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A comprehensive examination of University of Montana Forensic Cases 35A and 35B

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A Comprehensive Examination of University of Montana Forensic Cases 35A and 35B

By

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Abstract

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Director: Randall R. Skelton RS

This professional paper involves an examination of two sets of skeletal remains, which were recovered together. Forensic anthropologists are trained in osteology and are able to reveal information about skeletal remains in order to assist law enforcement agencies. The remains were analyzed in order obtain information about the sex, age, ancestry, stature and weight and pathology and trauma of UMFC 35A and B at the time of death. Several forensic anthropology methods were used in the examination of the remains.

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BACKGROUND INFORMATION

The skeletal material of two individuals currently known as UMFC 35A, an adult and UMFC 35B, a small child, were discovered on Cherry Street in the lower Rattlesnake area of Missoula, Montana in the fall of 1974. The remains were discovered near a residence on the street, which was undergoing some remodeling. The remains were revealed while soil excavation was being conducted, they were first noticed when a human skull was exposed. Unfortunately some bone material was lost during the initial excavation because it was not noticed right away. Pieces of wood and several metal handles (some still attached to wood), thought to be from a coffin, were found along with the remains. A site form was recorded for these remains by A. Murray and G. Knight on October 29, 1974. An excerpt from their description follows.

> At least two types of handles were found, one type being much smaller and plainer than the other. It has been suggested by Livingstone, the coroner and funeral director, that these smaller handles came from the child's casket. He also feels that the caskets were professionally made. On the basis of the packed dirt and on information given to us by the property owner about the positioning of the material when first uncovered, it appears that the caskets were laid in an east-west position. However, directional placement of the head is not known. Mr. Livingstone believes that because only one hole was dug for these two burials, it is possible that they were placed one on top of the other. None of the material except some pieces of wood were seen in context by the crew members present.

The material was first viewed at the Livingstone-Maletta Funeral Home. It was then brought to the University for study (Murray and Knight 1974).

It was originally thought that the remains were that of individuals of Chinese ancestry. This assumption was made from the directional placement of the bodies, the designs of the casket handles and a preliminary examination of skeletal material. The lower Rattlesnake area is historically known to have been a burial ground. In fact the deed to the property owner's house states that the area was once a burial ground. The area is sometimes referred to as a Chinese cemetery; however, such a term was used to describe a poor person's cemetery in the past as well.

Since 1974, when the remains were recovered, they have been housed at the University of Montana's Physical Anthropology Laboratory. Throughout the years the remains have been examined by many forensic anthropology students. The remains have provided students with significant opportunities to research the age, sex, race, stature and weight, and pathology and trauma from skeletal materials.

AN INTRODUCTION TO THE HUMAN SKELETON

There are about 206 bones in the human body, with some variation. The skeleton is divided into two general categories, cranial bones and postcranial bones. Cranial bones are bones of the skull and postcranial bones are all other bones of the skeleton. Each bone has several features, including projecting parts of the bones such as crests, spines, tubercles, tuberosities, condyles, and heads and depressions or spaces such as grooves, fossa, foramen, and sinuses. These features may be used to identify a specific bone if only part of the bone is recovered. It is extremely important for a forensic anthropologist to have thorough knowledge of each bone. Knowledge and experience will allow an anthropologist to correctly identify bones whether they are small (such as hand and foot bones) or fragmented. It is also helpful to be trained in the identification of non-human bones. During a recovery, non-human bones may be mixed with or located near human bones so, it is important to be able to distinguish between them.

A complete skull consists of a frontal bone, left and right parietal bones, left and right temporal bones, three auditory ossicles, an occipital bone, a maxilla, left and right palatine bones, a vomer, left and right nasal conchas, an ethmoid, left and right lacrimals, left and right nasal bones, left and right zygomatic bones, a sphenoid, and a mandible. According to White and Folkens, "the skull is the most complex portion of the skeleton and is of major importance for physical anthropology. It is one of the keys to aging and sexing" (White and Folkens 2000:45) of the human skeleton. There is some individual variation in the number of skull bones. Burns notes, "many of the extra bones are small bones isolated within the skull sutures. They are called wormian bones. An extra suture across the occipital can result in a triangular bone at the back of the skull called an Inca bone. Lack of union of the frontal bone results in a retained midline suture, a *metopic* suture and paired frontal bones" (Burns 1999:24).

The postcranial skeleton is further divided into the axial skeleton, the upper limbs, and the lower limbs. The axial skeleton is made up of a hyoid bone, the vertebral column, which includes seven cervical vertebrae, twelve thoracic vertebrae, and five lumbar vertebrae, a sternum, and eighteen ribs (nine lefts and nine rights). The upper limb region consists of right and left clavicles, right and left scapulas, right and left humerii, right and left radii, right and left ulnas, and hand bones made up of carpals, metacarpals, and phalanges. The lower limbs consist of a sacrum, a coccyx (three fused coccygeal vertebrae), left and right coxal bones, right and left femurs, right and left patellas, right and left tibias, right and left fibulas, and foot bones, which include tarsals, metatarsals, and phalanges.

Part I

A LITERATURE REVIEW OF DENTAL ATTRITION STUDIES: PAST AND PRESENT

Forensic anthropologists study both the bones and teeth to identify human remains. Teeth are made up of hard tissues and preserve very well after death. Odontologists, who include dentists, orthodontists, periodontists, oral surgeons, or oral pathologists are experts at dental analysis. They occasionally assist forensic anthropologists with issues that may arise with restored teeth or dental prostheses, etc. Generally, forensic anthropologists have thorough knowledge of teeth morphology, anatomy, and classification. According to Burns, the anthropologist is more likely to become involved in the study of genetic variation due to geographic and ethnic isolation, cultural differences in hygiene and nutrition, ritual practices, and diagenetic alterations due to burial conditions" (Burns 1999:110). One condition of teeth that has been studied extensively is dental attrition. Dental attrition is defined as loss of tooth crown due to abrasion (White 2000). Once deciduous teeth are lost and permanent teeth begin to erupt, they begin to wear.

Forensic anthropologists are interested in dental attrition for a variety of reasons. The analysis of dental attrition may yield information about age at death, sex differentiation in wear patterns, cultural practices, and diet. Forensic anthropologists are most interested in estimating age from dental attrition. According to White, "rate and patterns of wear are governed by tooth development sequences, tooth morphology, tooth size, internal crown structure, tooth angulation, nondietary tooth use, the biomechanics of chewing and diet" (White 2000:343). Toothwear is also quite variable from population to population.

It is important for anthropologists to be able to identify wear which may be related to cultural practices and natural wear. There are several ways teeth may be culturally altered. For instance, "pipes clenched between the teeth over long periods lead to approximately equal abrasion on the upper and lower teeth, often resulting in an ovate hole observable when the teeth are occluded" (Scott and Turner 1988:112).The use of probes such as toothpicks are common and their use affects the crown enamel and root. Dental mutilations including the complete removal of teeth, removal of parts of the teeth and chipping or drilling of the teeth are seen in a variety of populations (Scott and Turner 1988).

There were several early studies of dental attrition. In 1955, Zuhrt studied dental attrition from an 8^{th}-14^{th} century burial in Germany. He was able to establish rates of attrition for a period of years for children and adults. Another early study was conducted in 1956 by Thomas Murphy. He studied an Australian Aborigine skull collection and observed the "changing pattern of dentine exposure in each permanent tooth with increasing tooth attrition" (Murphy 1956:177). He illustrated the progression and the range of variation in dental attrition.

As mentioned previously, dental wear varies from population to population. Molnar believes, "this variability is possibly related to certain material aspects of culture such as diet, food preparation techniques and tool usage. In order to learn more about these relationships, extensive cross-cultural comparisons must be made" (Molnar 1971:175). Molnar studied dental attrition rates from the skeletal remains of Native North

Americans from three regions; California, the Southwest, and the Valley of Mexico. His study showed that there were differences in tooth wear between groups and between sexes within each group. Molnar found a correlation between tooth wear and cultural practices, related to dietary specialization and division of labor. He believes important information can be discovered about human-environmental relationships through the study of dental attrition. Molnar suggests further population studies of dental wear patterns. He sees several problems with previous studies, including "lack of a suitable method for recording various features of tooth-wear and associated alveolar bone" (Molnar 1971:177). He claimed that earlier studies were only concerned with degree of wear and dentine exposure and "no record was made of the form of the occlusal surfaces that were the result of wear" (Molnar 1971:177). His study was inconclusive about the differences in male and female wear patterns. Molnar suggested further studies of diet, age, and aspects of material culture, which can be indicated by the appearance of the teeth and supporting bone (Molnar 1971).

The teeth of modern populations exhibit less wear than prehistoric populations (Brothwell 1972). Brothwell believes the "study of degree of attrition has three principle uses when dealing with excavated material" (Brothwell 1972:67). These uses are age estimation, a determination of the number of individuals present, and "similarity in dental wear may enable fragments of jaw to be associated with the same individual" (Brothwell 1972:67). When estimating age from dental attrition, Brothwell says to watch for differences between sexes (cultural and physical reasons), and lessening of chewing strengths with age. However, "such differences do not appear to be great enough to upset age differences" (Brothwell 1972:68). Brothwell suggests comparing age results from dental attrition to the age range given by the pubic symphysis. This should "enable age-attrition standards to be established for a group, and should greatly assist in determining the age of other specimens where the teeth are the only available criteria" (Brothwell 1972:68). He also notes, "theoretically, one should not assess the age of specimen on attrition standards established on the basis of material belonging to another archaeological period and to a different era" (Brothwell 1972:68). His study was based on premedieval British populations. He came up with an attrition chart, which included adults and children and he compared his results with ages from the pubic symphysis.

Lovejoy (1985) studied modal patterns of occlusal attrition from the Libben population (332 adult dentitions). Lovejoy noted "wear patterns were very similar to those reported by Murphy (1956) for Australian Aborigines" (Lovejoy 1985:47). He did not find significant sexual differences in wear rates. However, "dental wear is concluded to be a highly reliable and important indicator of adult age at death for skeletal population if seriation procedures are employed" (Lovejoy 1985:47). According to Lovejoy, "the Libben population presents a highly regular and progressive record of dental wear resulting from a common hunter-gatherer diet, and this pattern was deemed a valuable source of information for estimating individual age at death" (Lovejoy 1985:47). Lovejoy believes that accurate information about dental attrition can only be obtained by examining a population and that an individual doesn't provide much information. "Opinions have varied widely as to the effectiveness of toothwear in the estimation of age-at-death" (Lovejoy 1985:54). Stewart (1962) commented on a study of the Indian Knoll site by Johnston and Snow.

> The fact that the authors emphasize dental attrition as an accessory means of age estimation or as an indicator of age raise doubts. Certainly it is valid to use dental attrition as an aid in distinguishing a young adult from an old adult, but when it comes to distinguishing a 30-year old individual from a 40-year old individual, attrition is no more reliable than suture closure. What is interesting to know is the variability of attrition at successive stages as determined by other criteria (Stewart 1962:143).

Miles believes that "in archaic populations, toothwear probably provides the best indicator of age if it can be used systematically" (Miles 1978:58). Lovejoy thinks Stewart and Miles are both right. Population studies are better than individual studies, which was evident in his study of the Libben population. His conclusions were that "the correlations between dental wear and other indicators are high" (Lovejoy 1985:54) and he suggested further studies.

There is little information on dental attrition rates for modern populations. Most studies of attrition aging are based on premodern peoples and are they are used to compare to contemporary peoples (Tromly 1996). "However, with so many factors affecting attrition and change in dental hygiene and diet over time, this approach is unlikely to yield truly accurate estimates of age for contemporary populations" (Tromly 1996:4). During his graduate research, Tromly developed an attrition chart which can be applied to a contemporary population. He used 54 Western Montana dental impressions and created a standard numbering and scoring system for estimating age from dental attrition.

Mayall and Kageyama came up with what they describe as "a new technique combining moiré contourography and digital image analysis, which allows the three-dimensional description of molar wear" (Mayhall and Kageyama 1997:463). They believe "it is possible to describe the amount of tooth material lost in a given time and the differing amounts of wear on individual cusps" (Mayhall and Kageyama 1997:463). The moiré technique is described in detail in Mayhall and Kageyama's 1997 paper in ***The American Journal of Physical Anthropology***. This technique, "can be used in conjunction with more conventional quantitative techniques or by itself to assist in age determination in a population. It can be used to describe small amounts of wear that hitherto were difficult to quantify" (Mayhall and Kageyama 1997:463). The author's note, however, this technique "is not recommended where the wear includes the greatest convexity of the crown (height of contour) or affects the central fossa" (Mayhall and Kageyama 1997:468).

Over the years many studies of dental attrition have been conducted. Teeth are made up of hard substances and they survive a long time after death. They can help provide a lot of information about an individual or a population after death. Some anthropologists disagree about the reliability of dental attrition patterns to estimate age at death, but attrition studies continue to reveal more and more information. Overall, as with many methods for determining age, sex, race, etc., it seems that the most accurate estimates are made by looking at several different methods and comparing the results.

Part II

THE SKELETAL INVENTORY OF UMFC 35A

Ideally, it would be great to recover a complete skeleton, however that is very rare. During the recovery process it is important to collect as many bones and teeth as possible. Analysis of the bones and teeth can reveal an individual's age, sex, possible ancestry, and stature and weight. It is also possible to "discern a variety of pathologies from which the individual may have suffered" (White and Folkens 2000:2). The analysis of the skeletal material will be a lot easier if several bones are available to examine. "Because the bones and teeth of the skeleton are resistant to many kinds of decay, they often form the most lasting record of an individual's existence" (White and Folkens 2000:2). Skeletal material may be found on the ground surface, under debris, buried, etc. Careful and thorough collection of bones is essential. Proper recovery methods should be followed and the correct tools should be used. There are several publications, which detail the steps to a good recovery, including Karen Ramey Burns's ***Forensic Anthropology Training Manual*** (1999). A recovery team should be knowledgeable of the correct recovery techniques and they should be well prepared.

Several skeletal elements were recovered for UMFC 35A. The skull was complete, except for some possible premortem pathologies and some postmortem traumas. These pathologies and traumas are discussed in detail in the pathology and trauma section. The occipital and the left and right parietals were complete. The frontal was partially complete. This bone exhibited a triangular defect, located superior to the frontal squama and it measured 51.8mm by 45.7mm at its widest points. The left temporal was partially complete. Two small holes on the squama, measuring 16.8mm by

5.9mm and 7.8mm by 5.1mm at their widest points, were observed. The mastoid process was quite deteriorated, due to a possible premortem condition. The majority of the zygomatic process was missing as well. The right temporal was incomplete, due to the absence of most of the zygomatic process. The right and left zygomatic bones were both missing their temporal processes. The right and left palatine bones were both present and complete. The left and right maxillas were present and complete. The left and right nasal bones were present and complete. The ethmoid was present and complete. The right and left lacrimals were present and fairly complete, except for some deterioration (see pathology and trauma). The vomer was present and complete, although it was slightly deteriorated (see pathology and trauma). The sphenoid was present and complete, except for a small amount of deterioration (see pathology and trauma). The mandible was present and complete.

Some complete maxillary teeth were recovered, including the right first incisor (RI^1), the right first molar (RM^1), the right second molar (RM^2), the left first premolar (LP^1), the left second premolar (LP^2), the left first molar (LM^1), and the left second molar (LM^2). Several maxillary teeth were absent including the right second incisor (RI^2), the left first incisor (LI^1), the right canine (RC^1), the right first premolar (RP^1), the right second premolar (RP^2), the right third molar (RM^3), the left second incisor (LI^2), the left canine (LC^1), and the left third molar (LM^3).

Several complete mandibular teeth were recovered, including the left second molar (LM_2), the left third molar (LM_3), the first premolar (LP_1), the right first molar (RM_1), and the right second molar (RM_2). Some teeth were present, but fragmentary, including the left second incisor (LI_2) and the left canine (LC_1). Many teeth were absent, including the left first incisor (LI_1), the left first premolar (LP_1), the left second premolar (LP_2), the left first molar (LM_1), the right first incisor (RI_1), the right second incisor (RI_2), the right canine (RC_1), and the right second premolar (RP_2). Most of the teeth that were missing were lost postmortem, but some of them were missing premortem. Tooth loss is discussed in more detail in the section on pathology and trauma.

Not all postcranial elements were recovered. However, several postcranial bones were recovered, some complete and some incomplete. All of the bones of the axial skeleton were absent, including the hyoid, the entire vertebral column (cervical, thoracic, and lumbar vertebrae), the sternum, and all ribs.

The bones discussed below were from the upper limbs, those which were present and those which were not. The right scapula was present, but was severely deteriorated. The only identifiable feature of the bone was the acromion, all other features were absent (see pathology and trauma). The left scapula was not recovered. The left humerus was present and complete, but the bone was deteriorated (see pathology and trauma). The right humerus was not recovered. The left ulna was present and complete. The right ulna was not recovered. The left radius was present and complete, except for some slight deterioration (see pathology and trauma). The right radius was not recovered. Several additional bones were missing, including the left and right clavicles, and all hand bones, including the carpals, metacarpals, and phalanges.

The following includes recovered and missing bones of the lower limb. The left femur was present, but fragmentary. The distal portion of the bone was missing; it was broken off inferior to the adductor tubercle. The right femur was present and complete, except for some deterioration of features (see pathology and trauma). The right tibia was present and complete, with the exception of some slight deterioration (see pathology and trauma). The left tibia was present, but incomplete. The proximal end of the bone was severely deteriorated. A significant portion of the bone, superior to the fibular articulation, but inferior to the lateral condyle, was missing (see pathology and trauma). The sacrum was present and complete, except for some deterioration of the left side (see pathology and trauma). The right patella was present and complete, with only a small amount of deterioration (see pathology and trauma). The left patella was not recovered. The left fibula was present and complete, except for a small amount of deterioration (see pathology and trauma). The right fibula was present, but incomplete. The distal portion of the bone was missing, including the lateral malleolus, the malleolar articular surface, and the malleolar fossa. The left portion of the coxal was present, but incomplete. The entire region of the pubis was absent, including the ischiopubic ramus, the iliopubic ramus, pubic symphysis, and the obturator groove. Most of the bone was deteriorated, as well (see pathology and trauma). The right coxal was not recovered. Some additional bones of the lower limb were not recovered, including all the foot bones (tarsals, metatarsals, and phalanges).

SEX ESTIMATION

Skeletal differences exist between males and females. White states, "in determining the sex of any skeletal element, the osteologist starts with 50% accuracy - random guessing will be correct half the time. It is extremely important to remember that sexual identification of human skeletal material is generally the most accurate after the individual reaches maturity. Only then do the bones of different sexes become differentiated sufficiently to be useful in sexing" (White and Folkens 2000:362). Females overall are smaller in size than males. "Female elements are characterized by smaller size and lighter construction. For this reason, the largest most robust elements with the heaviest rugosity are male and the smallest most gracile elements are female" (White and Folkens 2000:362-363). However, some skeletal remains do not exhibit significant dimorphism so, "osteologists have traditionally concentrated on elements of the skull and pelvis in which sex differences in humans are the most extreme" (White and Folkens 2000:263). White and Folkens also add, "in addition to the complications of individual variation within the population, incorrect sex identifications are sometimes made because of variation between populations" (White and Folkens 2000:363). In some populations males may be mistaken for females and females for males. "Some populations are, on the average, composed of larger, heavier, more robust individuals of both sexes, and other populations are characterized by the opposite tendency" (White and Folkens 2000:363). White and Folkens emphasize, "the osteologist should always attempt to become familiar with the skeletal sexual dimorphism of the population from which unsexed material has been drawn" (White and Folkens 2000:363). And they believe, "seriation can be a helpful approach in determining the sex of skeletal remains from a population" (White and

Folkens 2000:363). Several methods may be used to estimate the sex of skeletal remains, such as sex from the measurements and shapes of certain bones.

SEX ESTIMATION FROM THE COXAL AND SACRUM

One of the most reliable methods for determining sex is from the shape of the pelvis and coxal bone. According to Bass "the highest level of accuracy has been achieved using this bone" for sex determination (Bass 1995:210). A number of common female characteristics were observed on this individual. A wide sciatic notch was visible; it was determined to be wide using the "thumb test" described by Bass. Bass states, "if the notch is filled or there is only limited side-to-side movement possible, it is a male. If considerable movement is possible, it is a female" (Bass 1995:210). See figure1 below.

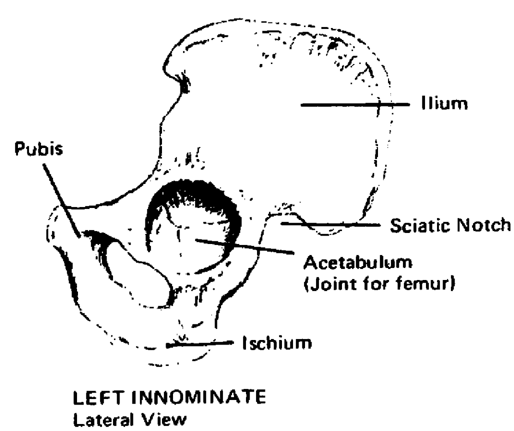
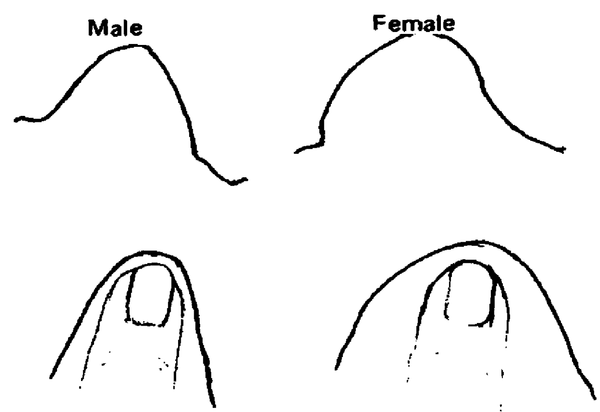


Figure 1
(from Bass 1995)



Sciatic notch thumb test.

The auricular surface of the coxal was elevated. Weaver defines auricular surface as "if the sacro-iliac surface was elevated from the ilium along its entire length and along both the anterior and posterior edges of the sacro-iliac surface, the auricular surface was considered elevated" (Weaver 1980:192). A preauricular sulcus was present on the coxal, which is a trait most often found in females (Bass 1995:210). The coxal also exhibited a relatively small acetabulum, a female characteristic.

Rogers and Saunders report on the accuracy of sex determination using 17 individual morphological traits of the human pelvis. They used a sample of 49 right and left hip bones and sacra of adult skeletons from a 19th-century cemetery, located on the grounds of the St. Thomas Anglican Church in Belleville, Canada. Their list includes four sections, which are the pubic bone, ilium, overall pelvis, and sacrum. UMFC35A displayed several female characteristics within these categories. Traits of the pubic bone could not be used to determine sex, because the bone was not recovered. Female characteristics of the ilium included; a wide and shallow sciatic notch shape, a raised auricular surface, a preauricular sulcus was present and its overall shape was large with circular depressions, and the shape of the ilium was laterally divergent. The pelvis had several additional female traits including; a small acetabulum, which was directed antero-laterally and a gracile, smooth appearance, not rugged and muscle-marked, as is common with male pelvises.

The sacrum exhibited the following female traits; a short, broad overall shape, 5 segments, and the sacroiliac joints were not visible from the posterior view of the bone (Rogers and Saunders 1994:1049). According to Bass, "the sacrum generally is more curved in males and flatter in females" (Bass 1995:113). The sacrum of this individual was flat and less curved than that of a typical male. The individual's sacrum was made up of 1/3 body and 2/3 ala, a female characteristic. Anderson "notes that in females the width of the first sacral body (articular area) is equal in width to each ala" (Anderson

1962:142). Overall, the sacrum appeared to be small and wide, both of which are female traits.

SEX ESTIMATION FROM THE SKULL

Bass believes, "the skull is the second best area of the skeleton to use for determining sex. Estimation of sex is based on the generalization that the male is more robust, rugged, and muscle marked than the female. Absolute differences seldom exist and many intermediate forms are found" (Bass 1995:85). UMFC35A displayed several common female traits of the skull. The nasal root was not sunken, "it is extremely rare for a woman to have a sunken nasal root" (Skelton 2002:14). Frontal bossing was present, which is a high, unsloping frontal bone, characteristic of females. The brow ridges were small and not prominent. The right and left mastoid processes were relatively small. The left mastoid process had some deterioration, see pathology and trauma section. The zygomatic arch did not extend beyond the external auditory meatus. The nuchal area of the occipital bone was not rugged and the nuchal crests were not prominent (see figure 2). The shape of the chin was round, with a point in the midline (see figure 2). The orbits appeared to be round, with sharp edges. The mandible was fairly thin, the gonial region was only slightly muscle marked, and the mandibular condyles were rather small.

This individual exhibited typical female skull characteristics, which indicated that the sex of UMFC 35A was most likely female. The overall size of the individual's skull was small and fragile. No male skull characteristics were observed. Some skull characteristics of both females and males are illustrated in figure 2.

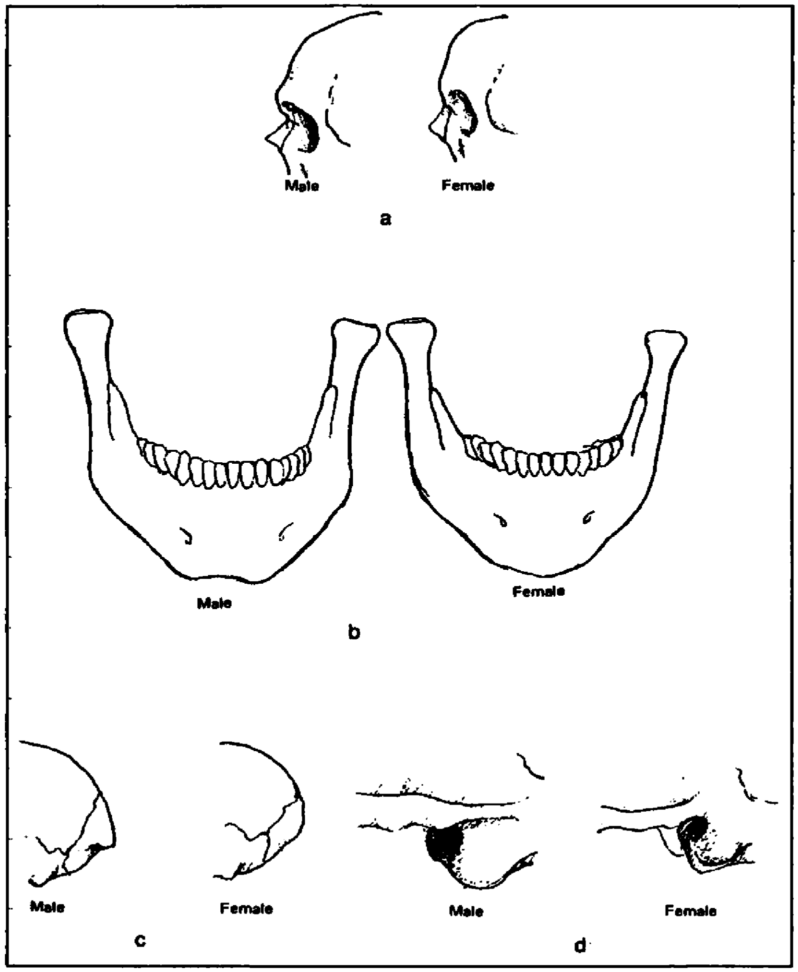


Figure 2 Distinguishing characteristics of the crania used to determine sex: a, brow ridge and forehead; b, the mandible; c, nuchal crest; d, the mastoid process (From Bass 1995:87).

SEX ESTIMATION FROM BONE MEASUREMENTS

Sex can also be estimated by measuring certain bones, such as the humerus, femur, and tibia. According to Krogman, "in general, sex differences in the adult long bones are a matter of size- typical male bones being longer and larger (more massive) than typical female bones" (Krogman 1962:143).

The humerus may be measured to determine sex, but Bass believes that it is a poor bone for estimation (Bass 1995:156). Stewart "has reported on the vertical diameter of the humeral head on dry bones for 50 males and 50 females from the Terry Collection" (Bass 1995:156). His results were: (Stewart 1979:100)

Table 1

	Females	Sex indeterminate	Males
Vertical diameter of humeral head	<43mm	44-46mm	>47mm

The vertical diameter of the humeral head of the left humerus of UMFC 35A measured 41.6mm. This measurement indicated a female based on Stewart's chart, in which female humerii are < 43mm. The right humerus was not recovered and therefore was unavailable for analysis. Dwight also studied the diameter of the humeral head. His results were: (Dwight 1905:19-32)

Table 2

	Vertical	Transverse
Male	48.76	44.66
Female	42.67	36.98
Difference	6.09	5.68

The vertical diameter of the humeral head of the left humerus of UMFC 35A was 41.6mm and the transverse diameter was 36.3mm. Both of these measurements fall below the average humeral head size for females. From this method, the humeral head measurements of UMFC 35A indicated a female.

Dittrick and Suchey "have studied sexual dimorphism of both the femur and humerus using prehistoric skeletal samples from central California. They report that the best single indicator for the humerus is the transverse diameter of the head. Accuracy obtained with this one measurement alone is 96% in Early Horizon, 86% in the combined Middle and Late horizons, and 88% for all horizons combined" (Dittrick and Suchey 1986:2). See table below.

Table 3

Sexing by Transverse Diameter of the Head of the Humerus in Prehistoric Samples from Central California (N= 258)

Sample	Male	Female	Male mean	Female mean	%Accuracy
Early Horizon	>42.8	<42.8	44.5	39.6	96
Middle Horizon and Late Horizon	>40.9	<40.9	43.3	38.6	86
Combined Horizon	>41.2	<41.2	43.5	38.6	88

From Dittrick (1979)
Measurements in mm.

The transverse diameter of the head of the humerus of UMFC 35A was 36.3mm, which was well below the measurements for females in these early populations.

The femur can also be used to estimate sex. According to Bass, "the femur is one of the most-studied bones of the skeleton and as such has contributed a great deal to the literature on sex estimation" (Bass 1995:225). Pearson has come up with a femur-measurement system to determine sex. However, "it should be cautioned that Pearson's measurements were taken on 17th century bones from London and that modern populations are larger" (Bass 1995:230).

Table 4

Rules for Sexing the Femur

	Female	Female?	Sex?	Male?	Male
Vertical Diameter	<41.5	41.5-43.5	43.5-44.5	44.5-45.5	>45.5
Popliteal length	<106	106-114.5	114.5-132	132-145	>145
Bicondylar width	<72	72-74	74-76	76-78	>78
Trochanter oblique length	<390	390-405	405-430	430-450	>450

After Pearson (1917-1919: Table 27).
Measurements in mm.

Measurements of the right femur of UMFC 35A were taken and they yielded the following results. The vertical diameter of the femur was 39.4mm, which corresponds to the <41.5mm female range above. A popliteal length of 105mm was measured, which indicated a female from the <106mm measurement from the table. The measurements of the bicondylar width (72.4mm) and the trochanteric length (392mm), both fit into the female ? category. Stewart took measurements of femoral heads from the Terry Collection and states "I feel reasonably safe in recommending the following adjustment in Pearson's range subdivision for use in sexing the dry bones of American Whites" (Bass 1995:231):

Table 5

Female	***Female?***	**Sex *indeterminate***	***Male?***	***Male***
<42.5	42.5-43.5	43.5-46.5	46.5-47.5	>47.5

(measurements are of greatest diameter of the femur head, in mm)

Using Pearson's measurements, the right femur of UMFC 35A indicated a sex of female. The measurement adjustments suggested by Stewart would still place UMFC 35A well into the female range for femur lengths.

Age may be estimated by measuring the tibia, as well. Symes and Jantz, "have been able to obtain accurate sexing with tibiae using multivariate discriminate function analysis" (Bass 1995:248). Their method involves three measurements. They suggest using an osteometric board for breadth measurements. And they state, "the circumference measurement should be taken with a metal tape pulled tightly around the shaft at the level of the nutrient foramen" (Bass 1995:248). After measuring the tibia, "simply compare that score to the univariate sectioning point, with males falling above and females below" (Bass 1995:248). Refer to table below.

Table 6

Univariate Discriminant Function Sectioning Points for White Tibiae

Group	Proximal breadth	%	Distal breadth	%	Circumference at nutrient foramen	%
Whites						
Sectioning point	75.11		49.24		90.16	
Male mean	79.56		52.23		95.97	
Female mean	70.66		46.24		84.34	
		88.75		86.25		82.50

From Symes and Jantz (1983)
Measurements are in mm.

Symes and Jantz also used Blacks and Arikara Indians in their analysis, however since UMFC 35A is thought to be of European ancestry (see race section), it is not necessary to include the data of these groups in this paper. The right tibia was used to estimate sex using Symes and Jantz's data. The left tibia was too deteriorated to be of any use. The right tibia had a proximal breadth of 66.9mm, which falls below the female mean. The distal breadth measured 45mm, which also falls below the female mean. The circumference at the nutrient foramen was 75mm, again well below the female mean. Using Symes and Jantz's data, UMFC 35A, fits well into the range of female tibia measurements.

SEX ESTIMATION FROM DISCRIMINANT FUNCTION ANALYSIS

Sex can be estimated by discriminant function analysis of the skull, using a formula developed by Giles and Elliot (1963). The discriminant functions method, "utilizes measurements of a bone plugged into a formula. Working through the formula yields a result, called a discriminant score, which is compared to a sectioning point. Sex is assigned based on whether the discriminant score falls above or below the sectioning point" (Skelton 2002:26). The accuracy of this method is 70% (Giles and Eliot 1963). The formula is shown below. See appendix II for a reference of the craniometric measurements.

2.14(g-op) + 1.000(eu-eu) + 6.224(zy-zy) + 6.122(po-ms) = [1495.40] 70%

The steps for completing this formula are as follows: (from Skelton 2002:26)

1. Take the measurements g-op, eu-eu, zy-zy, and po-ms. All measurements are in mm.
2. Multiply each measurement by the number next to the parentheses containing each measurement. For example, multiply whatever value you measured for g-op by 2.184.
3. Add (or subtract, as indicated) the products obtained in step 2. The total obtained is called the discriminant score for that individual.

4. Compare the discriminant score to 1495.40. If the score is greater than 1495.40, then the skull is male. If the score is less than 1495.40, then the skull is female. Assume that females have smaller scores, unless specified otherwise, because females are usually smaller in size overall.

This method was used to estimate the sex of UMFC 35A, the results follow.

$2.184(172) + 1.000(128) + 6.224(113) + 6.122(24) = 1353.89$

A discriminant score of 1353.89 is <1495.40, which indicated a female.

CONCLUSIONS

All of the methods described above for estimating sex from skeletal remains indicated that UMFC 35A was a female. None of the methods which were applied to the individual pointed to a male. Also, the overall gracile appearance of the remains supported this conclusion.

Several methods for estimating sex were not applicable because some bones were not recovered. Estimating sex from the measurement of the sternum and clavicle could not be used, due to the absence of these bones. Given that the sternum was not present, sex could not be determined from the shape of this bone. The right scapula was available for analysis, but it was quite fragmented (see pathology and trauma) so, it could not be used to estimate sex from the measurement of the bone or from its shape. The right coxal was recovered, although it was deteriorated (see pathology and trauma), but the left coxal was not. Therefore, determining sex from the measurement and the morphology of the entire pelvis was not possible.

RACE ESTIMATION

Race is a complicated subject for anthropologists. Generally, anthropologists believe that race is a cultural construct and that it does not have a biological basis. However, "despite the fact that many forensic anthropologists do not subscribe to the idea of distinct racial categories, law enforcement agencies and the public are better served by being provided with as much information as possible about the potential ancestry of a person than with a lecture on the race concept" (Skelton 2002: 21). There are a few general racial categories which are used by forensic anthropologists. The first category is Negroids, which includes most peoples of African origin. The second category is Caucasoids, which includes most peoples of European or Middle Eastern origin. The final category is Mongoloids, which includes the peoples of Asian, Pacific Island, or Native American origin. Skelton emphasizes, "these are very poor categories, poorly named, and not really reflective of the real worldwide pattern of human variation. However, they are still used by most authorities and we will reluctantly continue to use them ourselves" (Skelton 2002:21). The terms Caucasoid, white, and European ancestry; Negroid, black, and African ancestry; and Mongoloid and Asian ancestry are used as "racial" categories. In this paper the terms European ancestry, Asian ancestry, and African ancestry will be used, when referring to the remains of UMFC 35A.

There are two approaches to the analysis of race from the skull; "morphological and anatomical variations of the bone structure and anthropometric measurements" (Bass 1995:86). Krogman and Iscan note, "race differences in the skeleton are best known for American Whites and Blacks and on the basis of the usual morphological and morphometric studies, race can be determined from the skull in 85 to 90 percent of cases.

Using discriminant analysis, accuracy should be 80 percent for White vs. American Indian" (Krogman and Iscan 1986: 296).

Gill notes that if a physical anthropologist decides to "embrace the race concept and racial taxonomy as a valid and useful way of dealing with human variation, as 75% of forensic anthropologists do, a few important realities must be kept in mind. First, populations and races are not static or fixed, but are responsive to forces of selection and are therefore constantly changing and fluid. Races are also never pure or even all that homogenous. Nature maintains a high degree of genetic variation in all large populations and thus they remain responsive to external environmental changes. Furthermore, gene flow always occurs between adjacent populations. These two factors ensure that the boundaries between races remain quite blurred" (Gill 1995:784).

RACE ESTIMATION FROM SKULL CHARACTERISTICS

The skull can be examined for visual characteristics of race, often referred to as visual assessment of population affinity. According to Skelton, "the skull is the only part of the skeleton from which population affinity may be estimated with any degree of reliability by visual inspection. Even so, estimations of population affinity by this method are not extremely reliable. Probably, somewhere between 50 and 70% accuracy can be expected" (Skelton 2002:21). The following chart gives common characteristics attributed to the three general racial categories. These traits are visible in both males and females of each group.

Table 7

Bone/ Feature	European	African	Asian
Incisors	blade-form incisors	blade-form incisors	shovel-shaped incisors
Dentition	crowded, frequently impacted by 3rd molars	not crowded	not crowded
Zygomatics	small, retreating	small, retreating	robust and flaring
Zygomaxillary suture	jagged or S-shaped	curved or S-shaped	angled
Profile	little prognathism, orthognathic	strong alveolar prognathism	moderate alveolar prognathism
Palatine suture	Z-shaped	arched	straight
Palatine shape	parabolic	hyperbolic	elliptic
Palate width	narrow to medium	wide	medium
Cranial sutures	simple	simple	complex, with Wormian bones
Nasal bones	high and arched, with nasion depression	low, flat, shallow arch shaped	low "tented"
Nasal aperture	narrow	wide	medium
Nasal spine	large, long	little or none	medium, tilted
Nasal sill	very sharp	guttered	sharp
Chin shape	square, projecting	retreating	blunt, median
Ramus	intermediate	narrow, ascending	wide, ascending
Cranium	high	low, with postbregmatic depression	low, sloping
Sagittal contour	round	flat	arched

Coronal contour	long to round	long	round
Skull length	long to short	mostly long	long to short
Skull breadth	narrow to broad	narrow	broad
Frontal bossing	females only	both sexes	females only
Face breadth	narrow	narrow	broad
Interorbital distance	narrow	wide	medium
Orbit shape	angular to round	rectangular	rounded
Inion hook	present	not present	not present

(from Skelton 2002, Bass 1995, White and Folkens 2000, and Burns 1999)

UMFC 35A exhibited traits from all three "racial" categories. The individual had many characteristics that can be classified into more than one category. Several common European traits were observed, including little or no prognathism (orthoprognathism), a square projecting chin, an intermediate ramus width, a high cranium, a round sagittal contour, a long to round coronal contour, crowded dentition, small retreating zygomatics, a jagged-shaped zygomaxillary suture, a Z-shaped palatine suture, a parabolic palatine shape, a narrow to medium palate width, a narrow nasal aperture, high and arched nasal bones, a narrow skull breadth, a narrow interorbital distance an angular to round orbit shape, and an inion hook was present. Some traits that were visible on the skull, including blade-form incisors, simple cranial sutures, and a narrow face breadth are found in both

Africans and Europeans. There were also several skull characteristics that were from both Europeans and Asians, including a sharp nasal sill and a long to short skull length.

Overall, UMFC 35A exhibited cranial traits which were mostly of European ancestry. Some traits could be classified into African/ European or Asian/ European but, the common denominator for all characteristics appeared to be European ancestry.

RACE FROM THE SACRUM

Wilder (1920) developed a method for estimating race based on measurements of the sacrum. He used five populations in his racial indices of the sacral index, including Negroes, Egyptians, Andamanese, Australians, Japanese, and Europeans. The measurements he came up with for these populations are as follows.

Table 8

Racial Indices of the Sacral Index (from Wilder 1920:118)

	Males	Females
Negroes	91.4	103.6
Egyptians	94.3	99.1
Andamanese	94.8	103.4
Australians	100.2	110.0
Japanese	101.5	107.1
Europeans	102.9	112.4

(all measurements in mm)

A sliding caliper is needed to measure the maximum anterior height and the maximum anterior breadth of the sacrum. The maximum anterior height is a "measurement taken from the sacral promontory to the middle of the anterioinferior border of the last sacral vertebra (usually the fifth)" (Bass 1995:113). The maximum anterior breadth "measures the greatest distance across the wings (lateral masses) of the first sacral vertebra" (Bass 1995:113). The formula is as follows.

$$\text{Sacral Index} = \frac{\text{maximum anterior breadth} \times 100}{\text{maximum anterior height}}$$

The maximum anterior breadth of UMFC 35A's sacrum was 114mm and the maximum anterior height was 114.5mm, which equals a sacral index of 99.56mm. A sacral index of 99.56mm, placed this individual closest to the Egyptian population for females.

RACE ESTIMATION USING FORDISC

Steve Ousley and Richard Jantz from the University of Tennessee, Knoxville created a program called FORDISC. The program uses discriminant function analysis to determine the race and sex of an individual from cranial measurements. "FORDISC runs its analyses using data from two sources. The first source is the University of Tennessee's Forensic Database- a database of measurements of more than 1500 modern forensic cases. The second source of data is W.W. Howell's cranial database, which includes measurements of skulls from a variety of populations around the world" (Skelton 2002:29). FORDISC "allows an investigator to construct a craniometric analysis of two to four groups using one to thirty-four measurements" (Ousley and Jantz 1996:1).

The first step is to enter the cranial measurements (of the individual you are examining) into the FORDISC program. The program then runs the discriminant function analysis and "in both two-group and multi-group approaches, two statistics are provided that are not normally available in published discriminant functions. The posterior probability and the typicality probabilities" (Ousley and Jantz 1996:11). The difference between these statistics is that the posterior probability "evaluates the probability of group membership under the assumption that the unknown belongs to one of the groups in the function" and the typicality probabilities "represent how likely the unknown belongs to any particular group, based on the average variability of all groups in an analysis" (Ousley and Jantz 1996:11). It should be noted that there are some questions regarding the reliability of this program. In particular, Ousley and Jantz, the developers of FORDISC say that their program may have problems correctly classifying people whose race is not represented in the reference samples, hybrid groups, hybrid individuals, aberrant values affected by disease, disuse treatment, or trauma, non-adult individuals, and archaeological populations (Ousley and Jantz 1996:19-20).

Skelton believes that FORDISC has many advantages over the Giles and Elliot's discriminant function methods (presented below and in the sex estimation section). These advantages are, " FORDISC can be run with only a few measurements, you can use more measurements than Giles and Elliot require, and the Forensic Database population consists of modern cases. Conversely, the Giles and Elliot method should work better for 19^{th} century and early 20^{th} century cases" (Skelton 2002:29).

Cranial measurements were taken of UMFC 35A, which are listed in appendix I. These measurements were then plugged into the FORDISC program and yielded the following results. The individual was classified as a possible female of European ancestry, with .994 posterior probability and .209 typicality probability. As Ousley and Jantz noted, caution should be used when using this method to estimate ancestry. Whenever possible, this method should be used in conjunction with other methods for race estimation. The discriminant function results from FORDISC are presented, in detail in the charts below (figure 3).

Discriminant function results using 17 variables:
GOL XCB ZYB BBH BNL BPL MAB AUB UFHT WFB NLH NLB
OBB OBH FRC PAC OCC

Group	Total Number	Into Group WM	WF	BM	BF	AM	AF	JM	JF	HM	CHM	VM	Percent Correct
WM	166	120	17	2	0	3	1	4	0	11	8	0	72.3 %
WF	132	11	104	0	3	0	1	0	6	6	0	1	78.8 %
BM	125	7	1	70	17	2	1	8	3	10	5	1	56.0 %
BF	107	1	4	10	77	0	2	0	9	4	0	0	72.0 %
AM	46	0	0	0	0	32	5	1	2	0	5	1	69.6 %
AF	28	0	1	1	0	4	16	0	2	2	1	1	57.1 %
JM	100	1	0	8	1	10	1	47	10	7	11	4	47.0 %
JF	100	1	5	2	9	0	4	5	59	5	4	6	59.0 %
HM	37	4	0	3	3	1	1	2	0	19	3	1	51.4 %
CHM	79	1	0	6	0	0	6	7	2	5	48	4	60.8 %
VM	51	0	0	0	0	0	0	2	2	1	5	41	80.4 %
Total:	971			Correct: 633									65.2 %

Multigroup Classification of UMFC # 35A

Group	Classified into	Distance from	Probabilities Posterior	Typicality
WM		38.6	.000	.002
WF	** WF **	21.4	.994	.209
BM		44.8	.000	.000
BF		31.9	.005	.015
AM		67.3	.000	.000
AF		50.8	.000	.000
JM		52.9	.000	.000
JF		38.9	.000	.002
HM		41.1	.000	.001
CHM		56.5	.000	.000
VM		53.7	.000	.000

UMFC # 35A is closest to WFs

UMFC # 35A		Group Means WM 166	WF 132	BM 125	BF 107	AM 46	AF 28	JM 100	JF 100	HM 37	CHM 79	VM 51
GOL	172	187.9	177.9	186.7	178.5	179.9	177.6	180.1	171.7	179.7	180.8	172.1
XCB	128	140.9	135.9	137.3	133.6	143.0	137.9	140.9	136.4	138.1	139.4	140.6
ZYB	113	130.4	120.8	131.1	122.7	142.0	132.5	134.0	125.1	129.1	133.3	130.0
BBH	125	141.7	133.5	133.9	127.5	132.9	129.4	137.8	131.7	136.2	139.2	137.5
BNL	93	105.9	98.5	102.5	96.9	103.2	99.8	101.5	95.5	101.6	100.0	97.5
BPL	81	96.9	90.9	103.1	98.4	100.7	96.9	99.1	94.3	97.5	97.9	96.4
MAB	53	62.0	57.9	66.9	63.2	66.5	63.2	66.1	61.5	64.5	65.5	66.2
AUB	106	123.7	116.5	120.6	115.6	132.2	126.3	125.4	118.6	122.6	124.1	122.9
UFHT	58	71.7	67.0	72.9	68.0	73.8	71.0	70.6	65.8	73.2	72.3	71.4
WFB	96	97.5	93.5	96.9	93.8	97.1	92.1	93.2	89.7	94.4	92.7	94.6
NLH	44	52.6	49.3	51.7	48.0	54.0	51.9	52.5	48.7	52.9	52.4	53.0
NLB	21	23.7	22.2	26.0	24.8	26.0	25.5	25.4	24.8	24.4	25.9	26.2
OBB	34	40.4	38.3	39.7	37.7	42.9	41.0	39.6	38.1	38.8	40.7	40.4
OBH	32	33.5	33.2	34.5	34.4	35.4	35.1	34.9	34.2	34.6	34.2	33.8
FRC	110	114.2	108.7	111.8	106.8	110.7	108.0	111.6	106.4	111.1	112.7	111.9
PAC	113	118.0	113.5	118.0	113.7	109.5	108.1	112.0	108.7	112.2	115.5	110.1
OCC	90	99.8	96.7	96.8	94.4	93.8	93.6	100.5	97.4	96.5	98.0	98.5

Figure 3

ANCESTRY BY DISCRIMINANT FUNCTION ANALYSIS OF THE SKULL

Giles and Elliot developed a method for estimating ancestry based on a discriminant function analysis of the skull. "This method assumes that there are three populations (American White, American Black and American Indian) into which all the people in the world can be divided. The number of discriminant functions needed to correctly identify the group membership of a person is always one less than the number of possible groups. We need two functions to sort people as White, Black , or Indian" (Skelton 2002:27). The procedure is as follows (from Skelton 2002:28).

1. Take the measurements necessary to use the discriminant functions. In this case they are g-op, eu-eu, ba-b, ba-n, zy-zy, ba-ids, and al-al. All measurements are in mm.
2. Determine whether the individual is male or female.
3. Choose which function or functions to use, based on the sex and possible population affinity of the individual.
4. Plug your measurements into the function(s) to get discriminant scores.
5. Examine the graphs (figure 4). The one on the left is for males and the one on the right is for females. Choose one, depending on the sex of your specimen.
6. Determine where your specimen falls on either the male or female graph, based on its scores from the White-Black function and the White-Indian function. Assign population affinity to the individual as

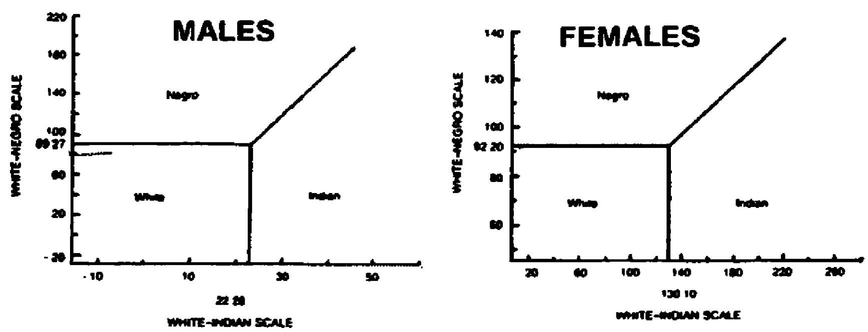
American Black, American Indian, or American White, depending on which area of the graph the individual falls into.

Figure 4

Specimen: ______ Date: ______ Measured by: ______

MEASUREMENT			MALE WHT/NEG	MALE WHT/IND	FEMALE WHT/NEG	FEMALE WHT/IND	SEX MEAS. NO. FACTOR
ba-ids	Basion–Prosthion Ht.	______ x	+3.06 = ______	+0.10 = ______	+1.74 = ______	+3.05 = ______	ba-ids x −1.00 = ______
g-op	Glabello-Occip. Ln.	______ x	+1.60 = ______	−0.25 = ______	+1.28 = ______	−1.04 = ______	g-op x +1.16 = ______
eu-eu	Maximum Width	______ x	−1.90 = ______	−1.56 = ______	−1.18 = ______	−5.41 = ______	ba-n x +1.66 = ______
ba-b	Basion–Bregma Ht.	______ x	−1.79 = ______	+0.73 = ______	−0.14 = ______	+4.29 = ______	zy-zy x +3.98 = ______
ba-n	Basion–Nasion Ht.	______ x	−4.41 = ______	−0.29 = ______	−2.34 = ______	−4.02 = ______	n-ids x +1.54 = ______
zy-zy	Max Diam. Bi-zyg.	______ x	−0.10 = ______	+1.75 = ______	+0.38 = ______	+5.62 = ______	TOTAL = ______
n-ids	Prosth.–Nasion Ht.	______ x	+2.59 = ______	−0.16 = ______	−0.01 = ______	−1.00 = ______	MALE ______ + 891.12
al-al	Nasal Width	______ x	+10.56 = ______	−0.84 = ______	+2.45 = ______	−2.19 = ______	FEMALE ______ −
		TOTALS					

*These measurements are used for calculating sex.



Giles and Elliot's method was used to estimate the ancestry of UMFC 35A. The results are below.

ba-ids = 82
g-op = 172
eu-eu = 128
ba-b = 127
ba-n = 92
zy-zy = 101 (estimated because the zygomatic arches were broken)
n-ids = 61
al-al = 21

wht/neg (female)	wht/ind (female)
82 x 1.74 = 142.68	82 x 3.05 = 250.10
172 x 1.28 = 220.16	172 x -1.04 = -178.88
128 x -1.18 = -151.04	128 x -5.41 = -692.48
127 x -.14 = -17.78	127 x 4.29 = 544.83
92 x -2.34 = -215.28	92 x -4.02 = -369.84
101 x .38 = 38.38	101 x 5.62 = 567.62
60.5 x .01 =.605	60.5 x -1 = -60.5
20.5 x 2.45 = 50.23	20.5 x -2.19 = -44.90
total = 67.95	total = 15.95

These measurements indicated that UMFC was well within the European ancestry range for both functions.

Gill does not believe this method is very effective in estimating the race of Native Americans and Blacks. He stated, "if the Giles and Elliot discriminant function method for racial identification has any utility, it would seem to be in confirming Caucasoid ancestry in cases where such ancestry is already suspected based upon other evidence" (Gill 1995:785). Snow and his colleagues tested the results of Giles and Elliot's results using 52 crania. They confirmed that Giles and Eliot's original study is still applicable to contemporary Blacks and Whites. "They did not, however, claim the same success for American Indians of Oklahoma" (Krogman and Iscan 1986: 278). There seems to be some disagreement about whether Giles and Elliot's method is useful for Blacks but, there seems to be an agreement that it is not reliable for Native Americans.

RACE ESTIMATION FROM INTERORBITAL FEATURES

Gill (1984) and his students developed "an anthropometric method using three indices that results in a ninety-percent-correct classification" (Bass 1995:93). This method involves the measurement of indices of the mid-facial region. Gill felt that the

Giles and Elliot discriminant function approach was ineffective, especially in identifying Native American populations. He stated, "as the failure of the Giles-Elliot method in the Northwestern Plains area became obvious, efforts were begun to search out new and better approaches to distinguishing Plains Indians from other groups, especially the commonly encountered early historic Whites" (Gill 1995:783).

A simometer is required for this method, which is a modified coordinate caliper with a depth gauge. The three indices used in this method are maxillofrontal, zygoorbital, and alpha. The maxillofrontal index is determined by dividing the naso-maxillo frontal subtense by the maxillofrontal breadth. Bass defined the maxillofrontal breadth as "the breadth between maxillofrontale left and right" (Bass 1995:97). Maxillofrontale is defined as "the intersection of the fronto-maxillary suture and anterior lacrimal crest, or the crest extended (medial edge of the eye orbit)" (Bass 1995:97). The naso-maxillofrontal subtense is "a subtense from the maxillofrontal points to the deepest point on the nasal bridge" (Bass 1995:97). The zygoorbital index is determined by dividing the naso-zygoorbital subtense by the zygoorbital breadth. The mid-orbital breadth is "the breadth between zygoorbitale left and right" (Bass 1995:97). Zygoorbitale is defined as "the intersection of the orbital margin and the zygomaxillary suture" (Bass 1995:97). The naso-zygoorbital subtense is "a subtense from the zygoorbital points to the deepest point along the nasal bridge" (Bass 1995:97). The alpha index is determined by dividing the naso-alpha subtense by the alpha cord. The alpha cord is "the deepest point on the maxilla, left and right, on a tangent run between the naso-maxillary suture where it meets the nasal aperture, and zygoorbitale. To determine alpha, a straight line is penciled connecting the above two points, then a straight edge is placed across the two points, and the skull is turned upwards until the profile of the straight edge and penciled line are visible. The deepest point is easy to find and it is marked on the penciled line. The deepest point usually coincides with the slight concavity from which the maxilla rises anteriorly to the nasal aperture. When the concavity forms a long shallow depression in profile and the deepest point is difficult to determine, then the mid-point along the penciled line is chosen" (Bass 1995:97). The naso-alpha subtense is "the subtense from the alpha points to the deepest point on the nasal bridge" (Bass 1995:97).

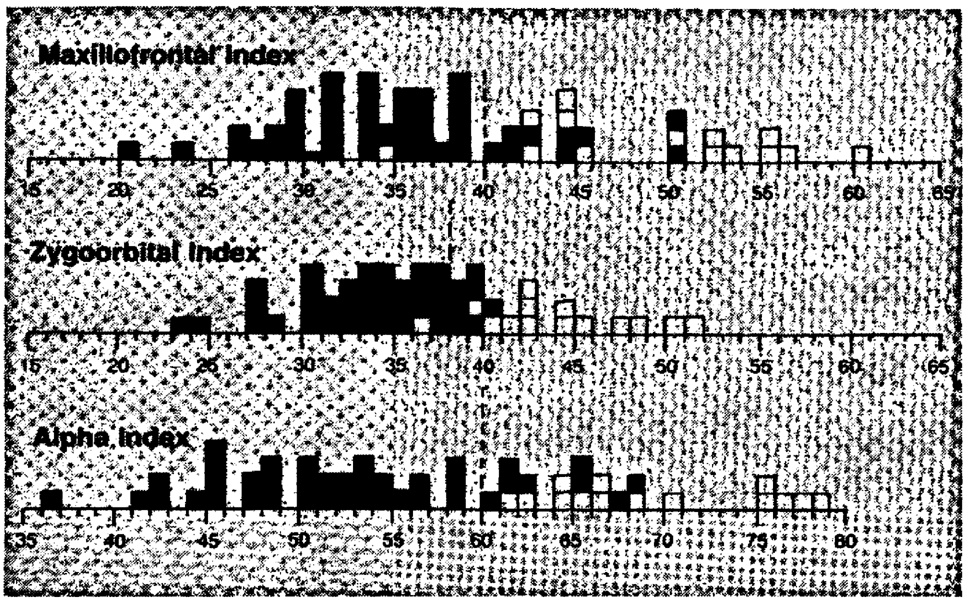


Figure 5 Indices for Indian-white racial differentiation (from Gill 1984)

Gill's method was used to estimate the ancestry of UMFC 35A. The maxillofrontal index was 51 (10.7 naso-maxillofrontal subtense / 20.9 maxillofrontal breadth = 51). The zygoorbital index was 41 (21.1 naso-zygoorbital subtense / 51.8 mid-orbital breadth = 41). The alpha index was 68 (20.5 naso-alpha subtense / 30.1 alpha cord = 68). These indices all fall well within the European range indicated in Gill's method (figure 5).

Krogman and Iscan consider "the accuracy of this study satisfactory, even though the authors did not consider sex differences in the statistical analysis. The results, however, indicated that the technique separated White females from the females of other groups more accurately (95%) than White males from other males (85%)" (Krogman and Iscan 1986:276).

CONCLUSIONS

The methods described above all indicated that UMFC 35A was most likely of European ancestry. Race from skull characteristics, FORDISC, the Giles and Eliot's discriminant function method and Gill's interorbital features method, which are all quite diverse methods, all pointed to European ancestry. Wilder's method, which estimated race from the sacrum, indicated Egyptian ancestry. However, a classification of Egyptian ancestry is rather subjective, since peoples of Egypt may exhibit traits of Europeans and Africans.

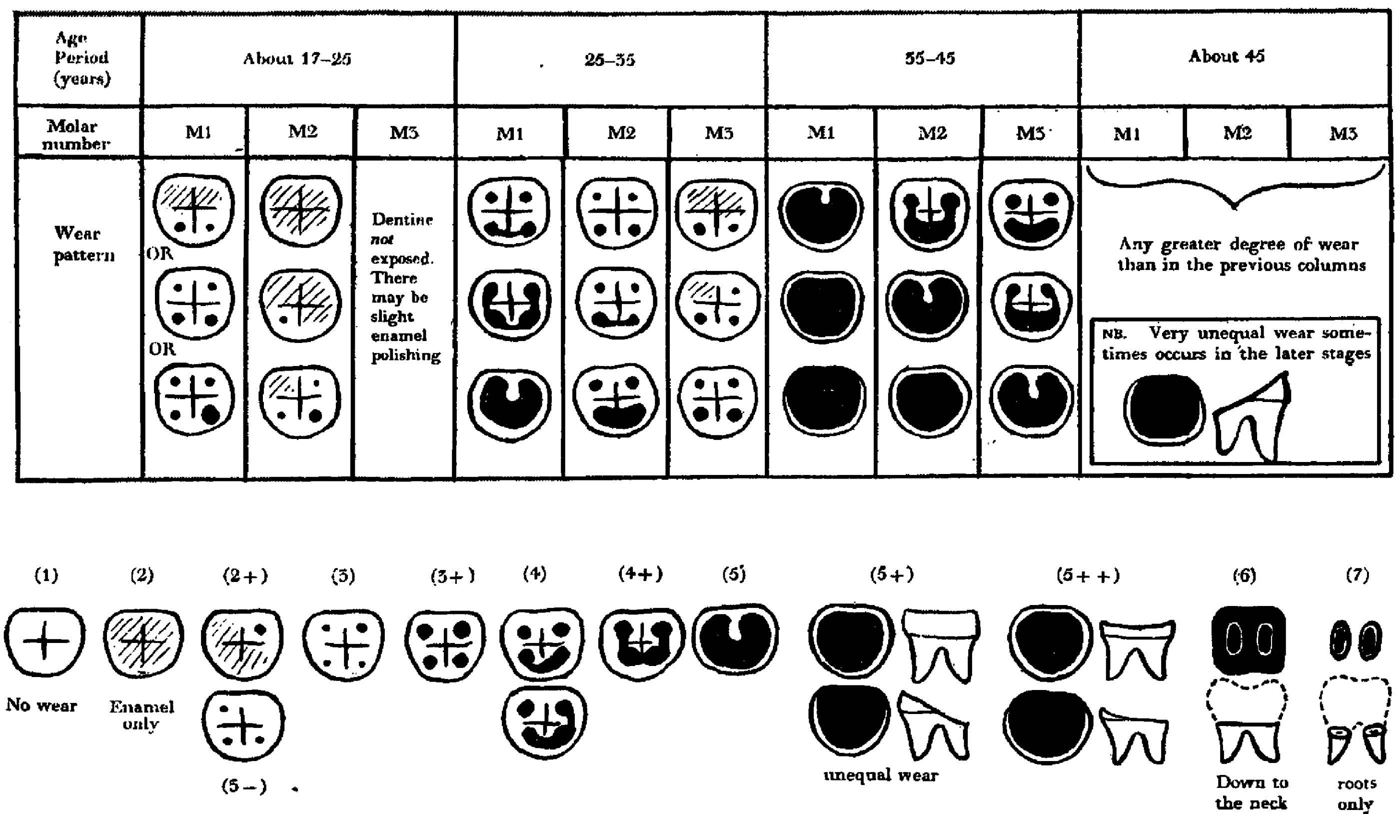
Some methods for race estimation could not be applied to this case, for various reasons. Race from the scapula could not be estimated, because the right scapula was deteriorated and the left scapula was absent. Methods for estimating race from the femur could not be applied because they required tools which were unavailable.

AGE ESTIMATION

There are many methods available to estimate the age of an individual from skeletal remains. Several different bones and teeth can be used to determine age, however, some bones are better to use than others.

AGE ESTIMATION FROM DENTAL ATTRITION

Brothwell (1965) developed a way to estimate age by examining tooth wear. His samples were taken from the teeth of premedieval British skulls (see figure 6 below).



Numerical classification of molar wear.

Figure 6 (from Brothwell 1972:69 Figure 30)

Based on a comparison made with Brothwell's results, UMFC 35A was between 25 and 35 years of age at the time of death. This was established by examining the individual's molars, including the upper right first molar (RM^1), the upper right second molar (RM^2), the upper left first molar (LM^1), the upper left second molar (LM^2), and the lower right second molar (RM_2). The lower right first premolar (RM_1) and the lower left third molar (LM_3) could not be used for this method because they had large caries (see pathology and trauma). Bass notes, "unfortunately, all the dentitions within a population do not wear at the same rate because of individual differences in diet and tooth structure. This severely limits the accuracy of age estimation by this method, and other criteria should be consulted whenever possible" (Bass 1995: 300-301).

Another method of age estimation using dental attrition was developed by Skelton (2002). According to Skelton, "this method is a way to estimate how old an individual is by the extent of dental attrition, or wear of their teeth. Dental attrition aging is fairly reliable within a population, after the rate of attrition has been calculated for that population" (Skelton 2002:42). This method consists of two parts, "the first part is scoring the amount of dental attrition and the second part is interpreting the attrition score in terms of age" (Skelton 2002:42). The dental attrition scoring system used here was taken from Skelton's ***Osteology Laboratory Field Manual*** (2002). Several teeth were used for this method. The age standards used were that of a Montanan population (adapted and reworked from Tromly1996). The only incisor that could be used was the upper right first incisor (RI^1), the lower left second incisor could not be used because it was broken. The upper right first incisor (RI^1) scored a 3, which indicated that dentine exposure was a line of discrete thickness. A score of 3 for incisors was within the 24-37 age range. The canines could not be used for this method, because they were either missing or broken. The left upper second premolar (LP^2) gave a score of 3, which indicated dentine exposure on both cusps, one of which was a pinpoint. An attrition score of 3 corresponded to a range of 34-44 years of age. The lower right first premolar (RP_1) and the upper left first premolar (LP^1) could not be used because they were broken. Several molars were able to be scored. The lower left second molar (LM_2) scored a 3. There was dentine exposure on 3 cusps, one of which was a pinpoint. A score of 3 corresponded with an age range of 30-37 years. The lower right second molar (RM_2), the upper right second molar (RM^2), the upper left first molar (LM^1), and the upper left second molar (LM^2) all scored a 4, which indicated dentine exposure on 3 cusps, one of which was a pinpoint. A score of 4 corresponded with a range of 30-37 years of age. The upper right first molar (RM^1) scored a 5, due to dentine exposure on all cusps, one of which was a pinpoint. A score of 5 indicated an age range of >37 years. The overall age ranges using this method were; a wide range of 24-44 and a narrow range of 34-37.

Another method for estimating age from the teeth was devised by Lovejoy and some colleagues (1985). Lovejoy has found, "on the population level, that dental wear was very regular in form and rate" (White and Folkens 2000:344). However, the assessment of a single individual in a forensic setting based on dental wear allows only a gross approximation of age, but if an entire biological population is seriated, tooth wear can yield precise results" (White and Folkens 2000:344). Lovejoy and his colleagues "concluded that dental wear is the best single indicator for determining age of death in skeletal populations. They found dental wear as an age indicator to be accurate consistently without bias" (White and Folkens 2000:344). Their dental wear method was based on the tooth-wear patterns of a prehistoric Native American population from Libben, Ohio. Wear was divided into phases for the right maxillary and left mandibular dentitions. Lovejoy, et als. study is described in the first section of this paper titled ***Literature Review of Dental Attrition Studies: Past and Present.*** Using their method, an age range of 30-35 years was estimated for UMFC 35A.

AGE FROM CRANIAL SUTURES

Todd and Lyon (1924) have developed a method for age estimation based on endocranial and ectocranial sutures. "Endocranial sutures are those visible when looking at the inside of the skull. Ectocranial sutures are those visible from the outside of the skull" (Skelton 2002:16). Skelton states, "most people feel that age estimations based on these sutures are unreliable, but Meindl and Lovejoy (1985) believe that they are not too bad. It is commonly believed that endocranial sutures are more reliable than ectocranial sutures" (Skelton 2002:16). The method is explained below.

Table 9

	Endocranial		Ectocranial	
Suture	Commencement	Termination	Commencement	Termination
Sagittal	22	35	20	29
Coronal	24	41	26	50
Lambdoidal	26	47	26	31
Masto-occipital	30	81	28	32
Spheno-temporal	30	67	36	never

(from Skelton 2002)

Skelton described the method as follows. "The technique to use is to score the 5 sutures as being open (o), commenced (c), or terminated (t), from both the endocranial (endo) and the ectocranial (ecto) perspectives" (Skelton 2002:16). He recommends following these steps (Skelton 2002:16-17):

1. For open sutures, score the age as younger than the age listed in the commencement column.
2. For commenced sutures, score the age as older than the age in the commencement column, but younger than the age in the termination column.
3. For terminated sutures, score the age as older than the age in the termination column.
4. Take the information from each suture into account by combining the ages from the 10 sutures to make the most logical pattern. It is very common for the sutures to give inconsistent results.

According to Skelton, "for suture closure it is wisest to find the broadest possible range. Do this by determining the absolute youngest age from any suture, which sets the lower end of the possible age range. Then find the oldest possible age from any suture, which is the upper end of the possible age range. You may wish to combine this with a narrowest possible range by choosing the absolute youngest age that the person could be looking at all the sutures, and the oldest they could be looking at all the sutures" (Skelton 2002:17). The following suture closures were observed on the skull of UMFC 35A, using this method.

Table 10

	Endocranial sutures		Ectocranial sutures	
Sagittal:	commenced	22-35	commenced	20-29
Coronal:	commenced	24-41	commenced	26-50
Lambdoidal:	commenced	26-47	commenced	26-31
Masto-occipital:	commenced	30-81	commenced	28-32
Spheno-temporal:	commenced	30-67	open	<36

The overall broad age range was 22-81 years of age and the narrow range was 30-31, using Todd and Lyon's method.

Baker (1984) developed another method to estimate age based on suture closure. According to Skelton, "the technique is similar to that for the Todd and Lyon method. There is a separate column for open sutures and the Baker method only utilizes the sagittal, coronal, and lambdoidal sutures" (Skelton 2002:18). Baker's table is presented below.

Table 11

Suture	**Open**	**Commenced**	**Terminated**
Sagittal Endocranial	<36	19-79	>25
Sagittal Ectocranial	<88	19-83	>33
Coronal Endocranial	<71	22-79	>25
Coronal Ectocranial	<85	24-89	>35
Lambdoidal Endocranial	<71	19-74	>22
Lambdoidal Ectocranial	<85	24-84	>22

(from Skelton 2002)

The following results were obtained using the Baker method:

Sagittal Endocranial:	commenced	19-79
Sagittal Ectocranial:	commenced	19-83
Coronal Endocranial:	commenced	22-79
Coronal Ectocranial:	commenced	24-89
Lambdoidal Endocranial:	commenced	19-74
Lambdoidal Ectocranial:	commenced	24-84

All of the sutures were considered commenced. The overall broad age range was 19-89 and the overall narrow age range was 24-74, using this method. Skelton noted, "both the broad and narrow ranges are wider than those obtained using the Todd and Lyon method" (Skelton 2002:18).

The suture site method is another technique to estimate age from cranial suture closure. This method was developed by Meindl and Lovejoy (1985). "They chose a series of 1 cm segments of ten sutures or suture sites and scored these on a scale of 0 (open) to 3 (complete obliteration)" (White and Folkens 2000:347).

Table 12

Site name	Description
1 Midlambdoid	Midpoint of L.lambdoid suture
2 Lambda	Intersection of sagittal and lambdoidal
3 Obelion	At obelion
4 Anterior Sagittal	One-third the distance from bregma to lambda
5 Bregma	At Bregma
6 Midcoronal	Midpoint of left coronal suture
7 Pterion	Usually where parietosphenoid suture meets the frontal
8 Sphenofrontal	Midpoint of left sphenofrontal suture

9 Inferior Sphenotemporal	Intersection between left sphenotemporal suture and line between articular tubercles of the temporomandibular joint
10 Superior Sphenotemporal	On left sphenotemporal suture 2 cm below junction with parietal

(from White and Folkens 2000)

"In the Meindl and Lovejoy system, scores are independently summed for vault (#'s 1-7) and lateral-anterior (#'s 5-10) sites" (White and Folkens 2000:347). Meindl and Lovejoy's scores and age correlates are below.

Table 12

Meindl and Lovejoy (1985) vault sutural ages (add scores for sites 1-7), (White and Folkens 2000:348):

Composite Score	Mean Age	Standard Deviation
0	---	---
1-2	30.5	9.6
3-6	34.7	7.8
7-11	39.4	9.1
12-15	45.2	12.6
16-18	48.8	10.5
19-20	51.5	12.6
21	---	---

Table 13

Meindl and Lovejoy (1985) lateral-anterior sutural ages (add scores for sites 6-10), (White and Folkens 2000:348):

Composite Score	Mean Age	Standard Deviation
0	---	---
1	32.0	8.3
2	36.2	6.2
3-5	41.1	10.0
6	43.4	10.7
7-8	45.5	8.9

9-10	51.9	12.5
11-14	56.2	8.5
15	---	---

The following results were obtained using this method:

Scores

1 Midlambdoid =1

2 Lambda =1

3 Obelion =1

4 Anterior Sagittal =1

5 Bregma =1

6 Midcoronal =1

7 Pterion =1

8 Sphenofrontal =1

9 Inferior Sphenotemporal =1

10 Superior Sphenotemporal =1

The sum of the vault suture sites (1-7) is 7, which correlates with a mean age of 39.4 (with a standard deviation of 9.1). The sum of the lateral-anterior suture sites (6-10) is 5, which corresponds with a mean age of 41.1 (with a standard deviation of 10). This method points to an age range of 39.4-41.1 years, with a standard deviation of 9.1-10 years.

AGE ESTIMATION FROM THE AURICULAR SURFACE OF THE ILIUM

The auricular surface is the area of articulation of the coxal bone and the sacrum. Lovejoy and colleagues "examined the auricular surface of the coxal as a possible site of regular change corresponding to age in the Hamann-Todd collection. The use of this surface to age individual specimens has some advantages, namely, that this part of the coxal is more likely to be preserved in forensic and archaeological cases, and the changes on the auricular surface, extend well beyond the age of 50 years" (White and Folkens 2000:355). This method from Lovejoy, et al. describes 8 auricular surface stages, with text and photos. Lovejoy, et al. described "age-related changes in surface granulation, microporosity, macroprosity, transverse organization, billowing, and striations" (White and Folkens 2000:355).

Skelton recommends following these steps:

1. Familiarize yourself with the regions of the auricular surface.

2. Examine illustrations and textual descriptions to find the best match for the auricular surface of the specimen you are working with, among the stage definitions. Use the pictures as an aid in doing this, but remember that it's more reliable to use the text definitions than to simply match your specimen to a picture.

3. When the best match is obtained, assign the age given with description of that stage to the specimen. (Skelton 2002:68)

Detailed descriptions of the auricular surface stages, both text and photos, can be found in several references, including White and Folkens (2000), Meindl et al (1985), and Lovejoy et al (1985).

Age from auricular surface was estimated for UMFC 35A, using the left coxal (the right coxal was not recovered). The following age estimations were made using the descriptions and illustrations from Lovejoy et al (1985), Meindl et al (1985), and Steele and Bramblett (1988). The auricular surface of this individual had the characteristics described in stages 3 and 4. Stage 3 was described as exhibiting a general loss of billowing, replacement by striae and coarsening of granularity and had an age range of 30-34. Stage 4 showed coarse granularity and had an age range of 35-39. Overall the age estimation from the auricular surface indicated an age range of 30-39, from combining the two stages.

AGE FROM EPIPHYSIS CLOSURE

Another method for estimating age is the epiphysis closure method, which is described in detail in the age section of UMFC 35B. The method is particularly useful for estimating the age of adolescents. The only thing it can tell us about adult skeletons is that the epiphyses of all bones are fused and the age at which they fuse.

The epiphyses of the right and left tibias of UMFC 35A were completely fused. The proximal end of the left tibia was deteriorated, but the epiphysis was still visible. The distal epiphysis of the tibia begins uniting at 11-13 years of age and is completely united at 17 and the proximal epiphysis begins union at 14 years of age and is completely united at 18 in females (Johnston 1962). This indicated that this individual was at least 18 years old at the time of death. The epiphyses of the left and right fibulas of UMFC 35A were completely fused. The distal end of the right fibula was deteriorated, but the epiphysis was still visible. The distal epiphysis of the fibula begins union at 14-15 years of age and complete union is at 17 and the proximal epiphysis begins union at 14-15 years of age and complete union is at 17 in females (Johnston 1962). These ages indicated that this individual was at least 17 years old at the time of death. The epiphyses of the left ulna of UMFC 35A were completely fused. The distal epiphyses of the ulna unite between 15-16 years of age and the proximal epiphyses unite between 15-18 tears of age in females (Johnston 1962). This indicated that this individual was at least 18 years of age at the time of death. The epiphyses of the left humerus of UMFC 35A were completely fused. The distal epiphysis of the humerus is completely fused by age 17-18 years of age, the head of the humerus is completely united by age 24, and the medial epicondyle is completely united by age 19 (Johnston 1962). These ages indicated that this individual was at least 24 years of age at the time of death. The epiphysis of the left radius of UMFC 35A were completely united. The proximal epiphysis of the radius unites to the shaft between ages 15-18 and the distal end unites between ages 16-17 (Johnston 1962). These ages indicated that this individual was at least 18 years old at the time of death.

This method is not useful for estimating the age of adults; it only gives a possible minimum age of an adult. Combing all the ages of epiphyseal unions, UMFC 35A was at least 24 years of age at the time of death.

MULTIFACTORIAL AGE ESTIMATION

Osteologists disagree about which methods for age estimation are most reliable and which ones should carry more weight. Lovejoy, et al note that these issues have led "to problems when large populations are aged by different observers using established methods" (White and Folkens 2000:361). However, White and Folkens believe "if more than one criterion is available for assessing age at death, all criteria should be employed" (White and Folkens 2000:361). Some osteologists object to their suggestion "because of the marked differences in the reliability between different age indicators" (White and Folkens 2000:361). An example is adjusting "the age at death based on the pubic symphysis face by additional data from cranial suture closure because of the latter's supposed unreliability" (White and Folkens 2000:362). However, combining the results of different methods should improve the accuracy of age determination. This is referred to as multifactorial age estimation.

AGE ESTIMATION CONCLUSIONS

A multifactorial approach was used to estimate the age of UMFC 35A at the time of death. All of the different age ranges, which were derived from the skeletal material were combined, to come up with overall wide and narrow age ranges.

The dental attrition method gave age ranges of 25-35 (Brothwell' method), 24-44 wide and 24-37 narrow (Tromly's method), and 30-35 (Lovejoy's method). Cranial suture closure methods produced age ranges of 30-31 narrow and 22-81 wide (Todd and Lyon's method), 24-74 narrow and 19-89 wide (Baker's method) and 39.4-41.1 ±9.1-10 years using the suture site method. Finally, the auricular surface of the coxal gave an age range of 30-39. The long bone epiphysis closure method led to an age of at least 24+.

The individual was at least 24+ years old based on epiphysis closure so, that means that the wide ranges for both the Baker and Todd and Lyon cranial suture closure methods can be disregarded. Overall wide and narrow age ranges were estimated using the remaining age ranges from the other methods. The wide range was obtained by using the lowest and highest possible ages. The lowest age range was 24 years (Brothwell, Tromly' narrow range, and Baker's narrow range). The highest age range was 74 (Baker's narrow range). Therefore, the wide range was 24-74 years of age at the time of death.

The narrow range was a little more complex. To estimate the narrow age range, you determine the highest "low" age and the lowest "high" age. In this case, the highest "low" age was 34, from Tromly's method. The lowest "high" age was 35, from Lovejoy's method. This gave a narrow range of 34-35 years at the time of death. It should be noted that this age range is considered to be quite restrictive. It may be best, especially if this case was going to be sent to a law enforcement agency, to extend the narrow range, if possible. In this instance, it may be more reliable to use age 37 (Tromly's method) as the highest "low" age, which would give an overall narrow range of 34-37 years of age. Overall, for the purposes of this paper, a wide age range of 24-74 and a narrow age range of 34-37 years at the time of death was estimated for UMFC 35A.

Several methods for estimating age could not be used due to the absence of some skeletal elements or tools. Age from vertebral osteophytosis could not be used, because no vertebrae were recovered. All ribs were missing so, age from the sternal end of the ribs could not be determined. Age from medial clavicle epiphysis could not be applied because, both clavicles were absent. Age from pubic symphysis could not be assessed, due to the absence of both the left and right pubic bones. Age from the appearance of the pubic symphysis is considered one of the most reliable methods to estimate age (White and Folkens 2000:349). The method described in Burns' ***Forensic Anthropology Training Manual*** for estimating age from degenerative changes in teeth could not be used because it requires the analysis of the teeth by radiograph and ground sagittal sections of undecalcified teeth. Radiographs of UMFC 35A's teeth were not available and destruction of dental material was not an option. Age from bone growth was not applicable because it is only useful for estimating the age of small children and adolescents.

PATHOLOGY AND TRAUMA

Because most forensic anthropologists do not hold medical degrees, we are at best, only marginally trained to diagnose specific diseases or identify specific traumas. Forensic anthropologists are however, highly trained in human osteology and therefore can be very effective in detecting abnormalities of the skeletal system, even if they are not qualified to diagnose a specific cause. Therefore, within a forensic report, words or phrases of description such as linear defect, deterioration, pitting, and lipping are used, rather than true diagnostic terms such as gunshot trauma or tuberculosis. Forensic anthropologists are also trained, for the most part in determining whether or not the abnormalities observed occurred prior to death (premortem), at or around the time of death (perimortem), or after death (postmortem). A trained medical professional such as a medical examiner or coroner will make the final diagnosis of specific causes of skeletal abnormalities and will make a final determination of the cause of death, if the evidence is clear enough.

A GENERAL OVERVIEW OF TRAUMA

Trauma is considered to be an injury or wound to the body. Several different types of traumas may affect bones. Forensic anthropologists often refer to a damaged area on a bone as a defect. Common types of trauma include fractures, sharp trauma, blunt trauma, gunshot trauma, and ritual mutilation. "Fracture in a bone occurs as a result of abnormal forces of tension, compression, torsion, bending, or shearing applied to the bone" (White and Folkens 2000:384). And according to Skelton, "fractures are common in all populations and the incidence of poorly set, poorly healed, and unhealed fractures is greater in pre-modern populations for obvious reasons" (Skelton 2002:99). Sharp trauma is a trauma produced by a sharp instrument such as a knife, axe, or sword. "The ribs, skull, sternum, and vertebrae are places to look for trauma in forensic cases. You can usually recognize sharp trauma by the very regular, 'V' shaped appearance of the defect" (Skelton 2002:99). Blunt trauma is a trauma caused by a blunt instrument. "The typical defect caused by a blunt trauma is a depressed fractured area, often roughly circular, with cracks radiating out from it. Usually more bone will be removed from the inner table than from the outer table as a result of a blunt trauma. Blunt trauma often shows up on the skull in forensic cases" (Skelton 2002:99). Gunshot trauma "can usually be recognized by the characteristic small circular defect that the passage of a bullet causes. Bullets usually cause more damage as they exit a bone or a body than they caused upon entrance and this fact can be used to distinguish entrance defects from exit defects" (Skelton 2002:99). Ritual mutilations are mutilations which occur for religious, ceremonial, or therapeutic reasons. Examples of ritual mutilation are foot binding and trepanation (a hole cut into the skull).

It is possible to determine when a bone defect was made "by examining it's characteristics in relation to the surrounding bone" (Skelton 2002:100). There are three categories into which the time of a trauma may be placed; premortem, perimortem, and postmortem. Premortem refers to trauma that occurred some time prior to death. "You can recognize premortem defects due to the fact that there will be some healing of the bone, giving the margins of the defect a smoothed appearance" (Skelton 2002:100). Perimortem trauma is a defect that occurred at or around the time of death. Therefore, this type of trauma might provide evidence for cause, manner, or circumstance of death. "Perimortem defects can be recognized by the fact that the margins of the defect are the same color and weathered to the same degree as the surrounding bone and there is no smoothing of the margins due to healing. Many perimortem defects have nothing to do with the individual's death. Since small differences in the extent of weathering are difficult to judge, defects that occurred a long time after the individual died may appear to be perimortem" (Skelton 2002:100). Postmortem trauma refers to a defect which occurred some time after death. "Postmortem defects can be recognized by the fact that the margins of the defect are not weathered to the same extent as the surrounding bone and there is often a difference in color due to exposing the unweathered interior of the bone" (Skelton 2002:100).

In addition to the traumas described above, there are some additional defects which commonly appear on bones. Carnivores, scavengers, and rodents can damage bones. "Carnivores and scavengers (often the same animal) such as dogs and coyotes, often chew bones. You can usually recognize this type of damage by its appearance as an oval puncture with cracks radiating out from it. Mice, squirrels, porcupines, and other rodents will gnaw bones for calcium. This type of damage is recognizable as more-or-less parallel flat-bottomed scratches" (Skelton 2002:100).

A GENERAL OVERVIEW OF PATHOLOGY

There are several different types of pathologies which can be observed on bones and teeth, such as infectious diseases, dietary and environmental conditions, tumors, degenerative joint disease, and dental pathologies.

Infectious diseases "are those that can be passed from individual to individual, sometimes by way of an intermediate host. There is usually a disease organism (bacterium, virus, fungus, etc) involved. If a disease causes a mark or pit or other change to a bone, that change is called a lesion" (Skelton 2002: 100). Some infectious diseases which may be visible on bone material include periostitis, osteomyelitis, chronic ear infections (such as auditory exostosis, osteitis of the mastoid process, and meningitis), tuberculosis, and treponematosis (such as yaws, bejel, syphilis, and pinta).

There are several dietary and environmental conditions which can be observed on bones. "Bone metabolism is as complex as the metabolism of any other part of the body and is sensitive to various dietary and environmental defects" (Skelton 2002:101). These conditions include porotic hyperostosis, enamel hypoplasia, Harris Lines, and rickets.

Several forms of tumors affect bone, both malignant and benign. Osteoporosis, which is a weakening of the bone due to calcium loss, may be observed on bone material. Osteologists use the term degenerative joint disease to refer to the deterioration and erosion of the vertebral column or other bones. This may include bony spurs, eburnation (polishing of the joint surfaces) or lipping of the vertebral margins.

There are a number of dental pathologies which may be observed on dental remains. Dental pathologies, especially untreated ones were very common in people who were living prior to 20th century medicines and treatments. "In pre-modern times it was often a race between dental attrition and dental decay to see which would destroy the teeth first" (Skelton 2002:103). Dental pathologies include caries or cavities, periodontal disease, enamel hypoplasia, abscesses, and general tooth loss. Dental caries are the most common type dental pathologies. They are considered to be "an infectious disease, it is the result of fermentation of food sugars, especially sucrose, in the diet by bacteria that occur on teeth" (Roberts and Manchester 1997:47).

PATHOLOGY AND TRAUMA OF UMFC 35A

UMFC 35A exhibited both premortem and postmortem defects, however, no obvious perimortem abnormalities were observed. Defects were found on the skull and the postcranium. These defects are described below.

This individual showed significant, most likely premortem pathology to the left side of the skull. The left temporal bone, the left parietal bone, the left portion of the frontal bone, and the left portion of the occipital bone all showed a pattern of deterioration, porotic erosion and pitting. The left temporal bone was severely deteriorated and had two small circular defects measuring 7.8mm and 16.8mm respectively. The left and right zygomatics were completely deteriorated and the arches were broken off. The mastoid process was quite worn and pitted. The mandible exhibited probable premortem deterioration and pitting of the left side, encompassing the left mandibular condyle and the gonial region all the way down to the symphysis.

There was some postmortem trauma to the skull. A linear defect, which measured 21mm was present on the left portion of the occipital bone, just superior to the nuchal crest. This defect was most likely postmortem, due to the coloration of the exposed bone. The frontal bone exhibited a large diamond shaped defect, measuring 51.8mm and 45.7mm at its widest points. This defect probably occurred during the excavation of the remains, which would make it postmortem. The color of the bone along the broken edges is consistent with postmortem trauma.

Some probable caries were present on the lingual side of the right second molar (RM_1) and the labial side of the left third molar (LM_3) of the mandible. Some teeth were missing parts of their crowns, including the right first premolar (RP^1), the left canine

(LC^1), and the right second incisor (RI^2), all from the maxilla. These teeth appear to have been broken postmortem. Premortem tooth loss was exhibited by the absence of the left first premolar (LP_1) of the mandible and the right third molar (RM_3) of the mandible, in which both tooth sockets were lost, due to resorption of the bone.

The left humerus showed possible premortem deterioration of the bone and pitting, which encompassed most of the distal end including the medial and lateral epicondyles, trochlea, and capitulum. The left radius exhibited deterioration along the borders; the distal end was deteriorated and pitted including the styloid process, ulnar notch, and the dorsal tubercle. The right scapula showed deterioration and pitting, the glenoid cavity was absent, the coracoid process was missing, and the scapular body was absent. The abnormalities of the scapula appeared to have been postmortem.

The left femur had a circular defect on the greater trochanter, which measured approximately 14mm at its widest point. This defect was most likely premortem. The distal end of the left femur was completely missing at the edge of the medial and lateral epicondyles. This portion of the bone was also quite fragile, deteriorated and was darker in color. These defects were also most likely premortem. The left tibia exhibited heavy pitting and deterioration of both the medial and lateral condyles at the proximal end. The proximal fibular articular surface was completely deteriorated and the distal fibular articular surface had a small amount of deterioration. There was some deterioration and pitting on the intercondylar tubercle and a large circular area of complete deterioration below the medial condyle. The distal end of the left tibia showed a small amount of deterioration on the medial malleolus. All of the abnormalities on the left tibia appeared to have been premortem. The left coxal bone exhibited possible premortem deterioration of the ischium and the anterior portion of the superior iliac spine. The pubis was broken off, most likely postmortem.

There was also quite a lot of wear and deterioration on the postcranial elements that was unlikely to have been caused by a traumatic or pathological condition prior to death. Those abnormalities may have been caused by other common phenomenon such as coffin wear or inadequate excavation techniques. This wear was present on the distal end of the left fibula, on the proximal and distal end of the right femur, on most of the right patella, and on the proximal and distal ends of the right tibia.

CONCLUSIONS

The defects mentioned above were either premortem or postmortem. Overall, there seemed to be much deterioration to the left side of the body including the skull, left tibia, the left femur, and left coxal, which may have been associated with a pathological condition such as tuberculosis or syphilis. I believe the skeleton may have been affected by a pathological condition for several reasons. First, the general appearance of the abnormalities appeared to exhibit evidence of healing, while the condition was affecting the bone. The edges of the defects were soft and rounded, and the coloration of the exposed interior portion of the bone was very similar to the outside of the bone. These factors seem to clearly represent a pathological condition prior to death. If the defects were caused by a postmortem process, the edges of the affected area would most likely be sharp, with no sign of healing and the coloration of the exposed bone would be lighter (due to less time exposed to the elements).

The suggestion that these defects may be caused by syphilis or tuberculosis was based solely on descriptive examples. I do not have a medical degree so; therefore I am not qualified to diagnose the pathology with any certainty. Tuberculosis seemed like a possible pathological condition because of the nature of the defect and the locations where it manifested itself on the skeleton of UMFC 35A. Tuberculosis "is a chronic infectious disease caused by mycobacterium tuberculosis of the human bovine type" (Ortner and Putschar 1981:141). Outside of the spine, "the areas of the hip joint and knee joint are the most commonly affected areas" (Roberts and Manchester 1997:137) of tuberculosis infections.

There could be any number of possible pathological causes for the pathology observed on UMFC 35A. However, tuberculosis does have "some general characteristics of diagnostic value" (Ortner and Putschar 1981:144). For example, the process of tuberculosis infection of the long bones "tends to remain localized, mostly to the metaphysical or epiphyseal portion" (Ortner and Putschar 1981:144). This is in contrast to the "massive sequestra, especially of cortical bone" (Ortner and Putschar 1981:144) seen most often in osteomyelitis. With the exception of the skull, the vast majority of the probable premortem trauma observed on UMFC 35A was confined to the joints, in particular the elbow joint of the left arm, the hip joint of the left femur and coxal, and the left knee joint. "In joints, the destruction of the articular surface may be minimal" (Ortner and Putschar 1981:144), which was something that was apparent on this individual. Although the pathology on the left side of the skull is not common in tuberculosis infections, the disease can manifest itself on the skull. The cranial vault is the "most common location of cranial tuberculosis" (Ortner and Putschar 1981:162). Ortner and

Putschar say that "the skull is a rare area of involvement except in young children" (Ortner and Putschar 1981:162). However, it is still found in adults and could possibly be the cause of the pathology exhibited on UMFC 35A. Although the affect of tuberculosis on areas of the skeleton other than the spinal column "is much more difficult to discriminate from other possible causes" (Schwartz 1995:233), the pathology observed on UMFC 35A could be tuberculosis of the skeleton.

As mentioned previously the defects are not consistent with osteomyelitis, based on the fact that the pathology was concentrated near the joints of the body. Syphilis does not seem to be a possible cause because the most common area of bone deterioration from this disease "is the skull, particularly in the perinasal area and the cranial vault" (Ortner and Putschar 1981:188). Although there was some pathology on the left side of the skull, there was absolutely no evidence of a pathology affecting the face of UMFC 35A. Syphilis does affect the tibia, "the entire surface [of the bone], with the exception of the cartilage-covered articular facets, may be involved" (Ortner and Putschar 1981:197). As mentioned previously, the pathology on the skeleton of UMFC 35A was concentrated around the joints. An arthritic condition was not likely to have been the cause of the pathology. Rhumetoid arthritis, for instance, often "involves multiple joints and is frequently symmetrical" (Ortner and Putschar 1981:403). The defects on the skeleton of UMFC 35A was most prevalent on the left side. Also, joints often become fused from this condition, which was not observed on this individual. Conditions such as degenerative arthritis often "manifest themselves as marginal lipping and extosis" (Ortner and Putschar 1981:419-420). These characteristics did not appear on the remains of this individual.

Based on the evidence mentioned above, I believe the pathology exhibited on UMFC 35A may be tuberculosis. Again, it must be emphasized that I do not have any medical training and this conclusion is based on comparisons made between the defects observed on UMFC 35A and descriptions and pictures found in various pathology oriented texts. A true and definitive diagnosis of this pathology can only be made by a medical professional.

No perimortem trauma was observed, therefore, there was no clear indication of a possible cause of death.

STATURE AND WEIGHT ESTIMATION

It is possible to estimate the stature of an individual from long bone length. "The studies of Trotter and Gleser (1952, 1958) are the most reliable. Various authors have demonstrated that estimation is complicated by racial differences among population samples. The racial affiliation of the sample must be known and the appropriate formulae or tables for that racial group must be used to estimate stature" (Bass 1995:26). Bones which may be measured to estimate stature include the humerus, ulna, radius, metacarpals, femur, tibia, fibula, and metatarsals. Osteometric boards are the favored instrument for measuring the bones. The bone measurements are then compared to a standard table for stature from bone length. There are separate tables for each sex and each sex has separate racial categories.

The stature of UMFC 35A was estimated using measurements of the left humerus, left radius, left ulna, right femur, the left fibula, and left and right tibias. The results are as follows.

Humerus = 275mm	Femur = 402mm
Radius = 190mm	Fibula = 306mm
Ulna = 215mm	Tibia =317mm (left), 319mm (right)

These bone lengths were then compared to the chart on page 65 (figure 7). UMFC 35A was most likely a female of European ancestry so; the measurements were compared to Trotter and Glesser's chart for White American Females. The long bone measurements are listed below with their corresponding stature estimates in centimeters and inches.

Humerus length = 275mm, stature = 150cm, 59 inches
Radius length = 190mm, stature = 145cm, 57.125 inches
Ulna length = 215mm, stature = 150cm, 59 inches
Femur length = 402mm, stature = 154cm, 60.625 inches
Fibula length = 306mm, stature = 149cm, 58.625 inches
Tibia length = 317, 318mm, stature = 154cm, 60.625 inches

Hum. (mm)	Rad. (mm)	Ulna (mm)	Stature (cm)	Stature (inches)	Fem. (mm)	Tib. (mm)	Fib. (mm)	Fem. + Tib. (mm)
			White American Females					
244	179	193	140	55.125	348	271	274	624
247	182	195	141	55.5	352	274	278	632
250	184	197	142	55.875	356	277	281	639
253	186	200	143	56.25	360	281	285	646
256	188	202	144	56.75	364	284	288	653
259	190	204	145	57.125	368	288	291	660
262	192	207	146	57.5	372	291	295	668
265	194	209	147	57.875	376	295	298	675
268	196	211	148	58.25	380	298	302	682
271	198	214	149	58.625	384	302	305	689
274	201	216	150	59	388	305	309	696
277	203	218	151	59.5	392	309	312	704
280	205	221	152	59.875	396	312	315	711
283	207	223	153	60.25	400	315	319	718
286	209	225	154	60.625	404	319	322	725
289	211	228	155	61	409	322	326	732
292	213	230	156	61.375	413	326	329	740
295	215	232	157	61.75	417	329	332	747
298	217	235	158	62.25	421	333	336	754
301	220	237	159	62.625	425	336	340	761
304	222	239	160	63	429	340	343	768
307	224	242	161	63.375	433	343	346	776
310	226	244	162	63.75	437	346	349	783
313	228	246	163	64.125	441	350	353	790
316	230	249	164	64.625	445	353	356	797
319	232	251	165	65	449	357	360	804
322	234	253	166	65.375	453	360	363	812
324	236	256	167	65.75	457	364	366	819
327	239	258	168	66.125	461	367	370	826
330	241	261	169	66.5	465	371	373	833
333	243	263	170	66.875	469	374	377	840
336	245	265	171	67.375	473	377	380	847
339	247	268	172	67.75	477	381	384	855
342	249	270	173	68.125	481	384	387	862
345	251	272	174	68.5	485	388	390	869
348	253	275	175	68.875	489	391	394	876
351	255	277	176	69.25	494	395	397	883
354	258	279	177	69.625	498	398	401	891
357	260	282	178	70.125	502	402	404	898
360	262	284	179	70.5	506	405	407	905
363	264	286	180	70.875	510	409	411	912
366	266	289	181	71.25	514	412	414	919
369	268	291	182	71.625	518	415	418	927
372	270	293	183	72	522	419	421	934
375	272	296	184	72.5	526	422	425	941

Figure 7 (From Trotter and Gleser 1952:498)

The results from the bone measurements above indicated a stature range of 57.125-60.625 inches, which is equivalent to 4 feet 8 inches to 5 feet 1 inch, at the time of death.

Genoves (1967) developed a method for stature estimation based on an examination of Mesoamerican skeletal remains. However, Bass notes "these formulae produce stature estimates that are significantly different from all other formulae derived by other researchers" (Bass 1995:33). This may be explained by the fact that Genoves conducted his study on a very short population. "Short people tend to have different body proportions and would require different regression formulae- thus explaining the difference" (Bass 1995:33). Genoves's formula for stature estimation is shown below.

Calculation of Stature (in cm) from Long-Bones[a] of Mesoamericans[b]

Males:[c]

All bones: Stature = - 2.52 Rad + 0.07 Ulna + 0.44 Hum + 2.98 Fib - 0.49 Tib + 0.68 Fem + 95.113 ± 2.614

Femur: Stature = 2.26 Fem + 66.379 ± 3.417

Tibia: Stature = 1.96 Tib + 93.752 ± 2.815

Females:

All bones: Stature = - 8.66 Rad + 7.37 Ulna + 1.25 Tib + 0.93 Fem + 96.674 ± 2.812

Femur: Stature = 2.59 Fem + 49.742 ± 3.816

Tibia: Stature = 2.72 Tib + 63.781 ± 3.513

Figure 8 (From Genoves 1967)

The stature of UMFC 35A was estimated using this method. The results are below.

-8.66 (19) + 7.37 (21.5) + 1.25 (31.7) + .93 (40.2) + 96.674 = **stature for all bones**
-164.54 + 158.46 + 39.63 + 37.39 + 96.674 = 167.614± 2.812cm (164.80-170.43) = 64.88-67.10 inches = 5 feet 4 inches to 5 feet 6 inches

2.59 (40.2) + 49.742 = **stature from femur**
104.12 + 49.742 = 153.86± 3.816 cm (150.04-157.68) = 59.07-62.08 inches = 4 feet 9 inches to 5 feet 2 inches

2.72 (31.7) + 63.781 = **stature from tibia**
87.18 + 63.781 = 150.96± 3.513 (147.45-154.47) = 58.05-60.81 inches = 4 feet 8 inches to 5 feet 1 inches

This method yielded some interesting results. The formula for stature from the measurements of all bones gave a relatively high stature range for this individual. However, the formulas for stature from the femur and tibia gave results consistent with those obtained from Trotter and Gleser's method. Genoves's method indicated that the stature of this individual could have been anywhere between 4 feet 8 inches to 5 feet 6 inches.

The combination of Trotter and Gleser's method and Genoves's method gave an overall stature range of 4 feet 8 inches to 5 feet 6 inches. UMFC 35A was a gracile female and was most likely closer to the stature given by Trotter and Gleser's method and by the stature estimate made from measurements of the femur and tibia from Genoves's method. Although it is possible that this individual was as tall as 5 feet 6 inches, as indicated by Genoves's stature from all bones formula, it is unlikely. It is most likely that this individual was closer to a stature of 4 feet 8 inches to 5 feet 1 inch at the time of death.

Weight is quite variable from person to person so, it is difficult to estimate. Height and weight charts like the ones doctors use may be used to estimate weight but, they usually show what a person should weigh not what they actually weigh. Also, "recent studies have shown that these charts underestimate ideal weights for people in modern western society by about 20% and it is only rarely that age is dealt with satisfactorily by these charts" (Skelton 2002:93). The chart on the following page is a height-weight chart for females from the Metropolitan Life Insurance Company (figure 9). The chart is separated into columns for gracile, medium, and robust peoples. Skelton notes, however, "there is no accepted way to estimate skeletal robusticity in order to choose which column to use" (Skelton 2002:93).

FOR FEMALES

STATURE		GRACILE	MEDIUM	ROBUST
INCHES	CM			
4'10	147	95±14	101±15	111±17
4'11	150	97±15	104±16	114±17
5'0	152	100±15	107±16	117±18
5'1	155	103±15	117±18	120±18
5'2	157	106±16	113±17	123±18
5'3	160	109±16	117±18	127±19
5'4	163	112±17	120±18	130±20
5'5	165	115±17	123±18	133±20
5'6	168	119±18	127±19	136±20
5'7	170	123±18	131±20	140±21
5'8	173	127±19	135±20	144±22
5'9	175	131±20	139±21	148±22
5'10	178	135±20	143±21	153±23
5'11	180	140±21	147±22	158±24
6'0	183	145±22	152±23	163±24

Figure 9 (From Met. Life Insurance)

The weight of UMFC 35A was estimated using the stature range of 4 feet 8 inches to 5 feet 1 inch. This individual most likely had a gracile build, based on the overall small size of the bones. A weight was estimated using the median statures of 4 feet 10 inches and 4 feet 11 inches. Based on the chart above this individual was most likely between 95±14 pounds to 97±15 pounds at the time of death. If the weight is adjusted for age, it is closer to 94.05± 13.86 – 95.04± 14.85 pounds, based on a height of 4 feet 10 inches to 4 feet 11 inches (Skelton 2002).

CONCLUSION

UMFC 35A was most likely a female of European ancestry, possibly between the ages of 34-35, with a height around 4 feet 10 inches to 4 feet 11 inches, with a weight around 94.05 ±13.86- 95.04 ±14.85 pounds at the time of death. The individual may have suffered from a premortem condition, such as tuberculosis. No perimortem trauma was observed. UMFC 35A has been dead for at least 29 years, due to the fact that the remains were found 28 years ago and they were completely skeletonized when they were recovered. It takes about a year in Montana for a human body to become completely skeletonized after it is buried. The remains of UMFC 35A will continue to be housed at the University of Montana's Physical Anthropology Laboratory for further analyses by students of forensic anthropology.

Part III

INVENTORY OF UMFC 35B

Several bones of the upper and lower limbs were recovered and all of them lacked fused epiphyses. Four epiphyses were recovered but, their corresponding bones could not be determined. The left and right humerii were present and complete. The right and left radii were present and complete. The left and right ulnas were present and complete, except for some slight deterioration (see pathology and trauma). The left and right clavicles were present and complete. The right scapula was present, but incomplete. The fragmented scapula was missing the following features; coracoid process, distal portion of the lateral border, inferior angle, a portion of the spinous process, most of the subscapular fossa, the medial border, and the oblique ridges. A complete left femur was present. The right femur was recovered but, the proximal end (which was present) was broken off. The right and left tibias were present and complete. One distal phalanx and three metatarsals of indeterminate side and position were present. Portions of the coxal were present, including the right ilium, right pubis, and left ischium (all unfused). Two sacral fragments were present, possibly the alae portion of the bone.

Some bones of the axial skeleton were recovered. Several vertebrae were present including nine thoracic, three lumbar, and one cervical (the atlas). Five unidentifiable cervical fragments and ten unfused vertebral bodies were present. There were also four unidentifiable vertebral fragments. Some ribs were present and complete, except for some slight deterioration, including the right and left first ribs and the right and left second ribs. There were also fifteen rib fragments which, due to their size were thin and fragile.

The skull was incomplete. The only cranial bones present, were a fairly complete frontal, a complete right parietal and a partial distal left portion of the occipital, which included the occipital condyle. The mandible was present and complete, with some deterioration (see pathology and trauma). Dentition included the right and left first and second deciduous molars and the right and left permanent first molars, which were visible but, not erupted.

A number of bones were not recovered including those of the upper and lower limbs, the axial skeleton, and the skull. Missing upper and lower limb bones included: the left scapula, all carpals, all metacarpals, and all phalanges of the hand, portions of the coxal (left ilium, left pubis, and right ischium), the right and left patellas, the right and left fibulas, all tarsals, all but three metatarsals, and most phalanges of the foot. Several bones of the axial skeleton were absent including: the hyoid, some cervical vertebrae (indeterminate positions- due to the presence of cervical fragments), three thoracic vertebrae, two lumbar vertebrae, the sternum, and a number of ribs. The skull was very fragmented, it was missing a number of bones. These bones included: most of the occipital bone (see above), the left parietal, the left and right temporals, the right and left maxillas, the right and left palatines, the vomer, the right and left inferior nasal conchas, the ethmoid, the right and left lacrimals, the right and left nasals, the right and left zygomatics, and the sphenoid.

AGE ESTIMATION

UMFC 35B was a sub-adult at the time of death. The overall small sizes of the bones, along with several other skeletal characteristics of a young age were evident. There are several methods available for estimating the age of a sub-adult, including the appearance and union of epiphyses, bone size and the formation, eruption and loss of teeth.

AGE FROM EPIPHYSIS CLOSURE AND BONE UNION

At birth the bones of the skeleton are not full sized so, they must grow. A typical long bone consists of a shaft or diaphysis, an epiphysis at each end, an epiphyseal plate or line, and a metaphysis. An epiphysis is "delineated from the diaphysis because, developmentally, it and the diaphysis each arise as separate elements that eventually fuse" (Schwartz 1995:9). The area that fits between the metaphysis and the epiphysis is a flat cartilaginous area called the epiphyseal plate or line. The end of the diaphysis where an epiphysis unites is called the metaphysis. "In determining the age of juveniles and young adults from skeletal remains, one can use the relative times at which epiphysis fuse to their respective diaphyses" (Schwartz 1995:9).

The coxal bone consists of three parts- the ilium, ischium, and pubis, which unite at about twelve years of age. The coxal of UMFC 35B was not united so; this indicated that the individual was <12 years of age at the time of death.

The clavicle may also be used to estimate age at death. According to Bass, an epiphysis "appears at the sternal end between 12 and 21 years of age and is the last of the epiphyses of the body to unite (in most individuals by age 25)" (Bass 1995:129). The clavicles of UMFC 35B were not united and no epiphyses were present, which indicated an age of <12-21 years of age at the time of death.

The distal epiphysis of the tibia unites before the proximal. The distal epiphysis begins union at 11-13 years in females, with complete union at 17 and 14-16 in males, with complete union at 20 (Johnston 1962). The proximal epiphysis begins to unite at 14 in females, with complete union at 18 and 16-17 in males, with complete union at 23 (Johnston 1962). Both the left and right tibias of UMFC 35B were not united and there was no evidence that they had begun to unite. Therefore, the individual was <11 years of age, if female and <14 years of age, if male.

The epiphyses of the proximal end of the femur unite before the distal epiphyses. The proximal epiphyses of the head, the greater trochanter, and the lesser trochanter unite at about 14-19 years (McKern and Stewart 1957). The distal epiphyses unite to the shaft between 14-18 years (McKern and Stewart 1957). Age differentiation was not mentioned. The epiphyses of the femurs of UMFC 35B were not united, which would indicate an age of <14 years of age.

The distal epiphysis of the humerus is completely united by 17-18 years, the head is completely united by 19, and the medial epicondyle is completely united by age 19 (McKern and Stewart 1957). Age differentiation was not mentioned for this bone. The left and right humerii of UMFC 35B were not united so; the individual was <17 years of age.

The proximal epiphysis of the radius unites to the shaft at about 15-18 years and the distal end unites in females from 16-17 and in males from 17-19 years (Greulich and

Pyle 1959). The epiphyses of UMFC 35B's radii were not united, which would indicate an age of <15 if female and <17 if male.

The proximal epiphyses of the ulna usually unite to the shaft at 15-18 years in females and by age 19 in males (McKern and Stewart 1957). The distal end unites to the shaft in females from 15-16 years and 17-18 in males (Greulich and Pyle 1959). The epiphyses of UMFC 35B's ulnas were not united and had not begun to unite so, the individual was <15 if female and <17 if male.

Another method for estimating age from epiphyses closure was developed by the Workshop of European Anthropologists (1980). Skelton believes this is one of the best and simplest methods. However, this method is not helpful in determining the age of young children with epiphyses that have not even started to fuse, such as those of UMFC 35B.

Age from epiphyses closure is most useful for estimating the age of teenagers and young adults, not for young children. Epiphyseal union begins at adolescence in all the bones mentioned above. UMFC 35B was a young child so; this method was only useful in confirming the individual's young age and removing the possibility of an older age (14+). None of the epiphyses of the long bones or clavicles were united on this individual. The coxal was not united either.

AGE FROM BONE LENGTH

Age may be estimated using measurements of the long bones in children up to about age 12-14 (Skelton 2002:82). "Most methods for relating long bone length to age assume measurements with epiphyses off for ages that are young enough that the epiphyses are normally not attached and epiphyses on for ages when the epiphyses are normally attached" (Skelton 2002:82). Most methods require that measurements of the long bones be taken first and then a comparison is made with a chart, such as the one on the following page (table 2). The data from this chart is from an Old Slavic population.

Age was estimated for UMFC 35B using this chart and long bone measurements. The results are as follows.

Table 1

Bone	Length (mm)	Age
Humerus	137 left, 138 right	2.5-5
Radius	95 left, 96 right	2-3
Femur	183 left, 184 right	3-5
Tibia	154 left, 153 right	3-5

Table 2

AGE FROM HUMERUS, RADIUS, FEMUR, & TIBIA LENGTH - OLD SLAVIC POPULATION
Reworked from the Workshop of European Anthropologists, 1980

HUMERUS LENGTH (mm)	AGE (yrs)	RADIUS LENGTH (mm)	AGE (yrs)	FEMUR LENGTH (mm)	AGE (yrs)	TIBIA LENGTH (mm)	AGE (yrs)
< 89	< 1	< 68	< 1	< 109	< 1	< 93	< 1
89 - 97	.5 - 1	68 - 75	.5 - 1	109 - 120	.5 - 1	93	.5 - 1
98 - 105	1 -1.5	76 - 85	1 - 2	121	1	94 - 101	1
106	1 - 2	86 - 89	1.5 - 2.5	122 - 134	1 - 1.5	102 - 105	1 - 1.5
107- 112	1.5 - 2	90 - 92	2 - 2.5	135	1 - 2	106 - 108	1.5
113 - 118	1.5 - 2.5	93 - 96	2 - 3	136 - 142	1.5 - 2	109 - 116	1.5 - 2
119	2 - 2.5	97	2.5 - 3	143 - 152	1.5 - 2.5	117 - 120	1.5 - 2.5
120 - 127	2 - 3	98 - 103	2.5 - 4	153 - 155	2 - 2.5	121 - 126	2 - 2.5
128 - 129	2 - 4	104	3 - 4	156 - 166	2 - 3	127 - 131	2 - 3
130 - 135	2.5 - 4	105 - 110	3 - 5	167 - 168	2.5 - 3	132 - 135	2.5 - 3
136 - 138	2.5 - 5	111 - 113	4 - 5	169 - 182	2.5 - 4	136 - 144	2.5 - 4
139 - 146	3 - 5	114 - 120	4 - 6	183 - 196	3 - 5	145	3 - 4
147	3 - 6	121 - 129	5 - 7	197	4 - 5	146 - 156	3 - 5
148 - 156	4 - 6	130	5 - 8	198 - 213	4 - 6	157	4 - 5
157 - 159	4 - 7	131 - 138	6 - 8	214 - 220	5 - 7	158 - 167	4 - 6
160 - 168	5 - 7	139 - 140	6 - 9	221 - 227	6 - 7	168 - 171	4 - 7
169 - 170	5 - 8	141 - 148	7 - 9	228 - 240	6 - 8	172 - 179	5 - 7
171 - 177	6 - 8	149 - 152	7 - 10	241 - 246	6 - 9	180 - 184	5 - 8
178 - 181	6 - 9	153 - 155	8 - 10	247 - 253	7 - 9	185 - 190	6 - 8
182 - 185	7 - 9	156 - 160	8 - 11	254 - 263	7 - 10	191 - 201	6 - 9
186 - 192	7 - 10	161 - 163	9 - 12	264	8 - 10	202 - 211	7 - 10
193 - 195	8 - 10	164	10 - 12	265 - 278	8 - 11	212 - 216	7 - 11
196 - 201	8 - 11	165	10 - 13	279 - 285	9 - 12	217	8 - 11
202 - 210	9 - 12	166 - 168	10 - 14	286 - 290	9 - 13	218 - 226	8 - 12
211 - 218	10 - 13	169 - 175	11 - 14	291 - 295	10 - 13	227	8 - 13
219	11 - 13	175 - 179	> 11	296 - 305	10 - 14	228 - 234	9 - 13
220 - 224	11 - 14	179 - 188	> 12	306 - 323	> 10	235	9 - 14
225 - 234	> 11	188 - 200	> 13	324 - 337	> 11	236 - 246	10 - 14
235 - 247	> 12	> 200	> 14	338 - 358	> 12	247 - 259	> 10
247 - 257	> 13			359 - 382	> 13	260 - 268	> 11
> 257	> 14			> 382	> 14	269 - 283	> 12
						284 - 301	> 13
						> 301	>14

This method resulted in a narrow age range of 2.5-3 years of age and a wide range of 2-5 years of age for this individual.

Johnston (1962) studied skeletal material from Indian Knoll, which led to the discovery of important information on the relation of age to longbone length in subadults. His data was used to estimate the age of UMFC 35B from the tibias, femurs, ulnas, radii, and humerii. The results follow.

Table 3

Estimation of Age Using Length of the Tibia[a]

Estimated age in years	N	Tibia Mean	Tibia Standard deviation
Fetal	6	55.50[b]	7.54
NB–0.5	65	69.28	6.33
0.5–1.5	38	96.87	14.47
1.5–2.5	7	120.57	5.45
2.5–3.5	10	138.20	8.54
3.5–4.5	10	154.30	8.10
4.5–5.5	7	178.43	4.53

[a]After Johnston (1962:Table 2).
[b]All measurements in mm.

The tibias of UMFC 35B measured 154mm (left) and 153mm (right). These measurements were closest to the mean of 154.30mm, with a standard deviation of 8.10mm, which was equivalent to an age range of 3.5-4.5 years of age.

Table 4

Age Estimation from Femur[a]

Estimated age in years	N	Femur Mean[b]	Femur Standard deviation
Fetal	7	61.86	6.33
NB–0.5	64	78.84	7.23
0.5–1.5	38	115.63	18.34
1.5–2.5	8	148.13	10.76
2.5–3.5	11	166.73	9.99
3.5–4.5	11	183.82	9.20
4.5–5.5	6	213.67	4.52

[a]After Johnston (1962:Table 2).
[b]All measurements in mm.

The femurs of UMFC 35B measured 183mm (left) and 184mm (right). These measurements were closest to the mean of 183.82mm, with a standard deviation of 9.20mm, which indicated an age range of 3.5-4.5 years of age.

Table 5

Age Estimation from the Ulna[a]

Estimated age in years	N	Ulna Mean[b]	Ulna Standard deviation
Fetal	5	54.80	4.12
NB–0.5	54	63.70	4.74
0.5–1.5	29	82.86	9.00
1.5–2.5	5	99.20	1.94
2.5–3.5	7	108.00	5.76
3.5–4.5	8	120.63	4.24
4.5–5.5	4	132.75	3.42

[a]After Johnston (1962:Table 2).
[b]All measurements in mm.

The ulnas of UMFC 35B measured 104mm (left) and 105mm (right). These measurements were closest to the mean of 108.00mm, with a standard deviation of 5.76mm, which correlated with an age range of 2.5-3.5 years of age.

Table 6

Age Estimation from the Radius[a]

Estimated age in years	N	Radius Mean[b]	Radius Standard deviation
Fetal	5	47.20	5.42
NB–0.5	60	55.05	4.24
0.5–1.5	24	73.96	8.36
1.5–2.5	6	91.33	4.42
2.5–3.5	7	97.86	6.47
3.5–4.5	8	108.50	2.28
4.5–5.5	5	120.00	2.76

[a]After Johnston (1962:Table 2).
[b]All measurements in mm.

The radii of UMFC 35B measured 95mm (left) and 96mm (right). These measurements were closest to the mean of 97.86mm, with a standard deviation of 6.47mm, which indicated an age of 2.5-3.5 years of age.

Table 7

Age Estimation from the Humerus[a]

Estimated age in years	Humerus		
	N	Mean[b]	SD[c]
Fetal	9	56.78	6.26
NB-0.5	71	67.66	5.94
0.5–1.5	42	93.14	12.11
1.5–2.5	7	113.57	5.66
2.5–3.5	11	125.64	6.86
3.5–4.5	9	136.78	5.56
4.5–5.5	6	154.67	5.42

[a]After Johnston (1962:Table 2).
[b]All measurements in mm.
[c]SD refers to the standard deviation.

The humerii of UMFC 35B measured 137mm (left) and 138mm (right). These measurements are closest to the mean of 136.78mm, with a standard deviation of 5.56, which correlated with an age range of 3.5-4.5 years of age.

Overall, Johnston's method for age estimation based on long bone measurements yielded an age range of 2.5-4.5 years of age.

AGE FROM DENTITION

There are several methods which are available to estimate the age of an individual based on dentition, including dental eruption and wear. White and Folkens note, "because of the regular formation and eruption times for teeth, and because these elements are the remains most commonly found in forensic, archaeological, and paleontological contexts, dental development is the most widely used technique for aging subadult remains" (White and Folkens 2000:342). The methods used to estimate age from dentition for UMFC 35B are presented below.

Age may be estimated using dental calcification standards such as those illustrated in figure 2. "Teeth form from the beginning of the tips of the cusps of the crown, with the last part to form being the tips of the roots" (Skelton 2002:41). An x-ray of the teeth is very helpful for examining the development of the teeth, particularly for encrypted teeth or permanent teeth which are developing below deciduous teeth. Skelton suggests, "to estimate age by tooth calcification (or dental development) simply note any teeth that are not completely formed yet and match their state of development to the dental calcification standards" (Skelton 2002:41).

An x-ray of the left side of UMFC 35B's mandible (figure 1) was taken in 1974 by Dr. Cole L. MacPherson of the Professional Service Corp. located in Missoula, Montana. In 1974, when Dr. MacPherson examined the teeth his conclusion was that UMFC 35B was a child with six year molars still encrypted in the bone, approximately four years old.

Examination of the x-ray revealed that the individual's teeth matched the development stage of 3 years old for deciduous teeth and the 2-4 years old stage for adult teeth. This was determined by comparing the deciduous molars and the erupting first molar, which were visible on the x-ray, to the calcification standard chart in figure 2.

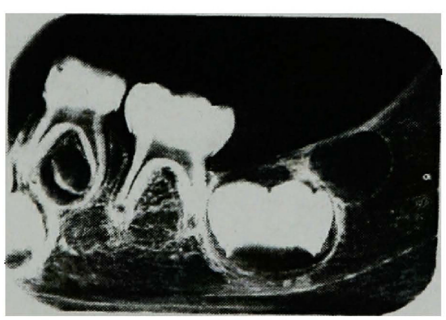
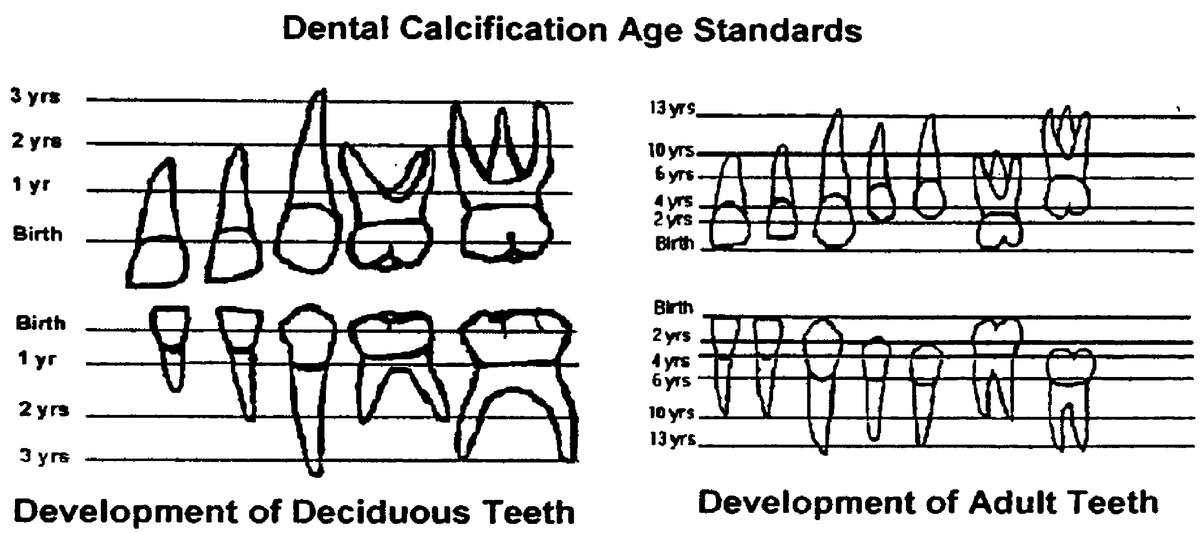


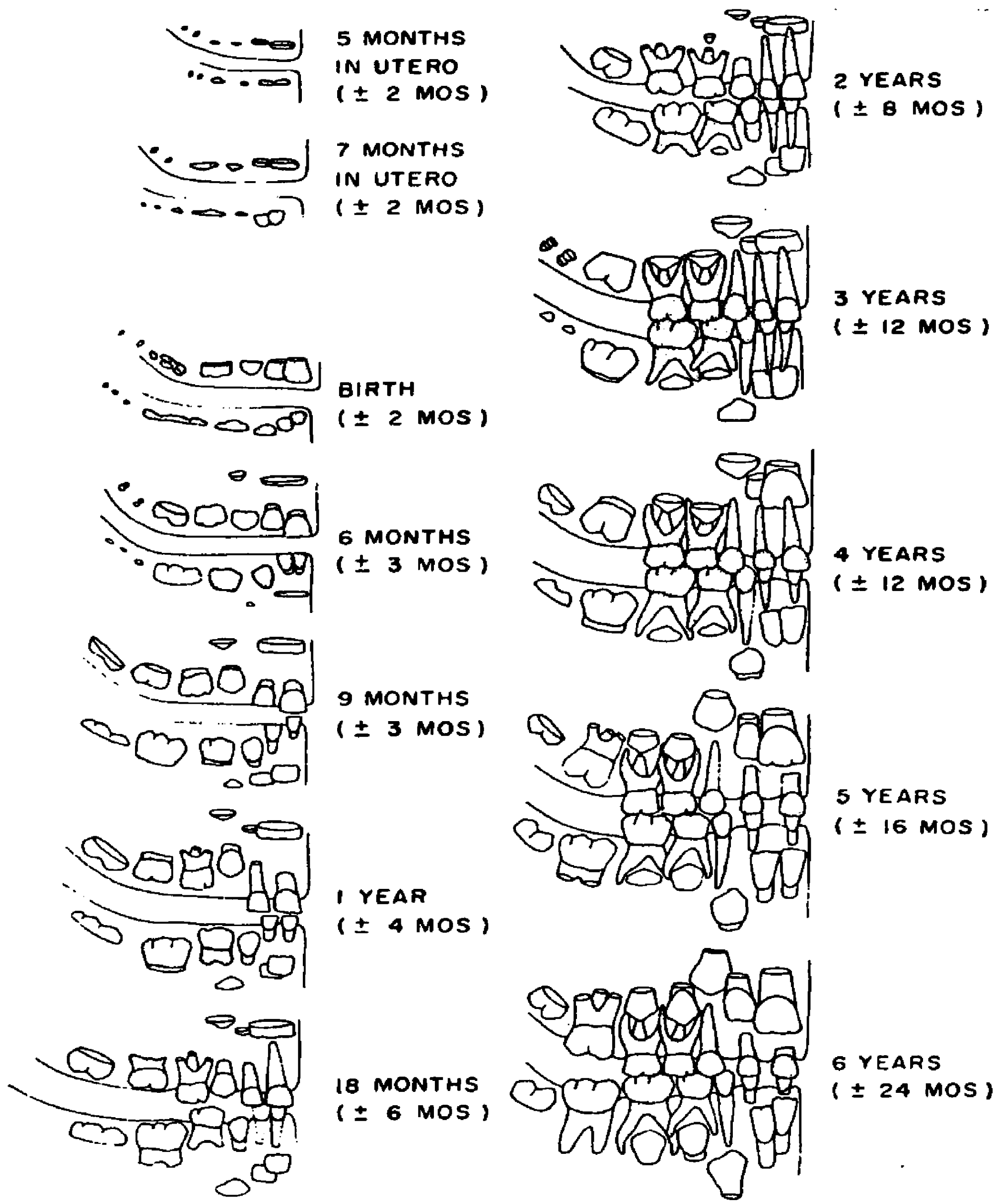
Figure 1 (From MacPherson 1974)

This method suggested an overall age range of 3-4 years of age at the time of death for UMFC 35B.



<u>Figure 2</u> (From Skelton 2002)

Age can also be estimated from dental eruption. Bass notes, "one of the more accurate indicators of chronological age through approximately age 12 is dental calcification and eruption. One of the best documented and current charts was compiled by Ubelaker (1978)" (Bass 1995:303). Ubelaker's chart was taken from "the sequence of formation and eruption of teeth among American Indians" (Bass 1995:304). See figure 3.



<u>Figure 3</u> (From Ubelaker 1978).

UMFC 35B had a dental eruption pattern similar to that of the stages of three to five years. The x-ray of UMFC 35B's left mandible (figure 1) helped estimate the age from dental development. The individual's first right and left molars had not yet erupted, which indicated an age of <6 years of age. The x-ray revealed that the left first premolar was beginning to erupt below the deciduous first molar, which indicated an age of >2 years of age. Ubelaker's dental development chart pointed to an overall age range of 3-5 years ±12 months.

CONCLUSIONS

A multifactorial approach was used to determine overall narrow and wide age ranges for UMFC 35B. Age from epiphysis closure gave an age of <12 years old, based on the coxal bones, which were not united. Using the data provided by the Workshop of European Anthropologist's for estimating age from bone length, an age range of 2.5-3 years of age was estimated. Johnston's method for age from bone length gave an age range of 2.5-4.5 years. Dental calcification analysis showed that UMFC 35B was most likely between the ages of 3-4 at the time of death. Ubelaker's dental eruption method gave an age range of 3-5 ±12 months.

Overall wide and narrow ranges were estimated from the data above. It can be said that this individual was a child of less than 12 years old, based on the coxal bones, which were not united. The method for obtaining wide and narrow age ranges was explained in UMFC 35A's age conclusions section. To obtain a wide range, you must determine the lowest possible age based on the ranges discussed above. Both of these ages came from the Ubelaker dental eruption method, which gave a wide range of 2-6 years at the time of death.

To obtain a narrow age range, the highest "low" age and the lowest "high" age were estimated. The highest "low" age was 3, based on the dental calcification method and the lowest "high" age was also 3, from the Workshop of European Anthropologist's age from long bone length method. Overall, a narrow age range of around 3 years old at the time of death was estimated. However, the narrow age range may be too narrow. It may be more accurate to use the dental calcification high age of 4, especially if this case was being analyzed for law enforcement.

Overall, for the purposes of this paper, a wide range of 2-6 years and a narrow range of 3-4 years of age at the time of death was estimated for UMFC 35B.

Several methods for estimating age could not be used because they were not applicable to an individual of this age. These methods included, age from dental attrition, age from sternal rib ends, age from cranial suture closure, age from auricular surface, age from vertebral osteophytosis, age from pubic symphysis, age from osteoarthritis of the lower back, and age from degenerative changes in teeth.

SEX ESTIMATION

There are no reliable methods available for estimating the sex of sub-adults, particularly young children. Hunt and Sheridan have concluded that "sex determination in sub-adult skeletons remains a problem area" (Bass 1995:210). White also notes "it is extremely important to remember that sexual identification of human skeletal material is generally most accurate after the individual reaches maturity. Only then do the bones of different sexes become differentiated sufficiently to be useful in sexing" (White 2000:362).

However, the coxal bones may show some sexual differentiation in pre-adolescents. According to Skelton, "the shape of the sciatic notch may be the most reliable criterion for younger children and the elevation of the auricular surface seems to be about 80% accurate for estimating sex in children. The shape of the pubis is not reliable for this age group-they will all tend to look male. If, however, a young individual has a pubis shape that looks female, you can be reasonably certain that it is female" (Skelton 2002:72). UMFC 35B exhibited a wide sciatic notch and a semi-raised auricular surface, which indicated a female. Sex could not be estimated using the pubis because the right pubis was missing and the left pubis was too fragmented to be of any use.

Several methods for estimating sex could not be used because they were inapplicable to a person of such a young age or the bones were not present. Inapplicable age related methods included; sex from features of the skull and sex from the shape and measurement of the sacrum. Some bones which are used for sex estimation were absent or incomplete but, even if they were present they would not have been very useful. These methods and their related bones were sex from measurements of the scapula and sternum, sex from the shape of the sternum, and sex from the shape scapula.

UMFC 35B may have been a female, but there is not enough evidence to definitively conclude the sex of the individual. A conclusion of indeterminate sex was made.

RACE ESTIMATION

Race estimation for sub-adults is a problem area for anthropologists. There are currently no methods available for sub-adult race estimation. It's not that the research is lacking, it's that racial characteristics do not appear on the skeleton until at least adolescence. Most of the typical racial traits visible on the skulls of the three commonly used "racial" categories do not appear until the bones are fully developed. All of the methods currently available for estimating ancestry are only useful in examining adult skeletons. UMFC 35B was quite young so, there was no way to estimate the race of this individual.

STATURE AND WEIGHT ESTIMATION

As mentioned previously, stature may be estimated from measuring long bones and comparing them to a stature standard table. White and Folkens note "the fact that the height (stature) of the human body correlates with limb bone length across all ages allows the osteologists to reconstruct an individual's stature from different skeletal elements" (White and Folkens 2000:372). The stature of UMFC 35B was estimated using two different methods. The first method which was used was Stewart's (1979) fetal stature method. His formulas are presented below.

Table 8

FETAL STATURE (Epiphyses Not Attached)
From Stewart, 1979

Fetal Stature =	7.92 X Humerus Length - 0.32	± 1.8cm
	13.8 X Radius Length - 2.85	± 1.62cm
	8.73 X Ulna Length - 1.07	± 1.59cm
	7.85 X Fibula Length + 2.78	± 1.65cm
	7.39 X Tibia Length + 3.55	± 1.92cm

The results of the stature estimation of UMFC 35B are below.

7.92 X 13.7 -.32 = 108.18 ± 1.8cm
13.8 X 9.5 -2.85 = 128.25 ± 1.62cm
8.73 X 10.4 -1.07 = 89.72 ± 1.59cm
7.39 X 15.4 +3.55 = 117.36 ± 1.92cm

All the measurements used were from bones of the left side of the body. The fibula could not be used because it was severely deteriorated. Using Stewart's method, the overall stature range for this individual was about 2 feet 9 inches to 4 feet 2 inches.

The second method used for stature estimation was subadult stature from femur length from El-Najjar and McWilliams (1978), which is illustrated in table 9.

Table 9

SUBADULT STATURE FROM FEMUR LENGTH
If Epiphyses are attached measure them, if not don't measure them.
From El-Najjar and McWilliams, 1978

FEMUR DIAPHYSIS (mm)	STATURE (cm)		FEMUR DIAPHYSIS (mm)	STATURE (cm)
80	50		195	111
85	55		200	114
90	58.5		210	116
95	61.5		220	119
100	64.5		230	122
105	67.5		240	125
110	70		250	127.5
115	73		260	130.25
120	76.5		270	133.25
125	79		280	135.75
130	81.5		290	138.5
135	84.5		300	141
140	87		310	143.5
145	89.5		320	146
150	93		330	148.75
155	94.5		340	151
160	96.75		350	153.75
165	99.25		360	156
170	101.5		370	158.75
175	103.5		380	161.75
180	105.5		390	165
185	107.5		400	170
190	109.5			

The femurs of UMFC 35B measured 183mm (left) and 184mm (right). Using the chart above, the estimated stature was closest to 107.5cm, which was equivalent to 3 feet 5 inches.

The overall stature estimate for UMFC 35B was 2 feet 9 inches to 4 feet 2 inches, which was quite a wide range. The stature of the individual, at the time of death was most likely closer to the estimate given by the measurement of the femur, which was 3 feet 5 inches. This assumption was based on the overall size of the individual and the age estimates.

The weight of UMFC 35B was estimated using growth charts developed by the CDC, which may be found at www.nal.usda.gov. A height of 3 feet 5 inches placed this individual in about the 50-75th percentile. The estimated weight for a 3 year old in this percentile was approximately 35-38 pounds.

PATHOLOGY AND TRAUMA

UMFC 35B did not have any visible perimortem traumas. The only traumas observed were likely postmortem or premortem. Most of the skeletal remains were thin and fragile, due to their small size. The most common traumas were deterioration of the bones and breakage.

The skull was severely fragmented, only the frontal, left parietal, a fragment of the occipital (measuring 43.5mm at its widest point), and the mandible were recovered. The frontal bone and left parietal were still articulated, however, the shapes of the bones were distorted, possibly due to soil pressure. Soil may sometimes accumulate in the skull while it is buried and as the soil becomes wet and then dries, the soil expands. The frontal and left parietal were also quite deteriorated. The left parietal had a crack measuring 55.5mm, located near the sagittal suture. All of the above traumas were most likely postmortem. There was some evidence of a premortem condition called cribra orbitalia on the superior surface of the inside of the orbits of the left and right sides of the frontal bone. Pin-cushion like holes were present on the bone. Cribra orbitalia is manifested "as a widening of the spongy diploe with a corresponding thinning of the outer dense cortical bone resulting in the appearance of surface porosity" (Cohen and Armelagos 1984:29). This condition is related to nutrition deficiency.

The mandible exhibited a lot of deterioration which was most likely postmortem. The left and right mandibular condyles, the left and right coronoid processes, and the left and right gonial regions were quite worn. Tooth loss included all deciduous incisors and canines of the mandible, which were lost post mortem. There was a probable postmortem crack below the left canine tooth socket.

Some bones of the axial skeleton were damaged and/ or deteriorated, most likely postmortem. Most of the recovered ribs were broken and deteriorated, which made their positions and sides indistinguishable. Five vertebral fragments were found and they were light and quite fragile. The left and right clavicles were deteriorated at both the distal and proximal ends.

Several postcranial elements of the upper and lower limbs were broken and/or deteriorated, possibly postmortem. The distal portion of the right scapula was broken off near the superior border. Both the left and right humerii were quite deteriorated, particularly at the proximal and distal ends. The left and right ulnas were also deteriorated throughout the shaft and at the proximal and distal ends. The distal and proximal ends of the right and left radii were deteriorated but the distal ends were quite damaged. The right femur was severely deteriorated at both the proximal and distal ends. The proximal end was broken off completely, most likely postmortem but, it was recovered. Both the proximal and distal ends of the left femur were deteriorated, especially around the greater trochanters. The right tibia was worn at both the proximal and distal ends. Both the proximal and distal ends of the left tibia had quite a lot of deterioration. The posterior side of the proximal end is severely deteriorated. One fibula was recovered but, its side was indeterminate, because it was extremely deteriorated, both the proximal and distal ends were worn away.

CONCLUSION

UMFC 35B was most likely a young child between the ages of 2-6 years old, with a height of around 3 feet 5 inches and a weight of 35-38 pounds at the time of death. The individual may have been a female based on visual assessment of the coxal, however, there was not enough evidence to make a definitive conclusion about the sex of the individual. Race could not be determined, due to the young age of the individual and the absence of most of the skull. UMFC 35B may have had a premortem pathological condition, such as cribra orbitalia. No perimortem trauma was observed. As with UMFC 35A, time since death is at least 29 years (see the conclusion section of UMFC 35A). The remains of UMFC 35B will continue to be housed at the University of Montana Physical Anthropology Laboratory for future study.

Appendix I

CRANIAL MEASUREMENTS
(all measurements are in mm)

MAXIMUM LENGTH (g-op): 172

MAXIMUM BREADTH (eu-eu): 128

BIZYGOMATIC BREADTH (zy-zy): 113 (estimated, zygomatics are broken)

BASION-BREGMA (ba-b): 125

CRANIAL BASE LENGTH (ba-n): 93

BASION-PROSTHION LENGTH (ba-pr): 81

MAXIMUM ALVEOLAR BREADTH (ecm-ecm): 53

MAXIMUM ALVEOLAR LENGTH (pr-alv): 41

BIAURICULAR BREADTH (ALB): 106

UPPER FACIAL HEIGHT (n-pr): 58

MINIMUM FRONTAL BREADTH (ft-ft): 96

UPPER FACIAL BREADTH (fmt-fmt): 98

NASAL HEIGHT (n-ns): 44

NASAL BREADTH (al-al): 21

ORBITAL BREADTH (d-ec): left 34, right 34

ORBITAL HEIGHT (OBH): left 32, right 32

BIORBITAL BREADTH (ec-ec): 91

INTERORBITAL BREADTH (d-d): 21

FRONTAL CHORD (n-b): 110

PARIETAL CHORD (b-1): 113

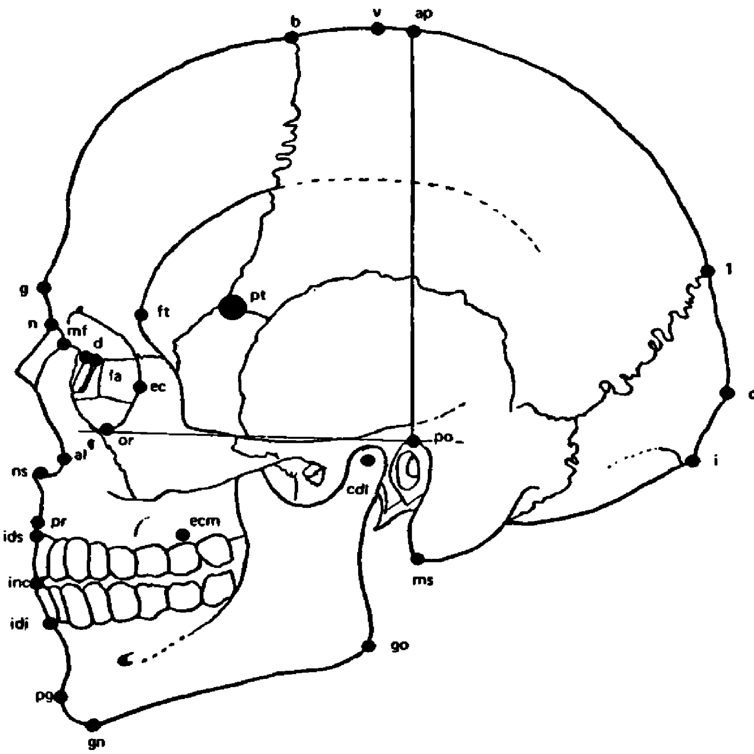
OCCIPITAL CHORD (l-o): 90

FORAMEN MAGNUM LENGTH (ba-o): 36

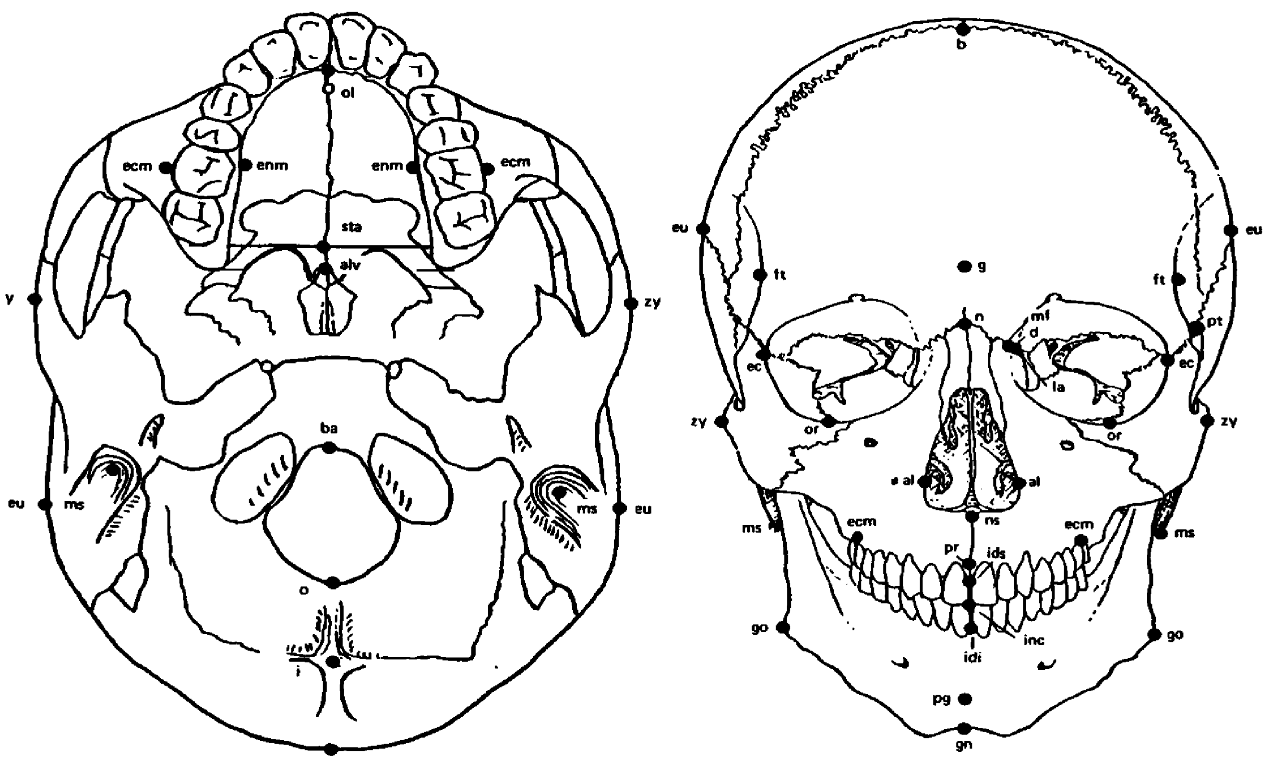
FORAMAEN MAGNUM BREADTH (FOB): 28

MASTOID LENGTH (MDH); left 24, right 24

<u>Appendix II</u>



ANTHROPOMETRIC LANDMARKS OF THE SKULL



(From Bass 1995:69-71)

Appendix III

POSTCRANIAL MEASURMENTS

		Left	Right
Humerus:			
	MAXIMUM LENGTH	275	N/A
	EPICONDYLAR BREADTH	44.7	N/A
	MAX. VERTICAL DIAMETER OF HEAD	41.6	N/A
	MAX. DIAMETER AT MIDSHAFT	16.1	N/A
	MIN. DIAMETER AT MIDSHAFT	13.1	N/A
Radius:			
	MAXIMUM LENGTH	190	N/A
Ulna:			
	MAXIMUM LENGTH	215	N/A
	MINIMUM CIRCUMFERENCE	32	
Sacrum:			
	NUMBER OF SEGMENTS	5	
	ANTERIOR HEIGHT	114.5	
	MAXIMUM BREADTH	114.8	
Coxal:			
	HEIGHT	N/A	N/A
	ILIAC BREADTH	N/A	132
	PUBIS LENGTH	N/A	N/A
	ISCHIUM LENGTH	N/A	N/A
Femur:			
	MAXIMUM LENGTH	N/A	402
	BICONDYLAR LENGTH	N/A	72.4
	MAX. DIAMETER OF HEAD	N/A	39.7
	CIRCUMFERENCE AT MIDSHAFT	N/A	70
Tibia:			
	CONDYLO-MALLEOLAR LENGTH	317	319
	MAX. DIAMETER NUTRIENT FORAMEN	27.2	26.8
	CIRCUM. AT NUTIRENT FORAMEN	74	75
Fibula:			
	MAXIMUM LENGTH	306	N/A

(all measurements in mm)

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