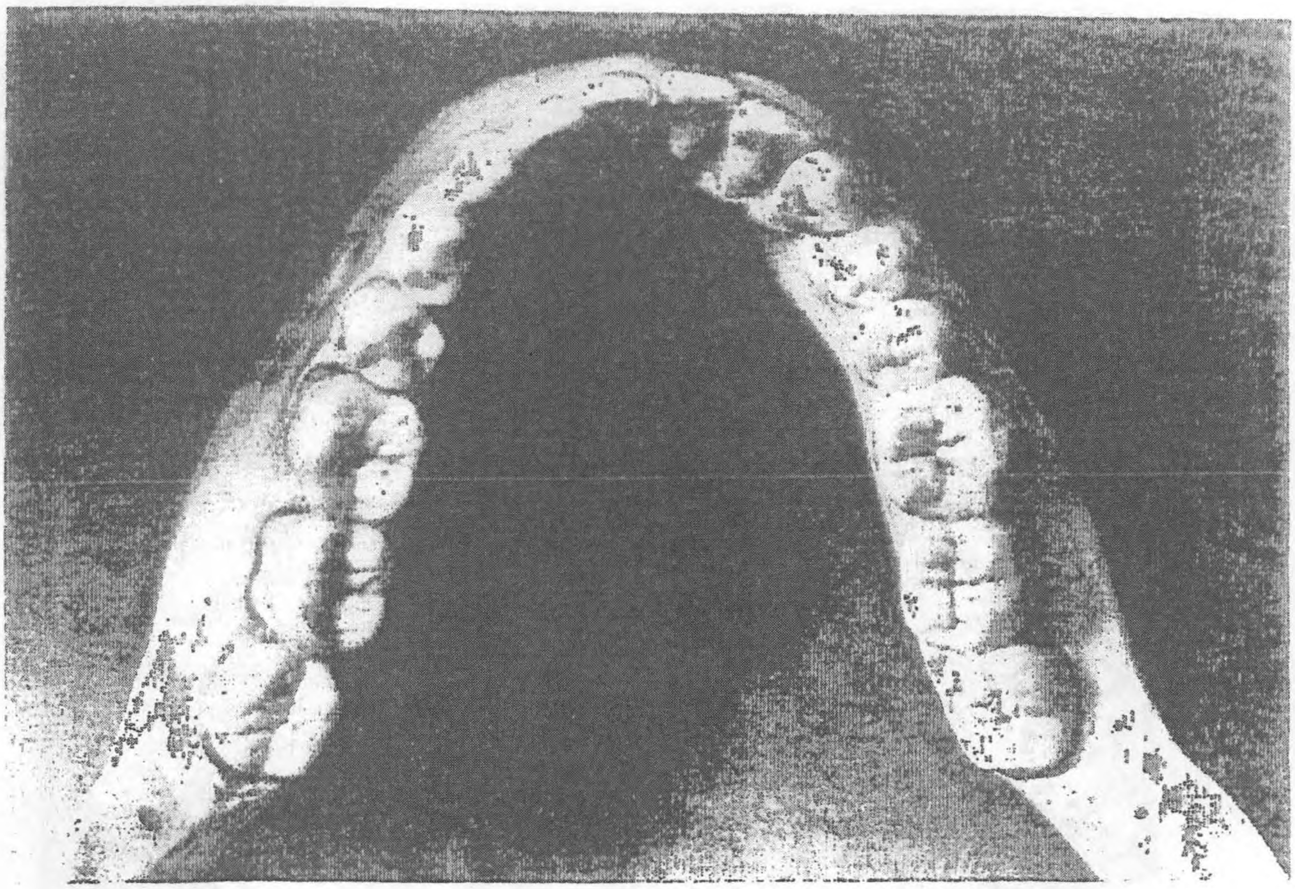


Figure 49. Mandibular adult dentition (occlusal view).

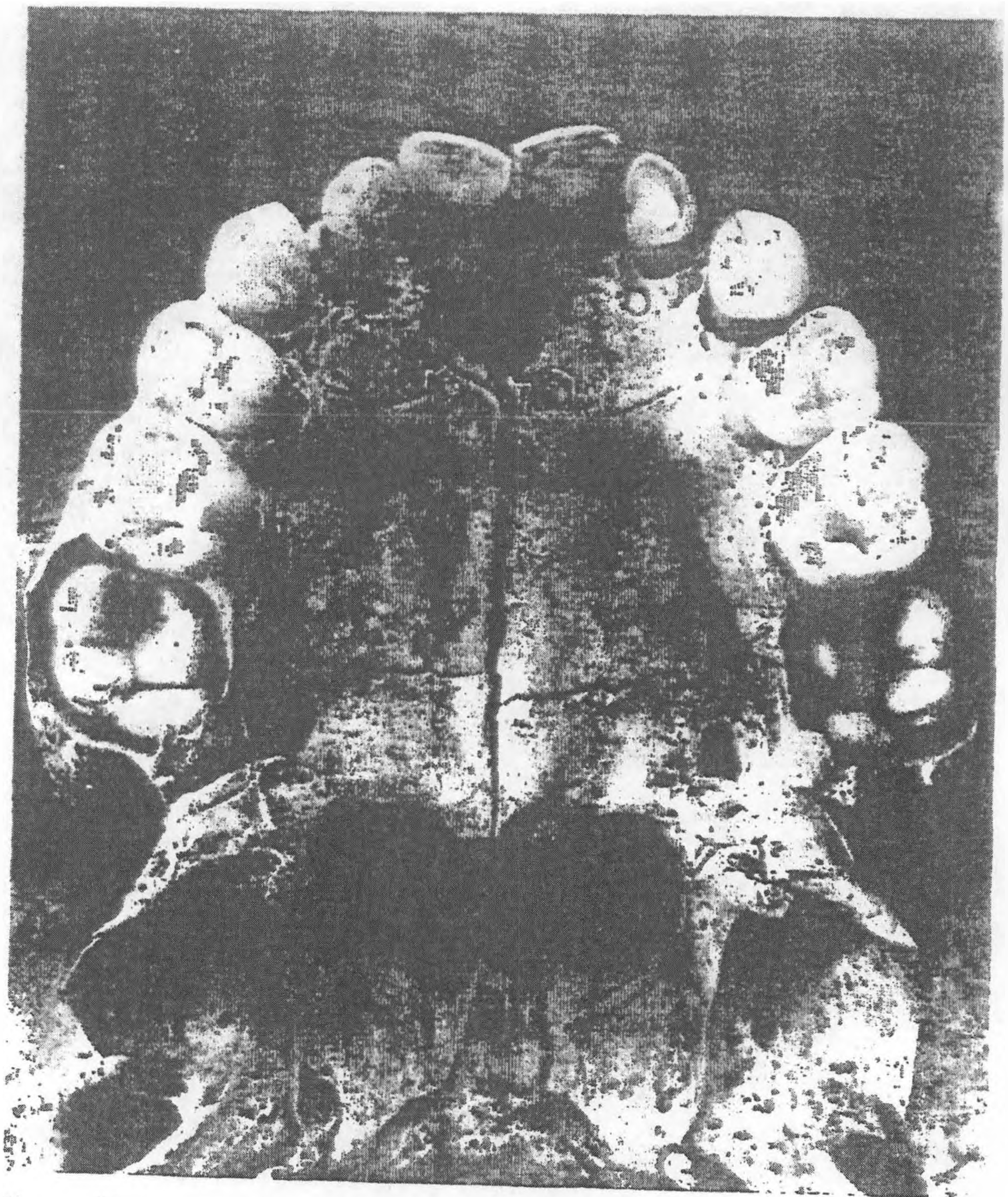


Figure 50. Maxillary milk dentition (occlusal view).

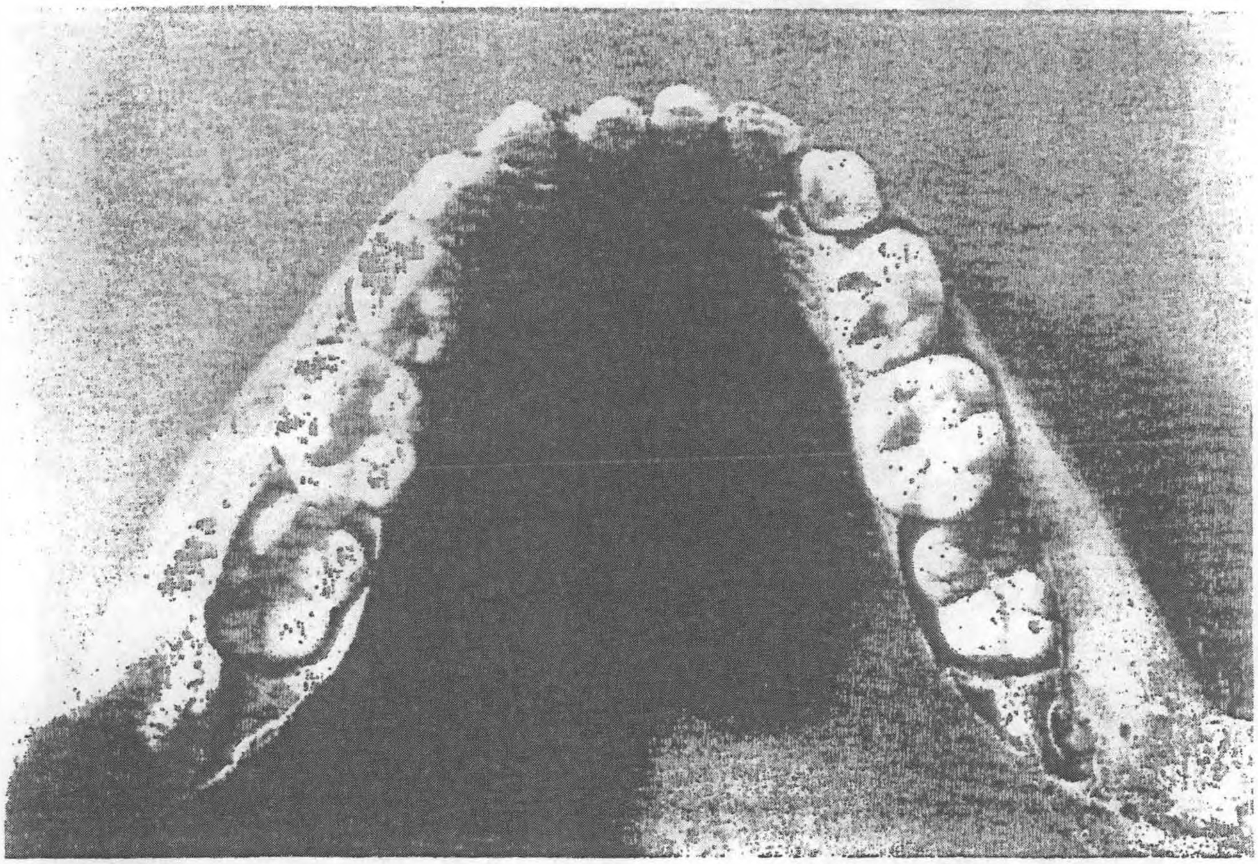


Figure 51. Mandibular milk dentition (occlusal view).

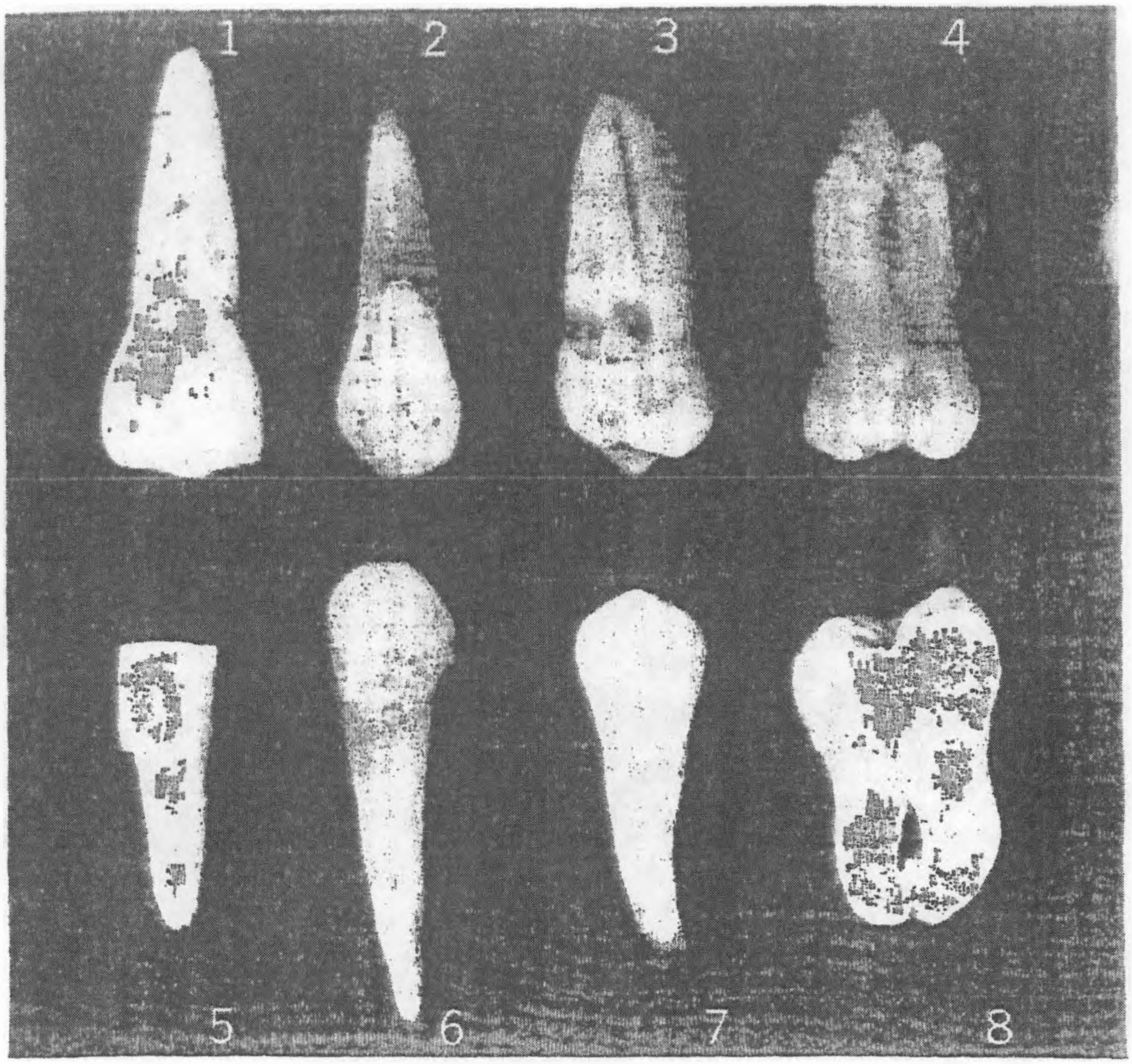


Figure 52. Representative adult teeth.
Maxillary: 1) incisor, 2) canine, 3) premolar, 4) molar.
Mandibular: 5) incisor, 6) canine, 7) premolar, 8) molar.

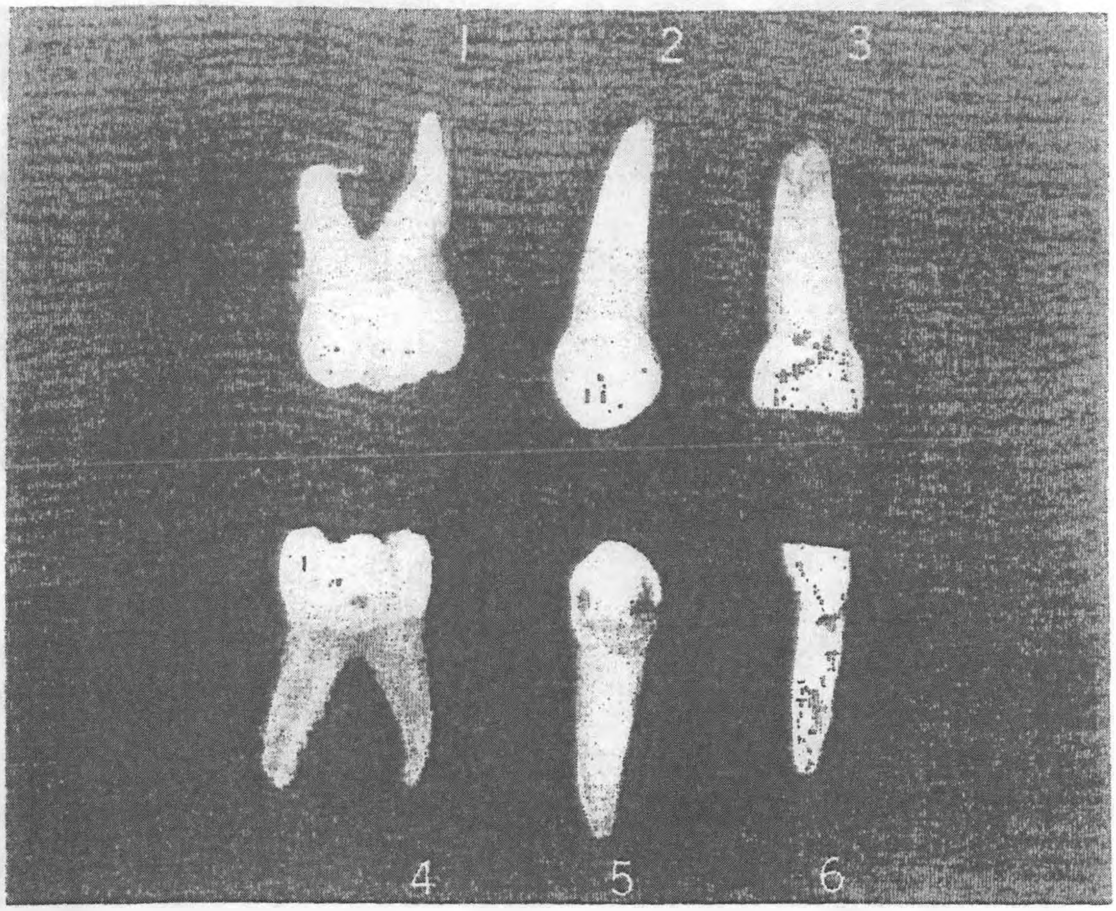


Figure 53. Representative milk (deciduous) teeth.
Maxillary: 1) molar, 2) canine, 3) incisor.
Mandibular: 4) molar, 5) canine, 6) incisor.

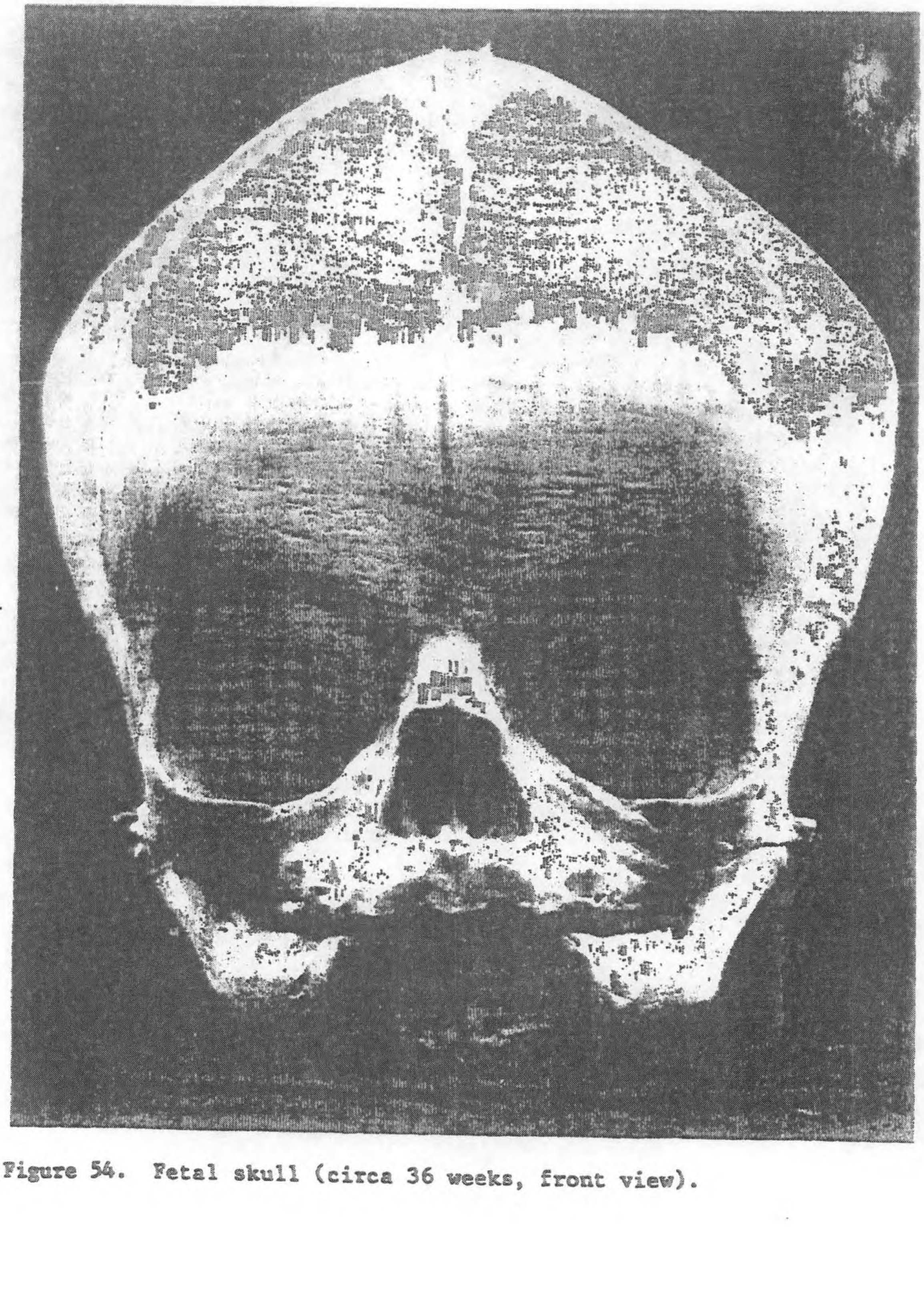


Figure 54. Fetal skull (circa 36 weeks, front view).

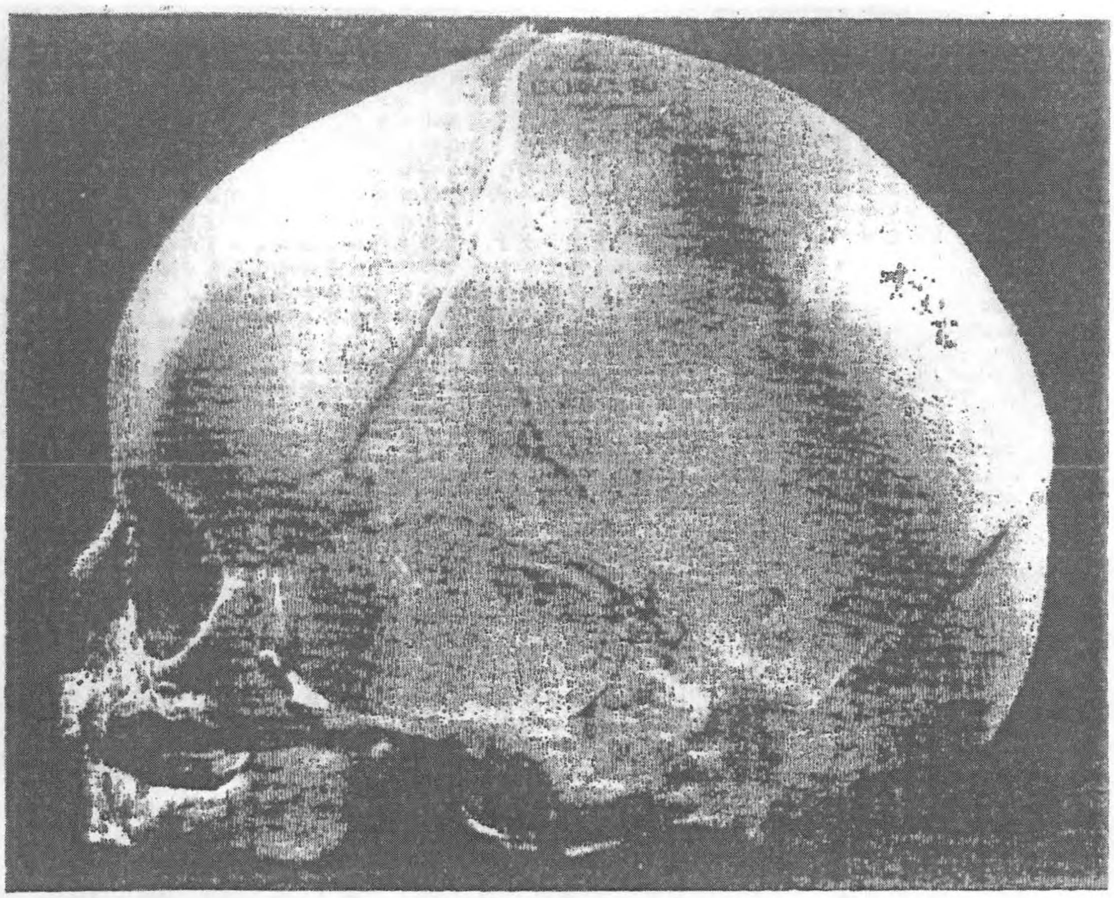


Figure 55. Fetal skull (circa 36 weeks, side view).

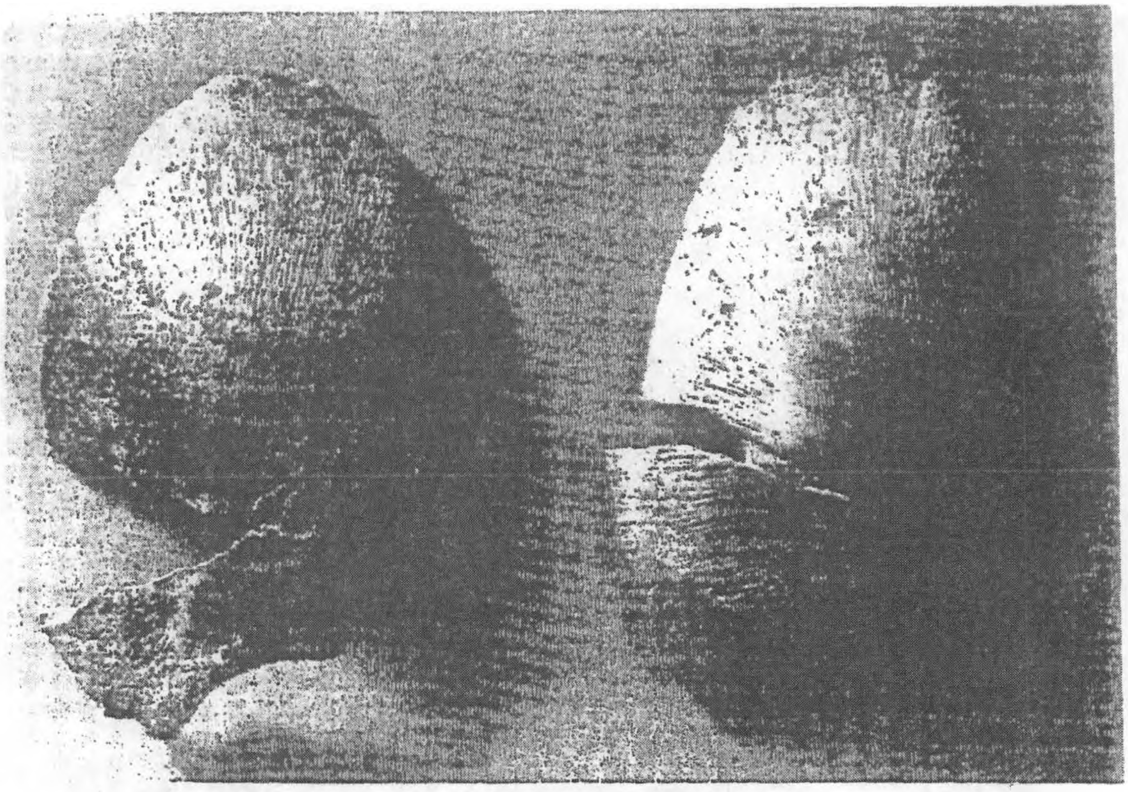


Figure 56. Fetal skull bones: frontals (circa 32 weeks).

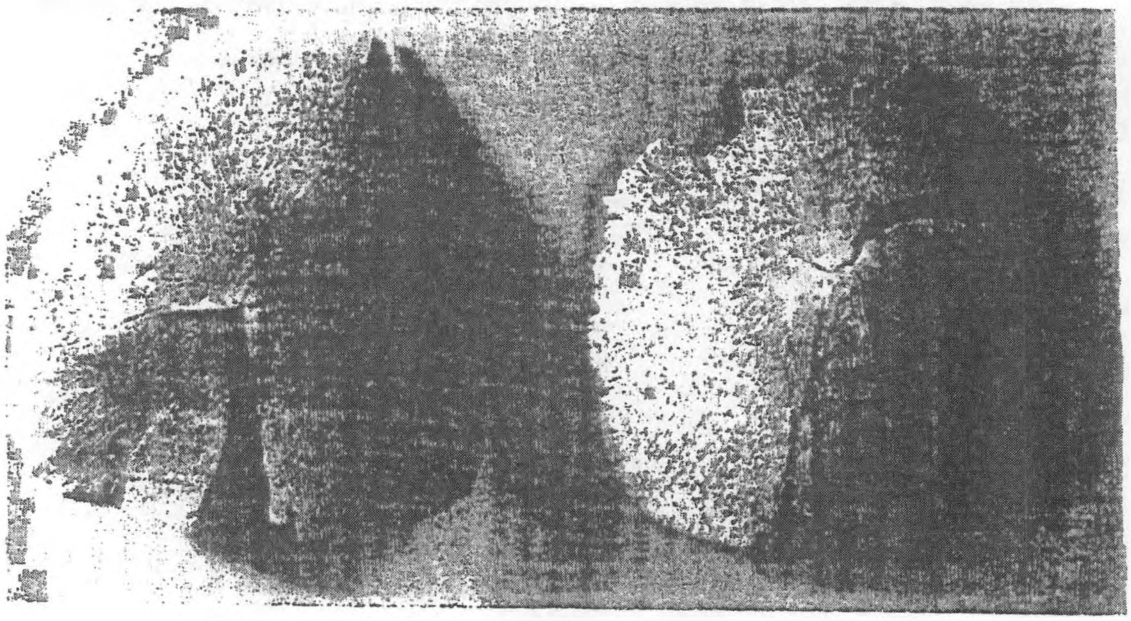


Figure 57. Fetal skull bones: parietals (circa 32 weeks).

Figure 58. Fetal skull bones: occipital. 1) squama, 2) basi-occipital, 3) two exoccipitals (circa 32 weeks).

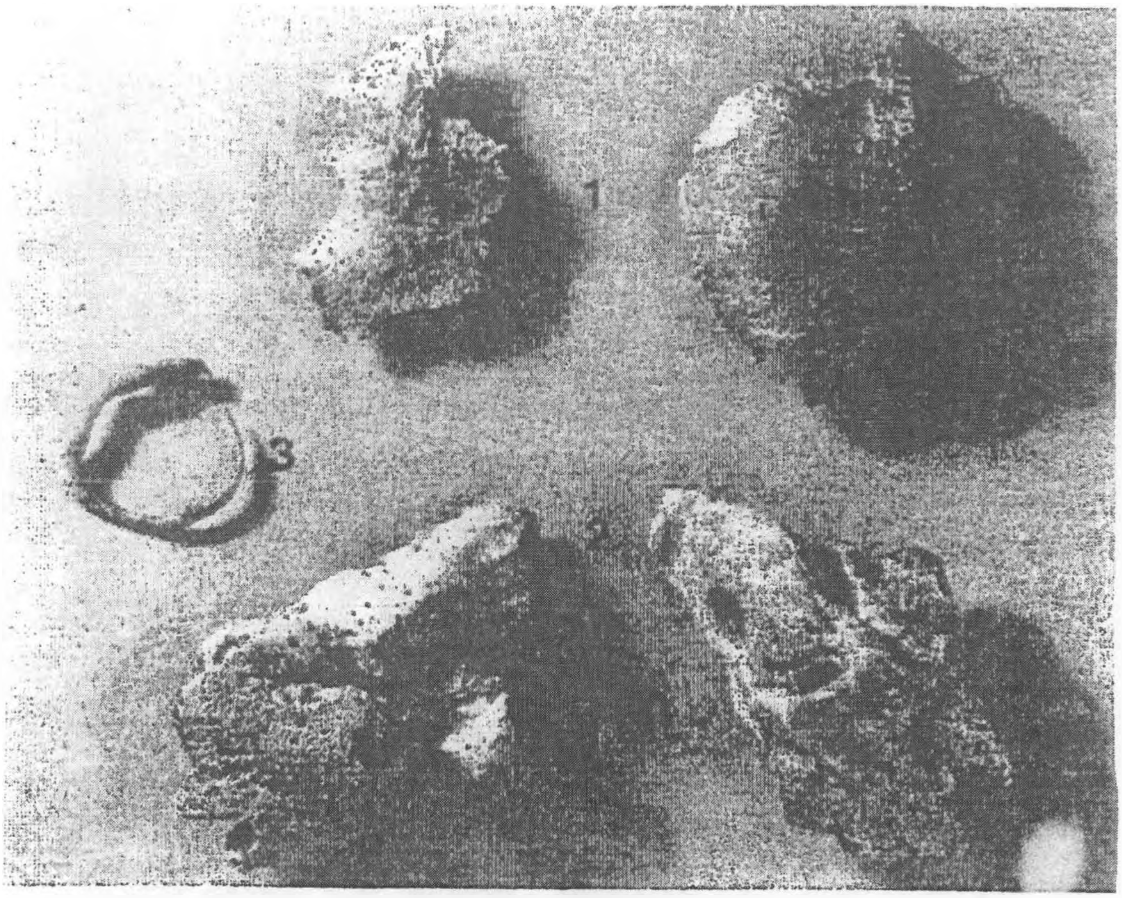


Figure 59. Fetal skull bones: temporal. 1) squamosal, 2) petrous, 3) annulus = tympanic ring (circa 32 weeks).

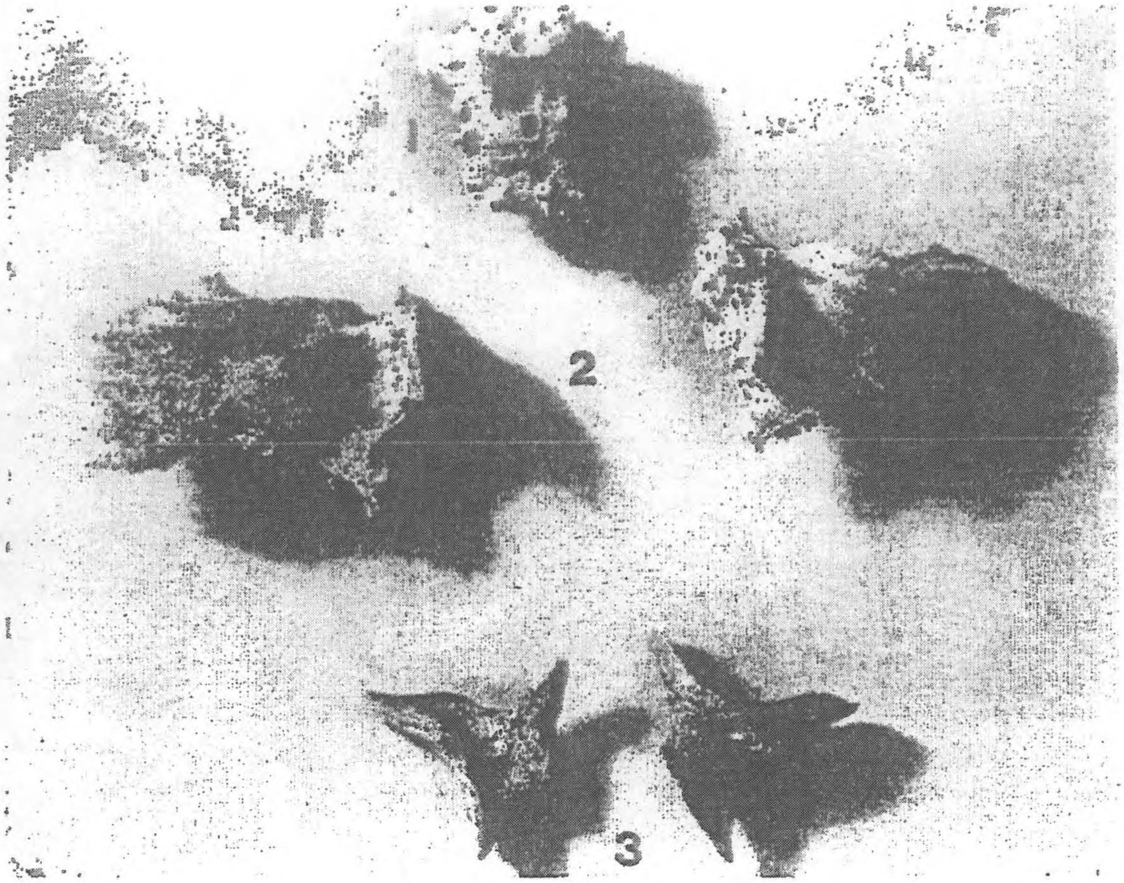


Figure 60. Fetal skull bones: sphenoid. 1) basisphenoid, 2) alisphenoids, 3) zygomae = cheek bones (circa 32 weeks).

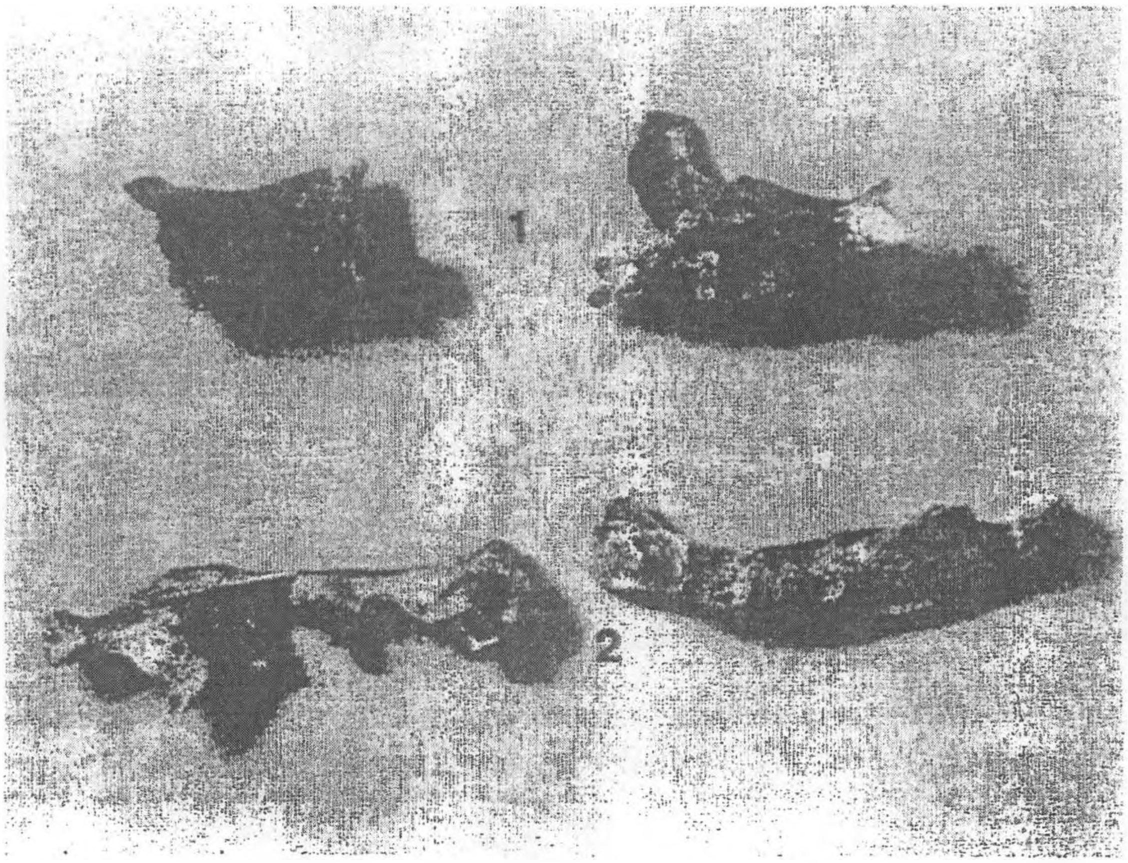


Figure 61. Fetal skull bones: right and left halves of 1) maxilla (upper jaw), and 2) mandible (lower jaw) (circa 32 weeks).

FOUND! HUMAN ERRATA

Page 19, line 16 - read 'proposition'

Pages 58, 59 and 147 - read 'Cullison'

Page 158, last line - read '5 each foot'