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Identification of Skeletal Remains

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duty the plane covers the East, Harlem, and Hudson Rivers, plus the Narrows, Gravesend, and Sheepshead Bays and parts of Coney Island.

The helicopter on Air Patrol Post 2 takes off one half hour before the 'copter from Post 1 lands and stops are made intermittently at Flushing Airport, Harts Island, and finally, Floyd Bennett Field again at 5:30 P.M. At Harts Island the crew lays over for two hours standing by for possible calls for assistance in the area of Orchard Beach and other resorts on Long Island Sound. This post covers the Rockaways, Jamaica Bay, Flushing Meadow, Long Island Sound, part of the East River, and Rikers Island.

The final patrol begins at 6:00 P.M. and covers Staten Island, making one stop at the airport there and another at Pier A before returning to Floyd Bennett Field at 7:45 P.M.

The Air Patrol Posts are set up to have a 'copter in the air, or available for immediate action, during the time of the day when police activity on the posts would be at their peak. On Post 1, harbor and river traffic are at their height during its hours of patrol in the morning and early afternoon. On Post 2, the recreational areas of Jamaica Bay, Orchard Beach, and the Rockaways are covered during the busy hours of the afternoon, and while at Harts Island, the 'copter is readily accessible to the penal institution on Rikers Island. On Post 3, which covers the area of the Atlantic Ocean and the perimeter of Staten Island, many calls are received from disabled boats and other crafts during the evening hours.

The routes of the sky patrol cover all fifteen sky ports and airports within the city limits, and from which itinerant flyers, student flyers, and reserve pilots operate.

Scope of Helicopter Work

"Helicops" are subject to respond to almost any kind of emergency call in which speed and mechanical agility are required. The decision to participate in these emergencies rests with the Commanding Officer of the Emergency Service Division after he confers with the officer-in-charge of the Aviation Bureau. The gravity of the call is weighed against the calculated ultimate risks involved. Here judgment and experience of the commanding officers are of paramount importance.

During regular patrol work, the helicopter pilot is "on his own" often performing air-land-sea rescues.

A look at the Aviation Bureau's blotter reveals the following "routine" investigations and missions completed by helicopter pilots in the year:

Low flying complaints	57
Forced landings	32
Crashes or crash landings	9
Photography flights	35
Traffic surveys	24
Search for missing boats	75
Injury flights	3
Body recovery (floaters)	15
Storm warnings	3
Boats interfering with bathers	10
Banner-towing aircraft	5
Submersion search	5
Search for escaped convicts	4
Stolen boats	3

While "on their own", ingenuity plays a great part in the success of the helicops' patrol. A pilot, seeing four boys adrift on a raft in the East River, maneuvered his helicopter in such a manner that he blew the raft to shore. "Helicops" observed an unpiloted sportscraft tearing wildly about heavily-trafficked Sheepshead Bay, endangering the lives of people in small craft. Synchronizing their speed and direction with the runaway boat, the 'copter pilot dropped his co-pilot into the boat, and the craft was brought under control.

The helicopters have performed spectacular missions which probably could not have been accomplished by any other aircraft in New York City: Picking up a pilot of a small seaplane overturned in the freezing water of Jamaica Bay; searching for a missing cadet in the lakelands and woodlands around West Point; rushing blood plasma from a pier on the East River and landing on the grounds of Marine Hospital, Staten Island, in time to save a life; saving a man sunk in the mud up to his chest in Jamaica Bay.

Cooperation with Other Departments and Agencies

The versatility of the helicopter is proven by the variety of requests for particular services from agencies outside the Police Department.

Aerial Dusting of marshlands for mosquito control (Health Department).

Aerial Photography: Furnishes Department of Correction with photos of prison sites and buildings; photos of land sites subject to litigation for

Board of Estimate; map fire zones for Fire Department; photos for Bureau of Smoke Control.

Aerial Searches: For Department of Correction in ferreting out escaped prisoners.

Air-Sea Rescues in cooperation with U. S. Navy and Coast Guard.

Cloud Seeding for Department of Water Supply, Gas, and Electricity in watershed areas in the Catskill mountains.

Advantages of a Helicopter

The author, as commanding officer of the Emergency Service Division since 1953, was instrumental in bringing the switchover from the fixed-wing plane to the helicopter in the Aviation Bureau. We pioneered helicopters for police work, and they simply can't be beat for the job they are doing. The advantages of helicopter operations far outweigh the limitations of the craft. Consideration of each comparison with fixed-wing planes will bear out this fact.

Speed. The average air rescue takes less than a half hour from the initial call to return to base. It only takes a helicopter 90 seconds to warm up as against five minutes for a plane.

Fact Finder. The 'copter provides an expeditious means of separating true and false reports of emergencies. "We get a call at 11:45 that there's a man in the river near the George Washington Bridge. At that time we know that No. 1 patrol is standing by at Dyckman Street pier, so we relay the call there. In three or four minutes we fly down there to check the report. After getting to the scene there is no trace of anyone. It would take a harbor patrol boat possibily 45 minutes to reach the spot. So we save the department a lot of time and money." An airplane responding to this call could not skim the water low enough to make a thorough search for the victim.

Poor Weather Patrol. When visibility and the weather are poor, the C.A.A. can order all planes to be grounded, but this order does not apply to police helicopters. Therefore, the helicopter can go up "even when the birds are walking" to do special police work.

Little Space Required. Helicopters do not need to be taxied, whereas a plane requires a runway. This allows the sky cops to land on compact heliports or emergency landing spots close to the scene of action.

Crime Prevention. The ubiquitous helicopter works a psychological hardship on potential lawbreakers. Harbor "cut-ups" obey maritime regulations as the whirly-birds swoop down on dangerous water games; weekend motorists in the middle of heavy traffic are reminded of safety rules as 'copters glide along the contours of key highways; attempted prison breaks are unwittingly thwarted by unexpected flights overhead.

The helicopter, like fixed-wing aircraft, has certain limitations which still leave something to be desired as the ultimate police air machine.

Darkness. Normally, no helicopter flights are made after dark. In a city like New York, tall buildings, bridges, smoke stacks, and high wires make helicopter patrol too risky. However, under certain imperative conditions, helicopter pilots are ordered to cover a specific scene of police action (usually a marine emergency).

High Winds. Helicopter patrols are cancelled whenever winds reach 35 mph. Other police units are alerted for disaster duty when this situation arises.

In an era of ever-changing aerial horizons, the Police Aviation Bureau will continue to improve its flying equipment to better serve the needs of a great metropolis. When and if the helicopter will be superseded by another type of aircraft is not foreseeable at this time.

IDENTIFICATION OF SKELETAL REMAINS

ALICE M. BRUES

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1st Gravedigger. Here's a skull now; this skull hath lain you i' the earth three-and-twenty years.
Hamlet. Whose was it?
1st. G. A whoreson mad fellow's it was; whose do you think it was!
Ham. Nay, I know not.
1st G. A pestilence on him for a mad rogue! a' poured a flagon of Rhenish on my head once. This same skull, sir, was Yorick's skull, the king's jester.

HAMLET, Act V, Scene 1.

INTRODUCTION

The identification of skeletal remains is a very specialized sort of work, and the number of people who are fully prepared for it is limited. These persons are called physical anthropologists, and it may be of some interest to consider how they come about. Physical anthropology is the study of the many features of the human body which vary from one individual to another; physical anthropologists begin their course of study with human anatomy, giving special attention to the skeleton which, as the most durable part of the body, furnishes information about prehistoric as well as modern peoples. Also, they must study the abundant literature in which human variations are analyzed with reference to sex, age, race, and environmental influences. Lastly, they should have direct experience in handling human skeletons in adequate numbers; this may be done either in medical school collections or, more frequently, in collections recovered from archaeological excavations. In the latter case they acquire experience in restoring broken material and drawing conclusions from fragments. Having completed their training, they are generally employed either as anatomists in medical schools, or as teachers and researchers in universities or museums, where they are concerned with the study of prehistoric human remains and the significant comparisons that may be made between them and the skeletons of living or contemporary peoples. Identification work is naturally a rather occasional occupation for them, except in rare instances such as mass programs for identification of war dead, which may employ a full-time anthropologist for two or three years. If a trained anthropologist cannot be located through a local university, material may be referred to the National Museum in Washington.

Some information about skeletal identification is usually found in textbooks of forensic medicine. In many cases this is rather meager and partly obsolete, representing uncritical copying of material from one text to another. However, in some recent texts in which special editors have prepared the chapters, very excellent accounts are given. These are valuable summaries for the working anthropologist, as well as informative for the law enforcement officer who encounters skeletal material, the pathologist to whom it is brought, and the attorney who may have to deal with testimony based on it. It is to be hoped, however, that the fullness of these accounts will not encourage too much do-it-yourself anthropology by persons who lack a first-hand familiarity with skeletal material. The present paper will not attempt to give instruction, but rather to acquaint the law enforcement officer with the type of information which may be derived from skeletal material, the degree of certainty or uncertainty with which various conclusions can be drawn, and the ways in which he can contribute to the success of the identification.

The procedure for handling an identification case varies with the circumstances under which the material is brought in. In some instances there is a

definite presumption of identity, and the task of the anthropologist is to verify the identification by determining that there are no contrary indications. These "directed" cases are quickly disposed of if the original supposition of identity is correct. Other cases are wide-open at the start, and the anthropologist must give a general description before the investigators can begin to pick "suspects" from missing persons files. In some cases, of course, individuals may never have been reported as missing, and it is hoped that press releases will elicit information from friends or relatives. As soon as definite possibilities emerge, the suspected individuals are checked as far as possible against the skeleton. Sometimes no possibilities appear, or all have to be discarded, and the case remains open.

It has generally been found satisfactory here to issue a verbal report, covering sex, race, and age, which the investigators can use as preliminary information and relay to the press. This gives the public the impression that something is being done by people who know what they are doing. The next report is a written one, generally not more than a page, confirming (or sometimes modifying) the offhand verbal report of the previous day, with supplemental information such as missing teeth, etc. This laboratory uses a mimeographed form for recording parts present, condition, pathology and anomaly, with sex and age estimates. A carbon copy of this, which is filled out as soon as possible, is enclosed with the preliminary report. A final and full report is made at leisure, for record purposes, sometimes not till the investigation is being closed by a successful identification. Frequent conferences between anthropologist and investigators are most desirable. It is difficult to convey in a written report the degrees of certainty and uncertainty with which assertions are made. Since the investigator's work involves dovetailing many probabilities and some contradictions within the evidence, both anthropological and other, direct discussion is necessary to ensure that each of the anthropologist's inferences is given neither too much nor too little weight. This sort of evaluation is difficult to handle on a mail-order basis.

Time and Cause of Death

One of the questions often asked in regard to skeletal or semiskeletal remains is the approximate length of time since death. This is not really within the province of the anthropologist, though after some experience he may be prepared to contribute to a discussion in which various factors are considered by those investigating the case. Most sections of this paper present both helpful hints and cautions: This one will be mostly cautions. Remember that a body shallowly buried in a northern climate, during months when the mean temperature is at or near freezing, is virtually in cold storage. On the other hand, this writer has seen the body of a 300-pound man reduced to a skeleton and a few scraps of dried tissue, during one month of warm weather; the body had been loosely covered, above ground and accessible to blow flies. The anthropologist who has had experience with archaeological material will recognize the characteristic condition of bones 100-years old or more, since he has handled material of that type in quantity. In other cases he will not be speaking as a professional, and often will prefer to turn the question over to the pathologist who may have had more experience with the earlier stages of decay.

Another question not properly in the anthropologist's field is the cause of death. In the majority of cases the cause of death will leave no marks on the skeleton; however, occasionally an instrument causing death may fracture a bone. The essential question is whether the breakage took place at the time of death, or after burial or during exhumation. The anthropologist will be familiar with the characteristic breakage of old bones in which the organic matter has been lost, and that due to animal depredations (discussed in a later section). If the fracture is not so attributable, it should be referred to the pathologist, who has observed fractures in fresh material, particularly in cases in which the circumstances of injury were known.

Condition of the Remains

The ideal case, from the point of view of the anthropologist, is the skeleton which has been completely cleaned by natural decay before it is presented for examination. But there are unfortunately all gradations between the reasonably intact body on which features and distinguishing marks may be observed, and the clean skeleton which may be studied by the anthropologist. The partially decomposed or partly burned body is not only one of the most objectionable, but one of the most useless objects conceivable. Some information may be derived by x-ray of the body, but this is inferior from the point of view of identification to inspection of the cleaned bones, just as any photograph is inferior to direct inspection of an object,

with the further disadvantage that the images of various parts are superimposed in the x-ray. When a partially decomposed body is received the pathologist should first be consulted, to obtain what information he can from the decayed tissues, or to concede that the soft tissues are no longer worth examining, as the case may be. A sample of the debris from the region of the abdominal cavity should be preserved for toxicological analysis. If hair is still present an ample portion should be preserved. X-rays should be taken to ascertain whether a bullet or any other significant metal object is embedded in the mass and should be searched out. Then the decayed tissues must be removed, and the bones disinfected and dried. In one case studied here, where a deformity of the toes due to improper shoes was a critical point in identification, the ligaments were left on the feet and allowed to dry in place so as to retain the characteristic distorted shape.

It is common in remains of all stages of decay to have more or less loss of parts. The most obvious case is that of the body dismembered before disposal, in which the perpetrator actually succeeds in permanently losing some of the pieces. More common, however, is the case in which an exposed or partially buried body is mutilated by dogs or wolves. In these cases certain parts, generally limbs, and most commonly hands and forearms, have been dragged away and chewed up and are never recovered. The rib cage and skull are most likely to be found because they are not meaty and hence not so attractive to animals. (The skull is always the bone most likely to be "found" in the sense that it is reported, because it is most recognizably human.) Hands are most likely to be incomplete because even rodents may carry portions off. Rodents also may cause considerable damage to a skeleton by chewing up more fragile portions of bone; they also frequently chew at the shafts of bones, leaving very characteristic marks which are apt to be interpreted by an inexperienced person as indicating that someone has attempted to cut the flesh off with a knife.

Breakage is a common occurrence and of course facilitates extensive loss of parts. The cause may range from death by explosion, reasonably successful attempts at cremation, to circumstances of exhumation. Buried bodies are most likely to be found quite unexpectedly, and no one may be aware of them till a skull or some other recognizably human portion suddenly appears in the gleanings of the steamshovel or bulldozer or in the wake of the farmer's plow. By this time the burial is thoroughly disturbed and many or most of the bones broken. Under such circumstances even the most careful worker will not recover all the material; however, every fragment counts. An extreme case is recounted by Dr. Bertram Kraus of the University of Arizona. An elderly man had a cabin in the woods which was known to contain amongst other things a keg of powder. In some fashion the keg was exploded, and scattered over a couple of acres of ground were small pieces of bone, none of which was much larger than a silver dollar. There was no particular suspicion of foul play, but the life insurance company was understandably reluctant to pay a death benefit without some assurance that the material was at least human. In spite of the smallness of the pieces it could readily be shown that the bone was human, and certain particularly diagnostic fragments established the sex and approximate age to the satisfaction of the insurance company. Another reason for great care in recovering all fragments became evident in this laboratory after an oversight had already been made. A female skeleton was brought in to us with six inches of underlying soil, so carefully that the removal of the skeleton from its matrix was actually performed in the laboratory. When all bones had been accounted for, the dirt was put aside very casually. Several weeks later it transpired, in the course of the investigation, that one likely missing woman had been five months pregnant at the time. There is not much bone in a five months fetus, but under such ideal conditions it might have been found, and constituted a valuable piece of evidence. Fortunately, this possible identification was rejected on anthropological grounds, before the missing lady turned up alive.

Some puzzling cases concern spare parts which turn up without the rest of the body. One woman's foot found in this city was never accounted for, and we can suggest only that it was removed from a funeral home by the same dog who gnawed much of the bone out of it. It is unlikely that the mortician would have reported such an incident. Less puzzlement attaches to various bits of anatomy returned to us by landladies who rent rooms to medical students. The anthropologist soon learns that the world is well supplied with practical jokers whose first thought, on encountering a recognizable piece of human remains, is to deposit it where someone else will find it. Some clue as to the origin of this material can be derived from a knowledge of the color and texture differences

produced in bone by different conditions of preservation. Burial in well-drained soil, burial in damp soil or under water, and surface exposure produce distinct color effects. The roots of plants produce an etching effect in time by removing mineral matter from the bone in a thready pattern. One skull supposed to have been washed up on the shore of a lake was found to have drilled in the center of the forehead the neat ⅛ inch hole which is made to inject hardening fluid into the brain—in medical school embalming rooms only!

Mummified material: i.e., that in which the soft tissues have dried without prior decomposition, is most fascinating to the finder, who often suspects that it must have "come from a museum". Natural mummification will occur only in arid, virtually desert, climates. Such material if found elsewhere must be suspected of having been preserved in some way so that decay was prevented while a slower drying took place. It has probably then been embalmed—reasonable assurance that it passed at one time through legal channels—and most probably can be traced to a medical school. It is perhaps not generally realized how often parts of bodies are issued by medical schools for special study by physicians or surgeons. Generally, provision is made for the return of the material to the school after use, but this requirement is often overlooked. Embalmed material will mummify quite completely at ordinary room temperatures and humidities in the course of a few months. Evidence of purposeful dissection, or a chemical test for common ingredients of embalming fluid, will establish the origin of the material, though it may have been passed from hand to hand by a series of practical jokers before it is finally found. The last such piece we encountered was "found" in an abandoned henhouse on the farm of a man who was, interestingly enough, in jail in another state at the time, and it gave rise to some interesting theories before its origin was established.

Species Determination

The layman can recognize a skull as human, and probably in most cases the skeleton without the skull if it is reasonably complete and arranged in a natural position. Most persons would not be able to state whether individual bones were human or animal except as a result of some rural familiarity with the bones of the commoner animals. Sometimes bones suspected of being human are first submitted for inspection to the local physician; this practice has resulted in severe embarrassment to all concerned. At the present time the medical school curriculum allows very little time for study of the skeleton, and the medical graduate has only a casual acquaintance with bones. The error most commonly made by the doctor is to identify an animal bone as human, not realizing how similar bones of different species may be in general outline. One of our graduates, an amateur archaeologist, brought in what he stated to be the right radius of a child; it was the right radius of a dog instead. Even with an anatomy book in his hand he had missed the details which distinguished them. A dentist, also with anatomy book in hand, identified as human a "finger joint" which was found in a bag of potato chips. His general judgement of morphology was good; it was the corresponding bone from a pickled pig's foot. In all cases correct judgement could be made instantly by a person who was thoroughly familiar with the human skeleton. Experience is the essence of recognizing bones; it is as easy for the expert as it is impossible for the beginner. And though some of the distinctions are not very obvious, they are very numerous, so that species can be determined generally from a handful of fragments. An Indian burial brought into our laboratory recently consisted of 289 fragments of bone, the largest of which was 4¼ inches long, together with 32 bits of stone, shell, etc., which the collector had taken for bone, and 8 teeth. This burial, like many aboriginal ones, had been made in soil already well stocked with animal bones from the camp refuse. The fragments were sorted out for size, and then according to whether they were definitely and readily identifiable as human or non-human. Of the fragments less than ½″ in greatest diameter, none were so identifiable; of those from ½ to 1″ in diameter, 9% were so identifiable; of those from 1–2″ in diameter, 28% were identifiable: of those from 2–4¼″ in diameter, 37% were identifiable. The judgement was very conservative; all doubtful cases were put into the "unidentifiable" category. (In the case of larger pieces the low percentage of identifiability was largely due to the numbers of rib fragments present.) The eight teeth were all identifiable as human; no complete tooth could ever be mistaken in this respect. It may then be said that if you have enough bone fragments (more than ½″ in diameter) to make a total of 5 or 6 inches laid end to end, it can probably be determined whether the remains are human or not.

An additional question which for some reason rarely occurs to the investigator, but is always re-

membered by the anthropologist, is that of the number of individuals represented. A comparatively scant collection of bone scraps may include duplicated skeletal parts indicating that more than one individual was present; in addition, parts mismatched for age, general size, sex, etc. show duplication. In the fragments described above two adults and two children could be established.

Age Determination

There are several scales by which an individual's age at the time of death may be determined. The first, which covers the period from birth to about 12 years, is the sequence of eruption of the deciduous teeth, followed by their loss and the development and emergence of the permanent teeth. This forms a definite time table on which the individual may be placed. Since there is individual variation in the rate of development of the dentition, with some children erupting teeth earlier or later than normal, there is a degree of inaccuracy amounting to about a year and a half by the time the age of 12 is reached. The next age scale, which holds good from the late pre-natal period up to about 25 years of age, is the development of the skeleton itself. Bone begins to appear in the second month after conception; as pregnancy advances the amount of bone in the fetus and its likelihood of recovery continually increases, giving the possibility of identifying the mother by duration of pregnancy. Then throughout the period of childhood there is a continuous series of changes involving first the appearance of new centers of bone formation and then the fusion of centers to form the adult bone. This method of assessing age encounters again the problem that all individuals do not grow and mature at exactly the same rate. This produces a natural error in aging by this method, which is for practical purposes about 10% plus or minus. This error is best expressed in percent, since the effect of developmental rates is cumulative, and a six months' error at the age of five is equivalent to a two and a half year error at the age of 25. There is also complication due to the fact that the average age for the various changes is not the same for the two sexes and also exhibits some racial differences which have not yet been fully studied. It should be noted, however, that the bone development scale avoids the error by which a child of tall or short stock might be judged older or younger on the basis of size alone. The usefulness of skeletal aging, despite its margin of error, was shown in a recent case handled in this laboratory. A headless female body, quite fresh, was first judged to be that of a fourteen-year-old girl, on the basis of physical development. The examination of the skeleton was made by x-ray, and to everyone's surprise indicated an age of from 20 to 23 years. This individual was positively identified shortly after (the head having been found) and proved to be 21 years old. The three-year range which it was necessary to give in stating the skeletal age was small indeed compared to the error originally made from inspection of the body itself.

After the last of the primary skeletal changes has occurred, at about 25, the estimation of age has to be based on other changes which are more difficult to judge and less reliable. The condition of the sutures of the vault of the skull is generally considered in judging age in this period. The bones of the skull vault are quite separate at birth, connected only by membrane, and readily moved about. Their edges approximate to form a complete surface in early childhood, but can be separated without breaking until the age of 20. After this time the sutures gradually close by actual union of the bones, and the thin lines of separation visible on the young skull gradually disappear, characteristically earlier in some parts of the skull than in others. The process is not generally complete (i.e., so that the suture lines are no longer visible) till about 60. This method of aging must be used cautiously; it is subject to much individual variation, and it has been recently shown that suture closure may be greatly delayed, even to the extent of never occurring at all, particularly in women. On the basis of the latest studies it seems wise to assume that the true age will generally not be more than 5 years *less* than that indicated by accepted standards of cranial suture closure, but may be very much more; that is to say, the skull gives us a more or less reliable minimum age, but a very poor estimate of the maximum. In some cases abnormal failure to close with advancing age may be given away by a thickening of the bone which makes the suture line appear sunken. As in all cases of natural variation, we can only say that the more marked the difference from average, the less likely it is to occur; but it is difficult to draw the line where impossibility begins.

Another portion of the skeleton which is valuable in determining age in the adult is the pubic bone which forms the midline of the pelvis in front. The right and left pubic bones are separated at the midline by a pad of cartilage. The surfaces of

the bone which face this cartilage go through a very complicated and interesting series of changes in texture and contour which begin at about 18 and go on till about 50. Todd, who developed this method, claimed accuracy of age determination within 10%. Most present authorities believe that this claim was overconfident, and would settle perhaps for 15% accuracy. (At estimated age 40, 15% on either side means a range from 34–46, which is hardly a pin-point prediction.) The data presented by Brooks show that, in contrast to the determination of age by the cranium, the age determined by the pubis is more likely to be greater than the true age (by a very wide margin). This suggests, that, as the cranium gives the more reliable minimum age, the pubis gives the more reliable maximum age. This concept is helpful in bracketing the true age, but there is still considerable margin of error. It should be noted, however, that this error is perhaps no greater than that in estimating the age of a living person, and less than might be involved in estimating that of a fresh body.

Although the skull and pelvis have been most intensively studied with respect to age determination, other bones exhibit changes indicative of age. In older individuals there is a tendency for bone to become roughened and ridged at the points of tendon attachment; sometimes bony tissue grows out into the ligaments connecting the vertebrae to the extent that adjacent vertebrae are joined by bridges of bone. The change in texture, like the change in skin texture of the living, gives a more accurate impression of age than can be conveyed in words. Such changes do not occur consistently in all individuals, but may give an over-all impression of age which is a valuable guide where indications of age in the skull and pelvis are contradictory or uncertain.

An additional indication of age may sometimes be derived from the degree of wear of the teeth. Decay and loss of the teeth are no respecters of age, but actual wear: i.e., grinding down of the crowns of the teeth by chewing, ordinarily occurs rather slowly, and if marked suggests considerable age. Disturbing factors here are abnormal softness of the teeth themselves, or abnormal constituents of the diet. In cases where the otherwise suspected age is over fifty, tooth wear however should be given some weight in the age estimate. The poorest age estimate the writer has ever made was in a recent case in which the condition of the teeth should have warned her to be more cautious.

Sex Determination

After species, sex is perhaps the thing which the investigator expects the anthropologist to determine with the greatest accuracy. The certainty of sex determination varies with the completeness of the skeleton, the age of the individual, and with race and individual characteristics. Most important for sex determination is the pelvis, which shows directly the functional adaptations for child-bearing. The remainder of the skeleton, particularly skull and teeth, reflects the respective ruggedness or delicacy of the male or female body, and in many cases is clearly diagnostic of sex. As will be discussed later, racial differences in size and sturdiness of body, as well as individual peculiarities, may complicate a sex determination.

In general, determination of sex from the skeleton is limited to adults, since the characteristic sex differences develop under the influence of endocrine changes occurring at puberty. There are some differences in growth pattern between the sexes during childhood, however, manifested primarily in accelerated skeletal development of the female, in preparation for the earlier puberty of the girl. Recently Hunt and Gleiser have shown that the relative acceleration of skeletal development in girls is not paralleled by an equal degree of acceleration in eruption of teeth. They therefore believe that in the child of unknown sex and unknown actual age, an estimate of sex may be made on the basis of comparison of skeletal development with dental development; the girl being further along than the boy in skeletal development, for any given stage in tooth development. This method is new but appears promising.

Beginning during puberty, the characteristic adult sex differences develop and are established by the time of full sexual maturity. The most characteristic of these differences are in the pelvis. The human pelvis is a compromise structure involved in both walking and child-bearing. Efficiency of gait is increased by narrowness, since this places the hip-joints closer together and more nearly in line with the center of gravity of the body; efficiency (or even sheer possibility) of child-bearing depends on adequate breadth of the internal pelvic aperture in several dimensions. Numerous rules are given for judging the sex of a pelvis by different authorities; some of these are based on observation, some on measurement; and many of them are clearly only different ways of describing the same thing. Washburn has analyzed

the sex differences of the pelvis and found two basic differences. The first is that in the female the pubic bone, which forms the anterior part of the rim of the pelvis, is longer relative to the rest of the pelvis. This difference is measured in terms of a ratio by Washburn and Grant, and results in a difference in configuration of the whole front of the pelvis; various authorities, pointing out different aspects of this overall change, have described it in various different ways. Washburn shows that a second basic difference, which appears to be independent of the first, is the widening of the sciatic notch, which throws the sacrum back out of the pelvic aperture and results in a widening of the birth canal in the front-to-back direction. He believes therefore that there are essentially only two factors of difference between male and female pelvis, in spite of the many ways in which the differences have been described. He estimates that 90% of pelves could be correctly sexed by the relative length of the pubic bone, and 75% by the width of the sciatic notch; since the two characteristics are independent, they should give a correct diagnosis of sex in 95% or more of cases, if both are used. He makes, however, one important qualification: Such success is based on the supposition that the skeleton is of known race. Comparative study shows that among Negroes the sex difference in the pelvis is less marked, with both sexes tending to be more "masculine" than the same sex in Whites. The highest certainty of sex determination, then, would depend on the presence of the skull to determine race; without knowledge of race, the error most likely to be made would be to judge a Negro female as "male". Interestingly, the sex indications of the pelvis are so specific that 2-inch fragments of a smashed pelvis may be useful as a whole bone.

The skull presents a considerable amount of sex differentiation in size and proportion. The size and distinctness of muscle attachment markings is generally greater in males, and the vault is generally thicker. In proportions, the male skull differs by having a heavier face in proportion to the brain-case, and heavier jaw in proportion to upper part of face; the dental arches are especially larger in the male, and the individual teeth larger. The facial structure of the male is more generous in amount of bone present; structures which are narrow or sharp-edged in the female tend to be thicker and coarser in the male. Stewart, a very conservative observer, states his accuracy of sex determination from the skull to be 77%. This is probably a minimum; it could be bettered, particularly if one were dealing with a group of skulls of known and uniform racial background. The judgment of sex by lightness or heaviness of skull and face must be done with allowance for apparent race and total body size, and due regard for the individual differences, apparent enough in life, whereby the basic structure of the face may approach that of the opposite sex in the rugged female or tenuous male.

In the absence of skull or pelvis, determination of sex is somewhat more speculative. The experienced observer will form an opinion on the basis of the general heaviness and ruggedness of the bones, and may in that way be able to give better than a guess on the basis of a few fragments. For this purpose the joint surface at the ends of bones are more valuable than the shafts. If the individual is typical for the sex, i.e. muscular if a male and delicate if a female, and does not come within the intermediate size range between average male and average female, a sex determination can be given with some confidence on fragments of the long bones, especially if the heads of the humerus and femur, or the joint surface which they fit, are present. Probably the anthropologist can give a confident opinion from the incomplete skeleton in from 30 to 60% of cases, depending on the individual characteristics of the skeleton and the portions present.

From time to time detailed work has been published on determination of sex from isolated bones purely on the basis of size. In evaluating these it should be remembered that total body size alone will determine sex in a considerable percentage of cases. In a series of living Americans in my own files it can be shown that if all persons over 169 cm. in height were assumed to be male, and all below 169 cm. to be female, the "diagnosis" of sex so made would be correct in 81% of cases (this would of course not work if individuals of a taller or shorter race were slipped into the series). This is interesting, but hardly adequate for selecting a blind date! Any bone the dimensions of which partake of general body size will give us about this good a prediction, and no bone which does not give us a better prediction than this can be considered to have any special virtue for estimate of sex. From results so far published it appears that this 80% value is about the upper limit of predictability of sex from size alone of any bone. And this, it should be remembered, will apply only if the general stature of the racial group involved is known.

Fortunately our two largest population groups, White and Negro, are about the same in all-over body size. But obviously a male individual of a small race would likely be judged as female if the size of isolated bones were used as sole criterion of sex. (There are no races consistently much larger than Americans, either White or Negro, so the opposite error would not be made.)

Determination of Stature

The determination of the most probable stature of the living individual, given the right bones in good condition, is a comfortably routine matter; the sources of error are known and can be allowed for. This is one task that can be done adequately by a non-trained person, provided he reads carefully the description of how length of a bone is measured—bones do not have square ends like rulers, and there may be more than one way of measuring them. Stature is most accurately determined from the long bones of the leg; femur, tibia, and fibula; any one of these gives nearly as adequate prediction as all three. Little is gained by having the bones of both sides, except in the rare case when one leg was noticeably shorter than the other. A measurement of these bones tells us in effect the length of the leg; when we predict stature from it we are assuming that the individual was of average proportions. Obviously there is a source of error if we are dealing with an individual with long legs relative to trunk and neck, or vice versa; this error is simply described by saying that our prediction is plus-or-minus an inch and a half. No satisfactory method has ever been devised for estimating the length of the trunk from the vertebrae. Part of the height of the vertebral column consists of the cartilaginous discs between the vertebrae, which are soft and may actually thin out with age; this introduces an unknown factor which would probably make stature prediction less rather than more accurate if it were introduced into the prediction formula. The bones of the arm are valuable insofar as arm length correlates with stature, which it does, to a less degree than leg length; our second best formulae are derived from arm bone lengths. The reader should be cautioned against some superstitions which seem still to be circulating, even in forensic medicine texts of the less inspired sort; one, for instance, to the effect that the "height of the head is one-eighth the height of the body." This is a rule-of-thumb for figure drawing, invented by artists and still used by them; it was first recorded by Vitruvius Pollo in the first century B.C., though it probably was already traditional at that time. Obviously, the luxuriance of variety in the size of the human head would make giants and dwarfs all around us if the size of the body were closely correlated with the head size.

The importance of the long bones for stature identification necessitates some special cautions for the investigator collecting the material. It is important that the bone be absolutely intact at its very ends. Bones are not nearly as hard as some believe; in the living much of their strength is due to organic material which is lost with decay. The most fragile part of the bone is the joint end, which is spongy in texture and covered with a rather thin compact layer. In a bone which has been buried in damp soil, especially if the soil is somewhat acid in reaction, these ends of the bone become soft and may be crushed or chipped by fairly light pressure. If the extreme end from which the standard measurement is taken is damaged, the length of the bone is partially a guess, with consequent inaccuracy of the stature prediction derived from it. So all long bones should be handled with special care, particularly when damp. Never try to squeeze them into a box that is a little too short: preferably it should be long enough to allow paper wadding at the ends. Another caution concerns the long bone of which the shaft is shattered into several pieces. A satisfactory length cannot be derived from a bone of which we have two ends, but a piece of unknown length missing in the middle. A rather small fragment may be the connecting link that transforms two separate pieces into a measurable long bone usable for stature determination.

Formulae for predicting stature from the long bones have been in use ever since the pioneer work of Rollet in 1888. The formulae now generally used are those derived by Trotter from her study of skeletons of American soldiers of known identity and with stature records in Army files. These are superior to earlier data because of the size of series, racial type exactly applicable to our local problems, and the fact that comparison is made with known living stature rather than with a length measurement done on a cadaver. Separate formulae are given for White and Negro, not very different, but making allowance for the known difference in proportional length of leg between the two races. Formulae for females, derived from accessory data, are also given. The sex difference in proportion and consequently in prediction for-

mula is much more significant than the race difference. With these formulae it is easy to derive very quickly the best possible estimate of stature within the necessary limitations outlined above. Actually, one of the more disconcerting complications of stature in identification is the inexact nature of the records of the living person's height. Most people believe themselves to be about an inch or so taller than they really are, especially if they are on the short side of average, and such height estimates regularly find their way into records. My own driver's license states my height one inch greater than it is, intentionally; if it did not, people would be looking for a slightly shorter person when I presented it as a means of identification. This sort of error must always be allowed for.

Race Determination

One of the most interesting aspects of identification, to the anthropologist, is the determination of race. The features by which race is judged are almost all features of the skull, and particularly of the face; racial differences in the rest of the skeleton are few and uncertain. This means that racial features must be sought in the very area where individual variation is most rampant. Further, race mixture sometimes confuses the picture; and it is not all of recent origin, for it has been such a constant factor in the development of the human species that most anthropologists would hesitate to assert that pure races in the popular sense of the word have ever had a chance to develop. This means that few characteristics can be counted on to be entirely absent or universally present in any racial group, and only by the consideration of a number of indications can the race of the skull be judged. Occasionally, a physician without special training will endeavor to judge race of a skull by certain generalizations which were formerly (not often at the present time) given in small print in anatomy books. These generalizations, mostly expressed in terms of certain measurements and ratios, represent moderate differences in average values between different races, arrived at by study of the general trends of racial groups and of no value in assigning a single skull to a particular race. In general, measurements of the skull are of less value for judging race than are certain morphological (i.e. shape) differences which are not susceptible to exact measurement.

Parenthetically, it should be noted that race determination may be greatly aided by even a small sample of hair; in fact typical Negro hair can make a race diagnosis without anything else. Hair is remarkably resistant to decay, though it is likely to be blown or washed away or carried off by rodents for nest material. In lifting a skull always look for hair on the under side; if none is apparent, save the soil beneath the skull to be washed out later.

Racial characteristics can be grouped in three classes: first, those which are apparent only in the soft tissues and are lost in the skeleton. These would include skin and eye color, the shape of the eyelids, soft parts of the nose, lips, ears, etc. Since these are among the characteristics most obvious to first glance, and commonly used in assessing race, the layman is prone to assume that racial identification from the skeleton is very mysterious. There is, however, a second class of characteristics, due to the contour of bone in areas where it closely follows the surface, which are apparent in both skeleton and living. These include the contours around the root and bridge of the nose—an area in which racial differences are especially well developed; and grosser contours such as the prominence of the cheek-bones in Indian or the forward protrusion of the jaw region in the Negro. A third class is that of characteristics which are apparent in the skull but not in the living. This includes: The formation of the lower border of the nasal aperture, very distinctive in reasonably full-blooded Negroes; characteristics of the zygomatic arches in Indian; certain details of the posterior surface of the incisor teeth in Indians; contours of the part of the cheek bone which is concealed by fleshy parts in the living; and certain extra suture lines of the skull, which although neither common nor absolutely confined to one race, give, if present, a rather high presumption of a particular racial diagnosis. Some individuals will be more clearcut and unmistakable specimens of their race than others; some, usually as the result of mixture, though not always, may be dubious. The greatest difficulty in such diagnosis is the fact that the anthropologist's judgment of race may be adequate biologically but fail sociologically. We have all seen individuals with a very black skin, but with facial features showing few if any negroid contours. Conversely, blond individuals may sometimes reveal distinct Negro features to a careful examination; both individuals may have the same mixture of White and Negro, but one will be living as a Negro and the other as a white person. If the features of the skull indicate a mixture of White and

Negro traits, we have to allow a wide leeway as regards the apparent race of the individual in life, since skin color and hair, which largely determine the lay diagnosis of race, are unknown. In parts of the Southwest, where the assumption of white or Indian social status by a mixed individual is to some extent a matter of personal choice, we can state only that the individual is "mixed".

Dr. T. D. Stewart, perhaps the most experienced anthropologist in the country, tells of giving a racial diagnosis of "mixed white and Indian" on a skull from Mississippi believed by the investigators to be that of a "Negro". He did not feel that, considering the state of race mixture in that area, this was necessarily a contradiction. Many of our diagnoses of race would have to be thus knowingly interpreted.

Identification of Individual Features

The matters so far discussed—species, age, sex, stature, and race—comprise a preliminary screening process which rules out a large number of possibilities. Generally the next stage in the study is to check the remains against known information (including photographs, if possible) of missing persons. The number of "suspects" may be large or small depending on other information which the investigators are able to obtain. The number of points that can be checked depends on the amount of descriptive material about the living individual which is available, as well as the completeness and state of preservation of the skeleton. The ultimate certainty of the identification will depend also on the unusualness or distinctiveness of the features which can be checked. Particularly valuable are abnormal or traumatic conditions such as loss of teeth and broken bones.

The teeth may present many features valuable for identification. If an individual has had good dental care, the dentist should have a detailed record of work done on the teeth, including the number of fillings, which teeth they are in, and what part of the tooth. In a final check, the dentist can often recognize the characteristics of his own style of fitting a filling. Such identifications are most satisfactory and claim the respect of the public. Unfortunately, the sort of person who is liable to drop out of sight without being missed, for a long enough time to reduce a body to a skeleton, seems rarely to be of the social class or personal habits which are conducive to systematic dental care. In a surprising number of skeletal identification cases we find only decayed teeth, or missing ones which may or may not have had an assist from a dentist in their final removal. The value of the teeth in these cases is limited to information obtainable from those who knew the individual in life, or from photographs. Loss of back teeth may be known by a member of the family; though such information is often given with great uncertainty; loss of front teeth may be noted by anyone who was acquainted with the person. Front tooth loss, especially of the uppers, may be checked from photographs. The front (particularly upper) teeth also, if visible in photographs, as they often are, may be checked in detail for shape, relative size, angle of protrusion, broken corners and other peculiarities. Unfortunately these teeth, unlike the back ones, have single straight roots and are liable to drop out after death. The investigator therefore should know how to tell the difference between tooth loss before death and tooth loss after death, so that he may institute a search for any teeth which might be found in the vicinity of the skull. Teeth are small and heavy, and readily drop into cracks in dry soil or sink into the mud if the soil has become very wet at any time. When a tooth is first removed from the bony gum, the socket of the tooth is seen as a clear deep hole with a sharp, almost knife-edged, bony rim all around it; if the tooth is lost after death, this appearance will remain the same. But in the living individual, when a tooth is removed, the sharp edge of the tooth socket begins to be absorbed within a few hours; this process continues rapidly, and eventually, by the disappearance of the sharp edge and the filling of the deepest part of the cavity with new bone, all trace of a socket disappears, and the gum area it occupied becomes a simple smooth ridge connecting the bases of the adjacent teeth. Sometimes the process appears partially complete, with the gum not rising to the height that it does on other teeth in the jaw, but with a bit of smooth-lined socket still left as if for the tip of the root. In this case we are probably seeing a case in which a tooth was soon to be lost from gum disease, but was still hanging on, probably loose, at the time of death. The importance of teeth in identification is such that a first rule in picking up the skull should be to check the gums and look for evidence that teeth have dropped out after death. When the missing teeth are found it is not a bad idea to try to fit them into the correct sockets and apply a little glue to prevent losing them again.

A history of broken bones in an individual is sometimes helpful, but by no means always. The investigator is liable to believe that a bone broken several years ago will give positive identification and comes to the anthropologist with the information in a high state of satisfaction. But bone, in spite of its hardness, is a remarkably adaptable tissue. Shortly after a fracture it rejoins, forming a large overgrowth or swelling at the point of fracture. This, however, is transitory; in the course of time the extra bone is absorbed, and the contours of the bone remodeled into a perfect facsimile of its original shape. Only if the fracture is badly handled, so that the broken ends are out of line with one another, or overlapped, will there be a visible deformity of the bone after the healing process is completed. One exception may be noted, in the case of ribs. Ribs are generally not set with special care since the muscles attached to them act as sufficient natural splints; so a broken rib nearly always heals with a slight "jog" in it. However, broken ribs are very common, and friends or relatives will so rarely recall exactly where they were, that this evidence becomes confusing, unless an old chest x-ray is available for a direct check.

Certain obvious physical deformities leave their mark on the skeleton; stoop-shoulder, flatfoot, a "limp" in many cases, or long-term paralysis of a limb. Arthritis (whatever that may mean in a lay diagnosis) or "trouble" in a joint or the back, will often correlate with physical changes in the bones. This is hard to make definite statements about, since a given degree of actual change in the joints may quite incapacitate one man, and hardly trouble another, depending on customary occupation and to some extent on personality.

Identification by characteristics which show a wide range of natural variation may be as conclusive, though less dramatic, than identification by fracture, disease, etc. To a great extent this depends on comparison with actual photographic records. This includes not only photographs in the usual sense, but x-rays. X-ray records have especially been used in the identification of burned bodies where the cleaning of the skeleton would be a formidable job. Of course x-ray diagnosis, like dental work, is not a prerogative of the "disappearing" type of person. However, industrial health programs now take many chest x-rays which display the ribs, sternum, and vertebrae, all bones which present numerous minor but very distinctive individual characteristics. Consequently, in any investigation of this type a special effort should be made to trace down any old x-rays of a suspected missing person.

Identification by comparison of a skull with photographs of the living face is always of special interest. It is based on some of the factors which we have mentioned in connection with diagnosis of race. In certain parts of the face the surface of the skin is separated from the underlying bone by a layer of soft tissue which is fairly thin and of uniform thickness, so that the contours of the bone reflect those of the living face very closely. Such areas are the forehead, the root and bridge of the nose, the protruding part of the cheek bone, and except in obese individuals, the lower border of the jaw. Areas in which the facial features are not predictable from the skull are the tip of the nose, the lips, and the fleshy part of the cheek. There are various ways in which the features may be reconstructed from the skull. One method (the one which appeals most to the lay imagination and is most popular in fiction) is to have an artist take a skull and do a drawing or sculpture from it. Data are available on the average thickness of the soft tissues on the face, which may be used as a guide. Such a reconstruction is presumably to be used by having persons who knew the suspect make a comparison. There are certain disadvantages to this method. In order to complete such a reconstruction, it is necessary for the artist to create out of whole cloth a nasal tip, lips, etc. He will have to compromise with ignorance by making these structures rather average and noncommittal. If the individual actually had rather marked peculiarities in just these features—which may indeed be among the most noticeable features of a face—the identification may be missed. In the drawing the artist can make these really unknown features hazy, so as to avoid this difficulty; but the sculpture allows of no such compromise, so that the latter procedure is probably best left to the ample literature of detective fiction.

A more satisfactory method, which allows for more careful judgement of the significance of various details, is comparison of the skull with photographs, by the anthropologist. Here much depends on the quality of the photographs. Standard police identification photographs are excellent, but in most cases the available photographs are far inferior to this. Commercial portraits generally are well lighted and show contours well, though one must watch out for retouching. This writer has seen one tremendously aquiline nose, in a