Missoula County Sheriff's Department case #8509102: A comprehensive forensic case report for "Christy Crystal Creek"

Sydney Wimbrow

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MISSOULA COUNTY SHERIFF’S DEPARTMENT CASE #8509102:

A COMPREHENSIVE FORENSIC CASE REPORT FOR

"CHRISTY CRYSTAL CREEK"

By,

Sydney Wimbrow

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Approved By:

[Signature]

Committee Chair

Dean, Graduate School

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Date
Abstract

Identification of skeletal remains is integral in the process of law enforcement. This case has been in the hands of the Missoula County Sheriff's Department for nineteen years, and still this victim remains unidentified. Using today's established methods of identification in forensic anthropology, I will determine sex from visual and metric analysis of the skull, scapula, humerus, os coxae, sacrum and femur. Age will be determined by visual assessment of cranial sutures, dental attrition, 4th rib, vertebrae, pubic symphysis, and auricular surface of the ilium. Ancestry is estimated by visual analysis of the cranium, dentition, and curvature of the femur. Hair samples will be included in this analysis. Using metric analysis of the cranium, I will estimate ancestry by discriminant function analysis and the computer program FORDISC. The scapula and sacrum will also be measured for ancestry. Pathology and trauma of the skeleton, as well as stature, weight, handedness and time since death will also be covered. As a literature review, the history of the study of parturition (childbirth) will be discussed. It is my intention that one day this victim will be positively identified and returned to her family, where she belongs.
Acknowledgements

I would like to thank the Missoula County Sheriff's Department for allowing me the distinct opportunity to work on this case. Dr. Randall Skelton has always encouraged me to pursue my educational goals while patiently answering the myriad of questions and correcting my mistakes. Dr. Thomas A. Poor has been with me since the beginning of my Anthropology career, sparking my interest with his intriguing teaching methods (even with statistics!) as well as his racy fashion sense. Thanks to Dr. Richard Bridges for sitting in on my committee and understanding every time I extended my studies another semester. Garry Kerr's wild enthusiasm is an inspiration to all students; after taking one of his classes everyone wants to be a forensic anthropologist.

My parents, Skip and Elizabeth, my big sister Heather, and lil' bro T.G. have always supported my decisions, no matter how obscure, and expect nothing less than the best from me. I thank them for that, because sometimes I forget that I can get what I want. I love you!

C. Milo McLeod has taught me the ins and outs of Cultural Resource Management in the Forest Service. He is a human encyclopedia; I am very fortunate to work for him. J. Rodger Free is my field buddy and knows the answers to all my questions. If not, he'll go look it up for me. Thanks, Rodg! Deirdre Boggs is a huge reason why I am where I am academically and career-wise, because she told me to get “my ass in gear” (Personal Communication, 2001); I hope I continue to make you proud.

Lastly, I'd like to thank my sweet favorite, Mr. ChrisBacon, for allowing me the quiet time to write this. He is the one who motivated me the most to get moving on this paper so we could move forward with our life together.
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Introduction

To obtain a Master’s Degree in Forensic Anthropology from the University of Montana, I will complete a comprehensive skeletal analysis of a forensic case on loan from the Missoula County Sheriff’s Department. This “cold case” has been placed on an inactive status, as almost 20 years has lapsed since discovery with no leads on identification. “Christy Crystal Creek” is a nearly complete skeleton that has been in the custody of the Missoula County Sheriff’s Department since its discovery in September 1985.

Osteological analysis of these skeletal remains is possible because of the various research tools and methods proposed by physical and forensic anthropologists in the past. Throughout the comprehensive study, I determine age, sex, racial affiliation, pathology/trauma, and stature and weight exhibited by this individual. A complete skeletal inventory of Christy Crystal Creek will occur and any cultural artifacts present in the case will also be addressed. The origin, or “chain of custody” of the skeletal remains is of great importance as well. I also intend to research corresponding documents associated with the case to locate authorities involved in order to determine a more accurate time since death.

Research of Christy Crystal Creek in the form of a comprehensive case report is valuable for a variety of reasons. Unfortunately, Christy Crystal Creek is only one of thousands of unidentified/missing persons in the United States. It is disturbing to think that this unlucky victim has no one that misses her; no family member or friend who has been trying to locate her. Any new piece of information related to this case could possibly assist in identification of this individual. It is of valuable importance to gather as much information as possible regarding this cases in order to gain a better understanding of their origins.
Each semester of graduate school has brought me to the physical anthropology lab for instruction, research and analysis. I feel confident with the work I have completed there, and I look forward to assisting the Sheriff's Department as well as the Anthropology Department. A gap between the unknown and familiar is becoming bridged as I, along with other students pursuing the same goal, complete comprehensive case reports for unidentified individuals found so close to home.

Materials and Methods

There are a variety of methods to be applied in order to conduct a complete skeletal analysis of an individual. These methods have proven accuracy, and therefore are widely used today. In determining sex, morphological features of the skull, coxal bones, the shape of the sacrum, and the measurement of the long bones will be employed. Metric analysis will include Giles and Eliot's (1964) discriminant function equation. To determine the age of this specimen, epiphyseal plates, growth stage of bone and cranial sutures, sternal rib ends, the pubic symphysis, eruption and/or attrition of the dentition will be studied. For ancestry determination, I investigate diagnostic features of the skull and dentition and femur. Craniometric analysis consists of discriminant functions equations (Giles and Elliot etc., 1962), and use of the FORDISC (Ousley and Jantz, 1996) computer program. Metric analysis of the scapula and sacrum discriminate function calculations will also occur. In determining the stature and weight of the individual, I will take measurements of long bones, in particular the femur, humerus and the tibia, and their corresponding heights and weights.

Pathology and trauma of the individual will be done through the close examination of any skeletal abnormalities that might be present. These abnormalities will then be described and an informal attempt at a diagnosis may be made. However, because I am not a medical professional the diagnosis will only be hypothetical in nature unless a
qualified medical professional has concurred in my evaluation. Using the glenoid fossa of the scapula as well as observation of tooth staining, I will determine handedness. Time since death will be possible through analyzing the decomposition rate of non-skeletal material as well as postmortem damage the skeleton has suffered.

**Implications of this Research**

I feel that the implications of research on Christy Crystal Creek will be an asset to the Missoula County Sheriff's Department as well as future students who are to analyze and hopefully obtain the identity this victim in the future. Most importantly, the Missoula County Sheriff's Department will have a compilation of all previous information related to this case as well as the author's new analysis using today's established forensic anthropological methods. In my pursuit for a comprehensive description of the individual's identity, my research will hopefully assist the professors in their instruction and enable students of forensic anthropology to gain accurate knowledge of the process of human identification. My goal is to record a complete description of this individual's life, and death, story for others to use in the years to come.
Background

Late in the afternoon on September 9, 1985, a man was bear hunting near Crystal Creek road just east of Missoula, Montana. He dropped down near the creek, and as he was “checking out the bear he observed a skull in the drainage” (Spring, 1985: 2). He picked up the skeletonized cranium, and after seeing metal fillings in the dental arcade, he realized it was human and called the sheriff.

Officer Martin Spring and Deputy Charles Muchmore accompanied the hunter to the location, later followed by Lieutenant Jerry Crego and Captain Weatherman (Spring, 1985). Other bones complimentary to the cranium were scattered throughout the area. It was secured for the evening and further action proceeded the following morning.

Captain Weatherman, Lieutenant Crego and Detective Tom Woods returned to the site the next day to conduct a complete survey and excavation. It appeared that the body had been dumped into the drainage and no attempt at a burial was made. Crego and Woods “searched the general area and upon finding bones we tagged them with orange fluorescent tags to show us a dispersion pattern...the bones were collected and bagged as to anatomical features after being photographed in place” (Crego, 1985). The officers excavated the site by “removing the top layer of humus” (Weatherman, 1984). Underneath the duff they located “the mandible and one half of the pelvis along with a shoulder blade and numerous other smaller bones” (Weatherman, 1984) and nine more teeth. A clump of wavy dark brown/black hair was also recovered near the skull.

The cranium exhibits circular defects that appear to be a gunshot wound on the right side of the frontal bone as well as one at the back of the skull at the junction of the right parietal and lambdoidal bones. On September 11, 1985 Weatherman took the skull to a Dr. Rivers for further analysis. He observed, “both holes in the skull were
entrance holes” (Weatherman, 1985). Criminalist William Newhouse “then measured these entrance holes and determined that one entrance hole was the was indicative of a nine millimeter, .38 or .357 weapon and the second entrance hole being at the top, forehead of the skull, was most likely a .44 or .45 caliber type weapon” (Weatherman, 2: 1985).

Officer Weatherman returned to Crystal Creek on September 12, 1985 with a sufficient metal detector and thoroughly searched the site for any additional metal objects linked to the case. “It should be noted” Weatherman stated, “that officers found no metal objects considered associated with the crime scene” (Weatherman, 1985). One additional left rib was recovered, however.

Later that afternoon, the cranium was taken to local dentist Dr. Vincent Ming for X-rays and charting. Dr. Ming proceeded to also make impressions of the dental arcade. While Weatherman and Ming were observing the skull, “a metallic object fell from the foramen magnum which appeared to be a spent bullet closely resembling a nine millimeter type weapon” (Weatherman, 1985). It was retrieved as further evidence.

The following day, September 13, Weatherman took the remains to University of Montana Physical Anthropology professor Dr. Sandy Smith for further Osteological evaluation. Preliminary analysis led Smith to believe that these were the remains of “a female in the neighborhood of 20 years of age and approximately 5’ in height, possibly a Caucasian” (Weatherman, 1985).

On September 19, 1985, Captain Weatherman delivered the remains to St. Patrick’s Hospital “for purposes of full body x-ray survey” and at that time “this officer noted a metallic object still present inside the skull” (Weatherman, 1985). Weatherman returned to the Missoula County Sheriff’s Department and proceeded to dislodge a second spent bullet hidden in a clump of dirt within the cranial cavity. This item was also retained as further evidence.
While Dr. Smith's formal osteological analysis and Dr. Ming's dental analysis were in process, the skeletal remains were sent to Dr. Michael Chamey, PhD, D-AFBA at the Center for Human Identification at Colorado State University on September 25. Dr. Michael Chamey, a facial reconstruction expert and diplomate on the American Board of Forensic Anthropology was to make an official analysis of Christy Crystal Creek. He completed a thorough analysis of the individual and replied with an abstract stating, "A female, Caucasoid, 25 ± 1 years, 5 feet, 0.2 ± 1.5 inches, 110 ± 5 pounds, right-handed" (Chamey, 1985). He even composed hypotheses based on this victim's skeletal anomalies. Chamey indicated that, based on "over-development of the shoulder muscles on the right" that the victim could be a "waitress, perhaps?" (Chamey, 1985).

Various attempts were made to identify this person. Reports containing a detailed description of this victim's description with individual anomalies as well as unique and extensive dental x-rays were sent to institutions around the country. Over the course of 18 years, over 50 different matches were attempted (Case file, 1985-present). To this day her remains have still not been identified.

After years of inquiry by the Missoula County Sheriff's department and no leads, the case was given an "inactive" status. Missoula County Detective Greg Newlan provided information as to why this inactive status occurs. "Leads dry up," stated Detective Newlan "and (cases) will go inactive until further information is gathered" (Personal Communication, 2003). Christy Crystal Creek's physical remains as well as the compilation of notes, reports, analyses, x-rays and photographs has been stored in a box in an evidence locker in the Missoula County Detective's Office, 200 West Broadway, Missoula, MT 59802. On June 5 2003, the skeleton and the case file were placed on loan to three students in the Anthropology Department at the University of Montana until January of 2005. During the course of this academic study, Christy Crystal Creek is securely stored in the Physical Anthropology Laboratory in the Social
Science Building on the University of Montana campus. All analysis of the individual will take place in the Physical Anthropology Laboratory, and the skeletal remains will not leave the building until it is returned to the Missoula County Sheriff's office upon completion of a comprehensive case report.

It should be noted that Debbie Deer Creek, another unidentified murder victim, was discovered approximately 3 miles (as the crow flies) northwest of Christy Crystal Creek just under a year before Christy's skeleton was found. On Christmas Eve, 1984, a nature photographer stumbled across human remains just north of the Deer Creek drainage. This victim also exhibited circular defects to the cranium, probably the same caliber of weapon as Christy's. Debbie Deer Creek was buried in a shallow grave, which, like Christy's remains, allowed various carnivorous animals to scavenge her remains.

These two individuals had experienced a similar cause of death, were found close in proximity, and were positioned in a comparable burial environment. In the mid 70's and early 80's, Missoula was plagued by a string of serial killings that terrified the community. Over the course of 11 years, eight victims, ranging from five-year old Siobhan McGuinness to 38-year-old minister's wife Deborah Pounds were found brutally murdered. All but two of these victims were identified. Christy Crystal Creek and Debbie Deer Creek were these two. Although it has never been proven that Wayne Nance murdered these women, the circumstances under which they had met their fates appear to suggest this connection. Unfortunately in some respects, Wayne was killed by his manager's husband in a fabled murder attempt of the couple and was unable to testify. All other six murders could be directly linked to Wayne Nance through physical evidence, but both Christy Crystal Creek and Debbie Deer Creek are to this day unidentified.
Introduction to the Human Skeleton

Typically the human skeleton consists of 206 bones, however human variation can produce less or more. They are classified as long (arm and leg bones), short (carpals and tarsals), flat (cranial vault, ribs, sternum and scapula), irregular (vertebrae, interior cranial bones) or sesamoid (patella). These bones are further categorized according to location within the skeleton, either cranial or postcranial.

Twenty-nine bones make up the skull, which according to Tim White "is the entire bony framework of the head, including the lower jaw" (White, 2000:53). Unpaired cranial bones include the frontal and occipital bones, sphenoid, ethmoid, vomer, and the mandible. Paired cranial bones are the parietals, temporals, maxillae, nasals, zygomatics, lacrimals, palatines, and nasal conchae. Ear ossicles, or “three pairs of tiny bones associated with hearing” (White, 2000: 54) also exist- the malleus, stapes and incus. The hyoid is an irregular located in the throat area and is “often included in discussions of the skull because it derives embryologically from the second and third branchial arches and thus belongs to the cartilaginous branchial arch skeleton” (Schwartz, 1995: 28).

The cranium can consist of a few extra bones, thanks to human variation. In some skeletal cases, extra bones are found sandwiched in between the flat bones of the cranium. Wormian bones are these small ossicles within cranial suture lines. “Inca” bones are large and triangular in shape and can be found in the posterior portion of the crania (White, 2000). A metopic suture is another indication of an extra cranial bone. If the frontal suture fails to close in early childhood, a metopic suture will be visible along the sagittal plane of the frontal bone.

Postcranial bones consist of those located below cranium, they are further subdivided into the axial and appendicular skeleton. The axial skeleton consists of paired and unpaired bones of the trunk, including the hyoid, sternum, cervical (neck),
thoracic (chest) and lumbar (lower) vertebrae, 12 pairs of ribs and the pelvic girdle (paired coxal bones, sacrum and coccyx, if present). Usually, there are 7 cervical, 12 thoracic and 5 lumbar vertebrae, however some humans have exhibited four or six lumbar, six sacral or 13 thoracic vertebrae (Skelton, 2001). Total number of ribs can vary, “there may be eleven or thirteen ribs on a side, with supernumerary ribs in either the cervical or lumbar segment” (Black and Schever, 1997, in White, 2000:161).

The appendicular skeleton is composed of paired bones of the shoulder and pelvic girdle as well as those of the arms and legs. Bones that compose the appendicular skeleton are as follows; left and right clavicles, scapulae, humeri, radii, ulnae, carpals, metacarpals and hand phalanges; the lower limbs consist of femora, patellae, tibiae, fibulae, tarsals, metatarsals and foot phalanges. Extra sesamoid bones can exist near the carpal or tarsal bones. Sesamoid bones are small more or less rounded masses embedded in certain tendons and usually related to joint surfaces (Internet source, http://www.bartleby.com/107/67.html). As stated above, variation can provide either more or less (or none) for each individual.

Each bone has unique features that allow it to be recognized and therefore differentiated from others. These features can either project outward (processes) or recess into the portion of bone. Some examples of processes are condyles, crests, facets, heads, spines and tubercles. Canals, grooves, fossa, foramina and sinuses are examples of characteristic bone depressions (Skelton, 2001). Knowledge of these distinctive landmarks is essential in identification, especially if the case involves fragmentary remains. Some forensic recoveries even contain non-human skeletal material that may or may not be related to the case. The ability to differentiate between human and faunal bones allows the investigator to identify a bone fragment based on one tiny feature.
In any forensic case, it is advisable to recover as many pieces of evidence as possible. Soft bodily tissues such as flesh and internal organs deteriorate rapidly in most depositional environments. Bones and teeth, however, "are resistant to many kinds of decay, they often form the most lasting record of an individual's existence" (White, 2000: 2). Each skeletal element has the potential to aid in solving questions about the circumstances of death. "It is possible to estimate an individual's age, sex and stature from the bones and teeth" (White, 2000: 2). Examination of teeth and bones can also assist in revealing the victim's possible ancestry as well as indicate pathologies and trauma endured in life that are unique to that person. In an ideal situation, a complete skeleton is recovered, however, this rarely happens. Time since death, depositional environment and the ability of the person or people recovering the bones all play a part in retrieval of skeletal remains and other evidence recovered. This is why it is crucial that the recovery team involved in the case is familiar with data recovery and evidence protection. In the case of Christy Crystal Creek, authorities visited the scene where she was found at least three times in order to retrieve as much evidence as possible pertaining to the case.

Christy Crystal Creek is a partially complete forensic case. Although more than half of the skeletal remains were recovered, most of the missing bones were from the right side of the body. Many of the bones exhibited postmortem damage, either "coffin wear" or carnivore scavenging. These traumas as well as pathologies are addressed in detail in the "Pathology and Trauma" section, page 62.

Skeletal inventory as well as succeeding sections on sex, age and race/ancestry will initiate with the cranium and continue posteriorly down the body. Although determiners of sex, age and race/ancestry may not always be the most reliable on the cranium, the author thought it logical to start at the top and head downwards.
Skeletal Inventory: Cranial Bones

Bones of the skull included with the case will be discussed first. The frontal bone is partially complete; a 12.3mm x 13mm circular defect is located 47.9mm superior to the supraorbital notch of the right orbit. Radiating fractures branch out from the circular defect, and concentric fractures are also evident as a result of the traumatic impact. A 42mm fracture runs posteriorly at the lower right side of the defect to the coronal suture. A 22.3mm fracture line runs from the superior border of the circular defect. A fracture line 78.3mm in length runs medio-posteriorly from the inferior portion of the defect to where the sphenoid meets the coronal suture. Finally, 23mm medially from the onset of the former fracture, a 64.5mm fracture line runs posteriorly towards the coronal suture.

The occipital bone is partially complete. A circular defect (see Pathology and Trauma, page 71) straddles the lambdoidal suture, therefore affecting both the occipital and right parietal bone. The semi-circular defect on the occipital bone measures 4.75mm x 2mm at the widest point. Other unpaired cranial bones present in this case are the sphenoid, with a 22mm fracture line moving anterior-posteriorly on the right lateral ptergoid plate, ethmoid, which is shattered in both the left and right orbits, and the vomer, which is shattered interiorly in the nasal cavity.

Paired bones of the cranium outnumber the unpaired bones. The left parietal is complete; the right parietal is partial due to the circular defect in the area. A 9.3mm x 7.6mm semi circular defect (see Pathology and Trauma, page 71) is present at the lambdoidal suture 28mm anterior to the squamosal suture. The left temporal bone is complete; the right temporal bone displays a 39.9mm fracture moving posteriorly from the external auditory meatus.

Small islands of bone called accessory bones are imbedded within the squamosal and lambdoidal sutures. The squamosal accessory bone is referred to as “epipteric”; it
is located at the pterion of the left temporal bone (Byers, 2002). It measures 11.5mm long by 5mm at the widest point. Two accessory bones lie along the lambdoid suture, the most common site for these ossicles (Byers, 2002). One lies at the junction of the sagittal and lambdoidal sutures, and is called a *lambdoid*, or *Wormian* bone (Byers, 2002). It is triangular in shape and measures 12.5mm long by 14.5mm at the base. Another smaller Wormian bone lies 8.5mm to the right of the lambdoid bone. This one measures 6mm long by 3.5 mm wide.

The left maxilla is partially complete; a 6.7mm fracture extends from the palatine suture into the palate. The right maxilla is complete. Both nasal bones are partial, having suffered to post mortem damage. At the longest points, both left and right nasal bones measure 21mm. Left and right zygomatic bones are complete. As for the left lacrimal, a 5.7mm fracture runs superiorinferiorly, 1.5mm behind the lacrimal groove. Only the lacrimal groove is present on the right lacrimal. The left palatine bone has a 3.5mm fracture running posteriorioanteriorly through the length of the bone, and extends into the palate of the right maxilla (mentioned above). The right palatine is complete. Left and right inferior nasal conchae as well as left and right ear ossicles (malleus, stapes and incus) were absent in the case. The hyoid is also not present with this case.

Christy Crystal Creek's dentition is somewhat complete. Some of the teeth were recovered after the skull had been removed from the scene and have since been glued into the appropriate alveolar sockets (Case File). Maxillary teeth present are the left first incisor (LI1), left canine (LC), left first premolar (LP1), left second premolar (LP2), left first molar (LM1), left second molar (LM2) and left third molar (LM3), right first incisor (RI1), right canine (RC), right first premolar (RP1), right second premolar (RP2), right first molar (RM1), right second molar (RM2), right third molar (RM3). Alveolar
sockets are the only remains of the left and right second incisors (LI2 and RI2, respectively), a sign of postmortem loss.

Mandibular teeth include the left first incisor (LI1), left second incisor (LI2), left canine (LC), left first premolar (LP1), left second premolar (LP2), left first molar (LM1), left second molar (LM2) and left third molar (LM3). The right first incisor (RI1) is fragmentary due to postmortem damage. Other right mandibular teeth include; right canine (RC), right first premolar (RP1), right first molar (RM1) and right second molar (RM2). Missing teeth from the mandible include the right second incisor (RI2), the right second premolar (RP2) and the right third molar (RM3). Alveolar sockets are present for RI2 and RP2, indicating post-mortem loss. Alveolar resorption is present in the area of RM3, providing evidence of tooth removal before the victim’s death and premortem bone remodeling.

Extensive dental work was performed on this individual. Despite the quantity of fillings and other distinctive dental procedures completed, eventual lack of oral hygiene has resulted in various caries and stains on the teeth. A comprehensive overview of dental pathologies is located in the “Pathology and Trauma” section, page 64.

**Skeletal Inventory: Postcranial Bones**

More bones were present from the left side than the right, as mentioned before. For a complete description of postmortem damage, see Pathology and Trauma, page 74. Bones of the axial skeleton present are as follows: a partially complete cervical vertebrae #1 (atlas), complete cervical vertebra #3, complete cervical vertebra #4, a partial cervical #6, missing the body and transverse process. Complete thoracic vertebrae present are T1, T2, T4, T5, T6, T8, T9, T11 and T12. Lumbar vertebrae include #1, minor post mortem wear, #2- with post mortem wear on the body and spinous and transverse processes, #4- complete and lumbar #5- complete. Vertebrae
not present with this case are C2 (axis), C5, C7, T3, T7, T10 and L3. All left ribs are present, although #’s 1, 2, 4 and 7-9 suffer from some post mortem damage. All right ribs are present with the remains with the exception of #1 and #12. Ribs #2-11 are complete. The right and left coxal bones are both present, and exhibit minor post mortem damage. A complete sacrum is present. Axial bones not present with the skeletal remains are the sternum and coccyx.

Most long bones of the appendicular skeleton were partially complete; the proximal and distal ends suffered the post mortem elements. Of the shoulder girdle, the left scapula is partially complete, with two semi-lunar fractures near the inferior angle. The right scapula is also partially complete, with all bony projections damaged by carnivores. Both left and right clavicles are present, but damaged by carnivores at the medial and lateral ends. Upper arm long bones present include; right humerus, missing the head at the greater tubercle, and complete left and right radii and ulnae. The left humerus is not present. As for the short bones (or carpals) in the arm, the left hamate, scaphoid, lunate, trapezium, trapezoid, and triquetral were present and complete. The left capitate and pisiform are absent as are all carpal bones on the right side. A few metacarpals and phalanges are present, including left and right 1st metacarpals (thumb), left 1st proximal phalanx, left 1st distal phalanx, right 2nd metacarpal, left and right 3rd metacarpals, left and right 3rd proximal phalanges, right 3rd medial phalanx, right 4th metacarpal, left 4th proximal phalanx and the left 5th proximal phalanx. All other lower hand long bones not mentioned above are not present.

As for the long and short bones of the legs, only the left femur, tibia and fibula are present. The left femur is partially complete with post mortem damage on the greater trochanter and distally at the epicondyles. Only the shafts of the left tibia and fibula are present, as carnivores have destroyed their proximal and distal ends. No other bones of the legs and feet are present in this case.
Non-Skeletal Remains

Also included with this case is a small vial of shavings recovered from the inside of the cranium labeled “content from inside skull, Crystal Creek 9-9-85” and signed by Sheriff Weatherman, as well as a brown paper bag containing a wad of brown/black wavy hair, presumably the victim’s.

Thus concludes the inventory of Christy Crystal Creek.
Estimation of Sex

Sex estimation is a primary element in the identification of skeletal remains. Determination of whether the subject is male or female factors out roughly 50% of the population sample. Lately there has been confusion regarding the terms “sex” and “gender”, and which word is appropriate for use in a forensic report. What is the difference between sex and gender? “In recent years the distinction between sex and gender has been at least partly obscured and needs explanation” (Skelton, 2001: 19).

In simple terms, sex refers to a person’s biological makeup- the presence or absence of a Y chromosome. Gender, on the other hand, is a socially derived term referring to how a person chooses to express him or herself in (or away from) society. Forensic anthropologists use the term “sex” rather than “gender” as a standard rule. In other words, a person’s skeletal remains will always reveal the true, biological identity.

Sexual dimorphism is the term used to describe size differences in males and females (White, 2000). Recognizing differences between the male and female skeleton aids the forensic anthropologist in identification. “Estimation of sex is based on the generalization that the male is more robust, rugged and muscle marked than the female” (Bass, 1995: 85). White elaborates on female skeletal traits, stating “in general, for all parts of the human skeleton, female elements are characterized by smaller size and lighter construction” (White, 2000:362). Of course, due to human variation the distinction may not be so clear in certain geographical locations. “Some populations are...composed of larger, heavier, more robust individuals of both sexes, and other populations are characterized by the opposite tendency (White, 2000: 363).

Many established methods exist for estimating the sex of the skeleton, ranging from visual morphological traits to mathematical formulas. The most reliable agents to work with in sex estimation are the pelvis and the skull, in that order (Bass, 1995). However, these bones may not be available in some forensic cases. Long bones of the post
cranium as well as teeth can also be measured for sexual dimorphism. This report contains a relatively complete skull and a complete pelvis. Based on growth stages and epiphsial closure of the skull and postcranium, the individual has reached adulthood (See Age, page 29).

**Sex Determination from Morphological Traits of the Skull**

At birth, all human skulls exhibit female traits. Male skulls start to change significantly at puberty, becoming more robust and muscular than their female counterpart. Because of this phenomenon, it is much more common for a male to exhibit female traits than a female to exhibit those of a male (Skelton, 2001). For example, a sunken nasal root, or “prominent glabellar region” (White, 2000:363) is a surefire male characteristic. Skelton places this feature as number one on his list of 12 traits of sex determination- “if the nasal root is sunken, then the skull is almost certainly male” (Skelton, 2001:20). With these 12 visual traits, he proposes a ‘3 to 1 rule’ which states, “it takes thee or more less reliable criteria to overrule a single more reliable criterion...we count each male trait as worth two female traits” (Skelton, 2001:20). In Christy Crystal Creek’s case, the 3 to 1 rule did not have to be applied; all morphological traits noted by the observer indicate female characteristics.

Visual assessment was used to compare Christy Crystal Creek’s characteristics with the following scoring system in White, 2000 (from Walker in Buikstra and Ubelaker (1994)). See figure 1 below.
Results are as follows: Nuchal crest- 2, Mastoid Process- 2, Supraorbital margin- 2, supra-orbital ridge/glabella- 2, mental eminence- 1.

No sunken nasal root exists on Christy’s skull. Frontal bossing, or “a high, unsloping frontal...characteristic of females” (Skelton, 2001: 20) is present. Brow ridges are not prominent, as in the male skeleton. Mastoid processes are small in proportion with the rest of the temporal area. Nuchal rugosity refers to the ruggedness of the nuchal area of the occipital bone. Christy’s nuchal area is smooth, and there is no crest present. Eye orbit shape appears to be more round than square, and the orbital rims are relatively sharp. The zygomatic arch is thin, and the muscle scars along the zygomatic bone are slight. Overall, the mandible appeared to be thinner, rounder and
more petite than a male’s. Prominent muscle scarring of the gonial region of the
mandible was not present, and the mandibular condyles were small and proportionate
with the rest of the bone.

This individual displays textbook petite female characteristics. As Dr. Michael
Charney stated in a forensic report of Christy Crystal Creek dated 28 October 1985,
“all skull features are female” (Charney, 1986, Case File). As stated above, no male
characteristics were observed using Skelton’s 3-to-1 rule or using White’s illustrations.

**Sex from discriminant function analysis**

Discriminant function analysis is a formula derived by Giles and Elliot (1963) for
the purpose of sex estimation from measurements of the skull. Skelton explains it best
by stating,

"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, 2001: 37)

**Discriminant functions formula:**

\[2.184(g-op) + 1.000(eu-eu) + 6.224(zy-zy) + 6.122(po-ms) = 1495.40\] 70%

Both spreading and sliding calipers were used to measure craniometric
points. For a complete index of craniometric points and measurements, please
see Appendix B, page 93.

Skelton goes on to explain the step-by-step process:

A. Take the measurements g-op, eu-eu, zy-zy, and po-ms. All measurements are in mm.
B. 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
C. Add (or subtract, as indicated) the products obtained in step 2. The total obtained is
called the discriminant score for that individual.
D. Compare the discriminant score to 1495.40. if the score is greater than 1495.40, then
   the skull is a make. 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.
E. The accuracy is 70%, so you expect this formula to give the correct result 70% of the
time (Skelton, 2001: 37)
Measurements and formula for Christy Crystal Creek is as follows:

\[
g_{-op} = 153\text{mm} \\
eu-eu = 121\text{mm} \\
zy-zy = 115\text{mm} \\
po-ms = 27.7\text{mm}
\]

\[
2.184(153) + 1.000(121) + 6.224(115) + 6.122(27.7) = [1495.40]
\]

\[
334.152 + 121 + 715.76 + 169.579 = 1340.491
\]

Discriminant function analysis reveals a score of 1340.491, placing this case well in the female range with 70% accuracy.

**Sex Determination from the Pelvis**

The pelvis, composed of the right and left coxal bone and sacrum, is the most reliable element in sex determination of the adult skeleton (Bass 1995; Burns 1999). At birth, human pelvic bones exhibit male-like traits and remain as such until puberty. After the skeleton has reached adulthood, differences in the male and female pelvic girdle are easily distinguishable in most cases. Unlike morphological characteristics of the skull, significant changes occur in the female pelvis rather than the male’s. “At puberty, male pelves change only slightly, whereas female pelves change significantly to prepare them for childbearing” (Skelton, 2001, 83). The female pubic area of the coxal bone appears to have been stretched toward the midline, the subpubic angle is broad and the pubic part of the ischiopubic ramus develops a slight ventral arc. Wider female hips and a larger pelvic inlet are the result of female puberty (Burns, 1999). For sex determination of the pelvis, Skelton (2001) uses another 3-to-1 rule. Priority in this circumstance is given to female traits, as “there are many more females with male pelvic traits than there are males with female pelvic traits” (Skelton, 2001: 83). Female characteristics of the coxal bone should outweigh male traits 3 to 1.
Table 1: Sex Determination From Morphological Traits of the Coxal Bones

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis as a whole</td>
<td>Massive, rugged, marked muscle sites</td>
<td>Gracile, less rugged and smoother</td>
</tr>
<tr>
<td>Sub-pubic angle</td>
<td>Narrow and v-shaped</td>
<td>Wide and U-shaped</td>
</tr>
<tr>
<td>Ischiopubic ramus ridge</td>
<td>Ridge absent</td>
<td>Ridge present</td>
</tr>
<tr>
<td>Pubic bone</td>
<td>Short and rounded</td>
<td>Long and square</td>
</tr>
<tr>
<td>Greater sciatic notch</td>
<td>Smaller, close, narrow</td>
<td>Larger, wider, shallow</td>
</tr>
<tr>
<td>Auricular surface</td>
<td>Not raised</td>
<td>Raised</td>
</tr>
<tr>
<td>Preauricular sulcus presence and shape</td>
<td>Absent or thin grooves</td>
<td>Large, circular depressions</td>
</tr>
<tr>
<td>Ilium shape</td>
<td>High, vertical</td>
<td>Laterally divergent</td>
</tr>
<tr>
<td>Pelvic inlet shape</td>
<td>Heart shaped</td>
<td>Round or ovoid</td>
</tr>
<tr>
<td>Acetabulum size and orientation</td>
<td>Relatively large, directed laterally</td>
<td>Relatively small, directed anterio-laterally</td>
</tr>
<tr>
<td>Obturator foramen</td>
<td>Large, ovoid in shape</td>
<td>Small, triangular in shape</td>
</tr>
<tr>
<td>Sacrum shape</td>
<td>Long, narrow</td>
<td>Short, broad</td>
</tr>
<tr>
<td>Number of segments</td>
<td>5+</td>
<td>5</td>
</tr>
</tbody>
</table>


Morphological traits exhibited of the coxal bones and sacrum in this case are all those characteristic of the female sex. Christy Crystal Creek’s pelvis as a whole is gracile with little muscle scarring exhibited on the bones. When facing the pelvic girdle from the superior viewpoint, it appears more round than heart shaped. The pubic bone is long and square, sub-pubic angle is greater than 90°. The greater sciatic notch is wide and large, the auricular surface is raised and a deep preauricular sulcus is present. Iliac blades flare laterally and the acetabulum is small and facing anterio-laterally. As for the sacrum, it is short and broad and 1/3 body and 2/3 ala. It is also petite and broad, unlike the male sacrum. A distinct curve exists on the inferior end of the sacrum, but is more likely to be a result of a healed trauma (See pathology and Trauma, page 70).
Figure 2: Female Pelvis

a- Ventral arc; b, subpubic concavity (dorsal surface); c- narrow medial aspect of the ischiopubic ramus.
From Bass (1995: Figure 3-82, Page 211).

Figure 3: Male Pelvis

a- left ventral view (no ventral arc); b- broad medial aspect of the ischiopubic ramus. From Bass (1995: Figure 3-83, Page 211).
Phenice (1969) proposed a new visual method for sex estimation, that is “the most accurate method yet known for determining sex of the individual from the skeleton” (White, 2000: 367). Three areas of the female pubic area have the ability to distinguish sex in over 95% of cases. These areas are known as the ventral arc, subpubic concavity and medial aspect of the ischiopubic ramus (Bass, 1995). Male coxal bones do not exhibit a ventral arc, rarely displays a subpubic concavity and the ischiopubic ramus when observed medially is much broader than the ridgeline of the female ramus (Bass, 1995). “When one or two of these three criteria is ambiguous, there almost always will be one that is definitely male or female” (Bass, 1995: 210). Observation of these areas of the coxal bones revealed a definite ventral arc, subpubic concavity and a sharp, ridge like medial aspect of the ischiopubic ramus.

Pelvic bones of Christy Crystal Creek exhibit all typical female traits.

Sex estimation of the coxal bones by metric analysis is another common method used in forensic cases. The ischium-pubis index is a measurement taken from lengths of the pubis and ischium using sliding calipers.

\[
\text{Ischium-pubis index} = \frac{\text{pubis length}}{\text{ischium length}} \times 100 = \frac{(69.6)}{(74.4)} = 93.55 \text{ left os coxae}
\]

\[
= \frac{\text{pubis length}}{\text{ischium length}} \times 100 = \frac{(70.0)}{(74.5)} = 93.96 \text{ right os coxae}
\]

According to Skelton’s (2001) chart taken from Bass (1995), the typical female index for a “white” (See Ancestry, page 47) is >95. Both bones measure below the core index number of 95.

**Sex Estimation from Long/Irregular Bones**

Although the skull and pelvis are the best indicators of sex in the human skeleton, they are not present in every forensic case. If neither is present, long bones of the arms and legs can be measured for sexual dimorphism, and an estimation of sex can be
made. The long bones examined for sex analysis in this case were the two partial clavicles, two scapulae (one partial), right humerus and left femur. The sternum was not recovered with the remains.

**Sex From the Clavicle Length**

Both left and right clavicles were missing the sternal and acromial ends due to post mortem damage. However, the length of the incomplete elements was measured using sliding calipers and applied to Theime’s formula.

**Table 2: Clavicle Length and Sex**

<table>
<thead>
<tr>
<th>Measurement (mm)</th>
<th>Sex</th>
<th>N</th>
<th>Mean mm</th>
<th>Standard Deviation</th>
<th>Error of Mean</th>
<th>Critical Ratio (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clavicle length</td>
<td>M</td>
<td>98</td>
<td>158.24</td>
<td>10.06</td>
<td>1.158</td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>100</td>
<td>140.28</td>
<td>7.99</td>
<td>0.800</td>
<td></td>
</tr>
</tbody>
</table>


The left partial clavicle measures 129.8mm and the right partial clavicle measures 122.7mm. Given estimation for length of missing sternal and vertebral ends, measurement of the complete bones should fall comfortably within the female mean length of 140.28mm.

**Sex from Analysis of the Scapula**

Some morphological differences in the male and female scapulae exist. The male scapula is “absolutely the larger” whereas the female scapula is “broader and shorter than the male” (Hrdliča, 1942: 383). The glenoid fossa tends to be deeper in females and is at about a 90° angle from the axis of the scapula. Males tend to have a shallower glenoid cavity, which juts superiorly (Skelton, 2001). When compared to a male scapula, Christy Crystal Creek’s glenoid cavity appears to sit at a right angle to the scapular axis, and the entire bone appears broader than the male’s.

Bass suggests Dwight’s (1994b) glenoid cavity length and maximum scapular length research in *Human Osteology: A Laboratory and Field Manual* (5th ed, 1995).
Glenoid cavity length was determined by measuring the superior-inferior length.

Maximum scapular length was measured at the superioinferior aspect of the scapula.

Both measurements were taken with slidding calipers.

### Table 3: Sex from Scapula Measurements

<table>
<thead>
<tr>
<th>Measurement (mm)</th>
<th>Females</th>
<th>Sex?</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenoid cavity length</td>
<td>&lt;34mm</td>
<td>34-36mm</td>
<td>&gt;37mm</td>
</tr>
<tr>
<td>Max. scapular length</td>
<td>&lt;140</td>
<td>140-159</td>
<td>&gt;159</td>
</tr>
</tbody>
</table>

From Bass (1995: 129) after Dwight (1894b)

Glenoid cavity length of the left scapula is 30.7mm and the right measures in at 29.8mm. Both measurements, less than 34mm, fall into the female category.

Maximum length of the left scapula measures 141.9mm, which places the result in between the female and indeterminate indices. The right scapula has suffered post mortem damage to the inferior angle and therefore was not used in maximum scapular length measurements.

**Sex estimation from Analysis of the Humerus**

Although Bass believes the humerus to be a poor indicator of sex in skeletal remains (Bass, 1995), forensic anthropologists’ research has proved viable results in sex estimation. Typically the male humerus is longer and more massive than the female’s, as in all other bones. A septal aperture is more common on the female distal humerus (Hrdlička 1932; Trotter 1934). Hrdlička defines this feature as “a foramen extending through into the olecranon fossa” (Hrdlička, 1932), located at the distal end above the trochlea. Septal apertures can vary in size from small to large. A pinhole-sized aperture is present on the right humerus, and the area surrounding the pinhole is thin and transparent when held up to the light. A left humerus is not included with this case.

Size measurements of the proximal rather than distal humerus appear to be the best in sex determination (France, 1983). Dwight (1905) and Stewart (1979) both reported
on the diameters of humeral heads and their relation to sex. Vertical diameter is “the direct distance between the most superior and inferior points on the border of the articular surface” (Moore-Jansen, Ousley and Jantz, 1994: 63). Bass describes the method for obtaining the transverse diameter of the humeral head; “using a sliding caliper take measurements at right angles to the shaft” (Bass, 1995: 158). Humerus length was measured using an osteometric board.

### Table 4: Sex from Humerus Measurements

<table>
<thead>
<tr>
<th></th>
<th>Vertical</th>
<th>Transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>48.76</td>
<td>44.66</td>
</tr>
<tr>
<td>Female</td>
<td>42.67</td>
<td>36.98</td>
</tr>
<tr>
<td>Difference</td>
<td>6.09</td>
<td>5.68</td>
</tr>
</tbody>
</table>


Post mortem damage has occurred on the head of the humerus posterior to the greater tubercle. Because of this an approximate measurement of 32mm was obtained for the vertical diameter. The transverse diameter is complete and measures at 36.5mm. Both measurements place the results in the female category.

Stewart (1979) studied humeral measurements of 100 individuals from the Terry Collection and formulated these results (Bass, 1995):

### Table 5: Sex from the Humeral Head

<table>
<thead>
<tr>
<th>Vertical diameter of humeral head</th>
<th>Females</th>
<th>Sex Indeterminate</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;43mm</td>
<td></td>
<td>44-46mm</td>
<td>&gt;47mm</td>
</tr>
</tbody>
</table>

From Bass (1995, 156) after Stewart

Once again, the approximate measurement of 32mm for the vertical diameter of the right humeral head falls into the female group.

**Sex from the femur**

“The femur… has contributed to a great deal to the literature on sex estimation” (Bass, 1995: 229). Pearson (1917-1919) was the first to study femoral measurements
to estimate sex (Bass, 1995). These results are still widely used, however, Pearson used 17th-century bones from London for his analysis. Modern populations, both female and male, tend to be larger (Bass, 1995).

DiBennardo and Taylor (1979) proposed a new method of assessing sex of the femur, expanding on Black’s (1978) studies of femoral mid-shaft circumference to determine sex. Whereas Black used prehistoric peoples in his analysis, DiBennardo and Taylor studied modern North American populations. They measured maximum femoral length as well as three mid-shaft measurements; circumference, anterior-posterior diameter and transverse diameter. Results proved that mid-shaft circumference analysis to determine sex of the femur is as accurate as any other (DiBennardo and Taylor, 1979: 635). Femoral length was measured with the osteometric board, and circumference was measured at midshaft using a tape.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>423.0</td>
<td>450.0</td>
</tr>
<tr>
<td>Circumference</td>
<td>82.0</td>
<td>90.0</td>
</tr>
<tr>
<td>Anterior-posterior diameter</td>
<td>27.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Transverse diameter</td>
<td>25.0</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Table 6: Sex from Femoral Length and Midshaft Measurements

Stewart (1979) also studied femoral head measurements of the Terry collection. He proposes the following:

<table>
<thead>
<tr>
<th>Female</th>
<th>Female?</th>
<th>Indeterminate</th>
<th>Male?</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.5mm</td>
<td>42.5-43.5mm</td>
<td>43.5-46.5mm</td>
<td>46.5-47.5mm</td>
<td>47.5mm</td>
</tr>
</tbody>
</table>

Table 7: Sex from Femoral Head Measurement

From Burns (1999: 100) after Stewart (1999)
The greatest diameter of the femoral head is 39.5mm, a typical female measurement.

Sex from the tibia

Length, breadth and mid-shaft circumference measurements have proved successful in determining sex from the tibia (Bass, 1995). İşcan and Miller-Shaivitz (1984a, 1984b) proposed mid shaft circumference measurements to be the best in sex determination of the tibia. In this case, this was the only measurement able to be tested, as only the left tibial shaft is present. İşcan and Miller-Shaivitz determined the female mean circumference at the nutrient foramen of the tibia is 84.34mm. Circumference of the left tibia at the nutrient foramen measures 76mm, well below the female mean.

Conclusions on Sex

Christy Crystal Creek exhibits traits most consistent with the female sex. Every method used to determine sex revealed female results. When compared to a male skeleton, the sexual dimorphism is readily apparent. The lack of typical male traits; a sunken nasal root, prominent brow ridges and prominent muscle scarring has assisted in sex determination. Discriminant functions results from metric analysis of the cranium placed this individual in the female category. The pelvis is typical of the female sex with a rounded birth canal, ventral arc, sub-pubic concavity and sharp medial aspect of the pubis, and the Ischium-pubis index (Skelton, 2001) places the results in the female range. Overall gracility of the long bones as well as results of metric analysis proves this individual is female. Also, a septal aperture is present on the right humerus.
Determination of Age

Age of the skeleton is an important factor to determine in any forensic case, as it narrows down the population, therefore assisting in the process of identification. It must be mentioned that ‘age’ refers to how old the person was at the time of death, not the length of time the individual has been dead. Taphonomy, or “the study of processes that affect skeletal remains between death and curation” (White, 2000:530), will be discussed in a later section.

As the skeleton ages, epiphysial centers grow and eventually fuse together to form a complete bone. In infancy, childhood and youth, our bones are constantly reproducing and remodeling and gradually slow down as age increases, leading to bone degeneration. The more bones of a skeleton available for analysis, the better estimation one can make of age at time of death. In Todd’s (1920) work on age related to pubic symphysis changes, he “took great pains to point out that the most accurate estimate of age can only be made after examination of the entire skeleton” (White, 2000: 361).

Age assessment can be made from skeletal observations and metric analysis. This is known as multifactoral analysis (White, 2000). Epiphyseal fusion, cranial suture observations, dental eruption and attrition, visual traits of the pelvis and long bone length are the most widely accepted methods used in age determination. Some bones, however, are better age estimators than others.

“A skeleton is considered to be an adult once all of the epiphyses have fused” (Steadman, 2003:10). An epiphysis is “the cap at the end of a long bone that develops from a secondary ossification center” (White, 2000:525). Steadman explains, “the last epiphysis to fuse is the medial clavicle, which occurs between approximately seventeen and thirty years of age” (Steadman, 2003:10). Due to post mortem damage, neither the medial nor lateral clavicles were used for analysis.
According to White (2000), Ubelaker (1999) and Buikstra and Ubelaker (1994), the next epiphysis to fuse is the iliac crest of the coxal bone, at an average age between 17-24. In this case, a thin epiphysial line is visible along the ilium of both os coxae, but is well advanced into epiphyseal fusion. Suchey (1979, in Bass, 1995:2207) considers this stage of union as “partial” in her research and the age estimation at this stage is between 14-23 years of age. All other epiphyses present with this case have fused, proving this individual has probably reached puberty.

**Age from Visual Assessment of Cranial Sutures**

Cranial sutures are locations of fusion between the flat bones of the skull. There are at least three different methods proposed for observing cranial suture sites; endocranial, ectocranial and segmental. Ectocranial sutures are located on the outside of the skull; endocranial sutures are located on the inside of the skull, and are easily seen on fragmentary crania or with a flashlight through the foramen magnum.

Segments of the ecto- and endocranial sutures can also be observed for age. There are three stages of suture closure. A suture is *open* when it is visible as a crack over the entire length of the skull, *commenced* when the suture has filled in with bone in at least one place, but still open in other spots, and *terminated* when the suture has filled completely with bone and is no longer visible anywhere along its length (Skelton, 2001).

Cranial suture closure was the most accurate aging method until the onset of studies of the pubic symphysis aging methods in the 1950’s (White, 2000). Although now it is not as esteemed as other methods, it is still helpful in age determination. Todd and Lyon (1924) proposed the following results for age by cranial suture closure.
Table 8: Ectocranial Suture Closure, Todd and Lyon Method

<table>
<thead>
<tr>
<th>Ectocranial Suture</th>
<th>Commencement</th>
<th>Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Coronal</td>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>Lambdoidal</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>Masto-occipital</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Spheno-temporal</td>
<td>36</td>
<td>Never</td>
</tr>
</tbody>
</table>


All ectocranial sutures on the skull of Christy Crystal Creek are open, therefore expressing an age of less than twenty (>20) years of age at the time of death of this individual based on the Todd and Lyon ectocranial suture method.

Todd and Lyon (1924) also studied endocranial suture sites on the human cranium. To observe these sites, a flashlight was shined through the foramen magnum.

Table 9: Endocranial Suture Closure, Todd and Lyon Method

<table>
<thead>
<tr>
<th>Endocranial Suture</th>
<th>Commencement</th>
<th>Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>Coronal</td>
<td>24</td>
<td>41</td>
</tr>
<tr>
<td>Lambdoidal</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>Masto-occipital</td>
<td>30</td>
<td>81</td>
</tr>
<tr>
<td>Spheno-temporal</td>
<td>30</td>
<td>67</td>
</tr>
</tbody>
</table>


All endocranial sutures were scored as open to the observer, with the exception of the coronal suture. Partial commencement has occurred on the right side of the endocranial coronal suture. Todd and Lyon’s method indicates commencement for the endocranial suture begins at age 24. Based on other methods, this age appears to be too old for Christy Crystal Creek.

Baker (1984) proposed a method for cranial suture observations by combining ectocranial and endocranial suture observations into one chart and consequently updating previous studies. This new method has included data for open sutures and allowed for a wider range of variation than previous studies (Skelton, 2001).
Table 10: Baker Endo/Ectocranial Suture Method (1984)

<table>
<thead>
<tr>
<th>Suture</th>
<th>Open</th>
<th>Commenced</th>
<th>Terminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal endocranial</td>
<td>&lt;36</td>
<td>19-79</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Sagittal ectocranial</td>
<td>&lt;88</td>
<td>19-83</td>
<td>&gt;33</td>
</tr>
<tr>
<td>Lambdoid endocranial</td>
<td>&lt;71</td>
<td>19-74</td>
<td>&gt;22</td>
</tr>
<tr>
<td>Lambdoid ectocranial</td>
<td>&lt;85</td>
<td>24-84</td>
<td>&gt;22</td>
</tr>
<tr>
<td>Coronal endocranial</td>
<td>&lt;71</td>
<td>22-79</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Coronal ectocranial</td>
<td>&lt;85</td>
<td>24-89</td>
<td>&gt;35</td>
</tr>
</tbody>
</table>

Adapted from Skelton (2001).

Again, all ecto- and endocranial sutures listed in the Baker method were open except for the coronal endocranial suture. This suture site is partially commenced along the right side, exhibiting a wide age range of 22-79. Taking into account that the coronal endocranial suture does not terminate before the age of 25, we can narrow the age range down to 22-25.

Buikstra and Ubelaker (1994) adapted Walker's method of suture fusion segments on the skull. Scoring methods range from 0 (open) to 3 (completely obliterated suture), and are measured in 1cm increments (White, 2000).

Table 11: Cranial Suture Fusion Sites

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Midlambdoidal</td>
<td>Midpoint of left lambdoidal suture</td>
</tr>
<tr>
<td>2) Lambda</td>
<td>Intersection of Sagittal and lambdoidal</td>
</tr>
<tr>
<td>3) Obelion</td>
<td>At obelion</td>
</tr>
<tr>
<td>4) Anterior sagittal</td>
<td>1/3 the distance from bregma to the lambda</td>
</tr>
<tr>
<td>5) Bregma</td>
<td>At bregma</td>
</tr>
<tr>
<td>6) Midcoronal</td>
<td>Midpoint of left coronal suture</td>
</tr>
<tr>
<td>7) Pterion</td>
<td>Usually where parietosphenoid suture meets the frontal</td>
</tr>
<tr>
<td>8) Sphenofrontal</td>
<td>Midpoint of left sphenofrontal suture</td>
</tr>
<tr>
<td>9) Inferior sphenofrontal</td>
<td>Intersection between left sphenotemporal suture and line between articular tubercles of temporomandibular joint</td>
</tr>
<tr>
<td>10) Superior sphenotemporal</td>
<td>On left sphenotemporal suture 2 cm below junction with parietal bone</td>
</tr>
</tbody>
</table>

From White and Folkens (2000:348, Figure 17.4).
Add scores 1-7 to get this score

Table 12: Cranial Fusion Sites #1

<table>
<thead>
<tr>
<th>Composite score</th>
<th>Mean Age</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1-2</td>
<td>30.5</td>
<td>9.6</td>
</tr>
<tr>
<td>3-6</td>
<td>34.7</td>
<td>7.8</td>
</tr>
<tr>
<td>7-11</td>
<td>39.4</td>
<td>9.1</td>
</tr>
<tr>
<td>12-15</td>
<td>45.2</td>
<td>12.6</td>
</tr>
<tr>
<td>16-18</td>
<td>48.8</td>
<td>10.5</td>
</tr>
<tr>
<td>19-20</td>
<td>51.5</td>
<td>12.6</td>
</tr>
<tr>
<td>21</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Add scores 6-10 to get this score

Table 13: Cranial Fusion Sites #2

<table>
<thead>
<tr>
<th>Composite score</th>
<th>Mean Age</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>32.0</td>
<td>8.3</td>
</tr>
<tr>
<td>2</td>
<td>36.2</td>
<td>6.2</td>
</tr>
<tr>
<td>3-5</td>
<td>41.1</td>
<td>10.0</td>
</tr>
<tr>
<td>6</td>
<td>43.4</td>
<td>10.7</td>
</tr>
<tr>
<td>7-8</td>
<td>45.5</td>
<td>8.9</td>
</tr>
<tr>
<td>9-10</td>
<td>51.9</td>
<td>12.5</td>
</tr>
<tr>
<td>11-14</td>
<td>56.2</td>
<td>8.5</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

From White and Folkens (2000: 348, Figure 17.4), after Meindl and Love (1985).

For the first table, all seven cranial suture locations were observed as open (score=0); therefore the mean age is undeterminable. However, in the second table the sphenofrontal suture location, or “midpoint of left sphenofrontal suture” (White, 2000:348) has a score of 1, minimal closure. When this is plugged into the second chart, the mean age of scores at 32 years.

Dentition as an Estimator of Age

It is always helpful when teeth are included in a forensic case, as they have much to reveal. Teeth are constructed of dense and hard inorganic material, resist decay in the ground and in many cases outlast bone (Bass, 1995). Formation of deciduous (or baby)
teeth occurs early in life, and “these teeth are systematically shed and replaced by their permanent (secondary) counterparts throughout childhood and adolescence” (White, 2000:111). In most forensic cases, the presence or absence of deciduous teeth can quickly determine whether or not the individual has reached adulthood. Also, permanent molars erupt at certain mean ages; the first molar at 6 years, the second molar at about 12 years and the third molar or “wisdom” tooth at about 18 years. This allows the observer a built-in age calibration (Skelton, 2001). In the case of Christy Crystal Creek, the third molars have erupted and even show signs of minor attrition. Based on this method, an age of at least 18 years is estimated.

Brothwell (1965) studied dental attrition in the molars of primeval British skulls and produced age classifications based on his observations (Bass, 1995). All molars were analyzed with the exception of the mandibular right third right molar (RM₃), which had been extracted premortem. The mandibular left third molar (LM₃) is fragmentary, however an assessment was made of the partial occlusal surface.

This individual fits into Brothwell’s “about 17-25” (Brothwell 1965, in Bass, 1995) category. Dentin exposure is present in small amounts on all first and second molars, and only enamel polishing is evident on the third molars.

Lovejoy (1985) studied dental attrition of the prehistoric Libben population of Ohio. His results concluded that at a populational level, dental wear occurs regularly in form and rate of attrition (White, 2000). He also noted “the assessment of a single individual in a forensic setting based on dental wear allows only a gross approximation of age,” (White, 2000: 344) and attrition analysis can be more precise with a group of individuals living together in a common area. When compared to the Lovejoy’s attrition phase table (White, 2000: 346), both maxillary and mandibular tooth wear were consistent with those of Bz with an age between 16 and 20 years.
Skelton (2001) explains another method of dental wear analysis by scoring the amount of dental attrition and interpreting the results in terms of age. Individual teeth of this case were compared and scored based on Skelton's "Dental Attrition Age Standards for Montanans" chart (adapted and reworked from Tromly, 1996) in his Fall 2001 Osteology Manual. The first upper (maxillary) incisors (LI and RI) score a 3, as dentine exposure is a line of discreet thickness. The second incisors are absent and unavailable for analysis. As for the lower (mandibular) incisors, only those on the left side are included with the case. The first incisor (LI) scores a 3 with a discreet dentine line, and the second (LII) incisor scores a 2 with a hairline of dentine exposure.

Canine dental wear is as follows- LC- 2 (pinpoint of dentine exposure), RC- 3 (shape of dentine is not a point), LC- 2 (pinpoint of dentine exposure) and RC- 1 (some wear but no dentine exposure).

Premolars present for analysis are LP, RP, LP, LP and RP. LP contains a filling on the occlusal surface and was not used for analysis, and the RP is absent from the case. All premolars observed score a 1 (some wear, but no dentine exposure) with the exception of RP, which scores a 2 (pinpoint of dentine exposure on one cusp).

All molars except the lower right third (RM) were available. LM scores 3 (dentine exposure on two cusps, one of which is a pinpoint), LM scores a 3, LM scores a 1 (some wear, but no dentine exposure), RM scores a 4 (dentine exposure on three cusps, one of which is a pinpoint), RM scores a 3 and RM scores a 1. The mandibular molars are as follows: LM- 3, LM- 3, LM- 1, RM- 3 and RM- 2 (pinpoint dentine exposure on one cusp). Using this method to determine age, the wide age range is 18-47 and a narrow age range is 18-21.
Age from the Sternal End of the 4th Rib

Ișcan et al. (1984, 1985) have studied the ossification patterns of the 4th sternal rib ends to determine age in male and female skeletons (Bass, 1995). "The structure, position and function of the rib make it a particularly good site from which to observe the effects of age" (Ișcan and Loth, 1989:27). He also indicates that because of the rib’s location on the body it is "not directly subjected to the effects of weight bearing, locomotion, pregnancy and parturition, as are the pubic symphysis, auricular surface of the ilium and long bones...reflecting age rather than the effects of ‘function and stress’" (Ișcan and Loth, 1989: 28). Although both left and right 4th ribs were present with the remains, the left rib’s sternal has suffered postmortem damage. Only the right rib was used for analysis. Upon observation, the rib displayed features similar to those of phase 2. The rounded, wavy rim is first beginning to show some scallops forming at the edge, and when viewed from the side, a V-shaped pit is seen. The inner pit of the sternal end is deepening due to the thick, smooth walls (Ișcan et al., 1985). Age estimation from analysis of the 4th right sternal rib end is between 16-20 years.

Age from Vertebrae Analysis

In her Forensic Anthropology Training Manual, Burns (1999) discusses age changes expressed by vertebral bodies. Assessment of the fusion of the epiphyseal rings can indicate progression in age. Visual analysis of the vertebral bodies in this case fell into the “Late Teenager (16-20 Years)” range- “The epiphyseal ring is in the process of fusing. Note the line of fusion on the lateral view and the slight chipping of the ring on the superior view” (Burns, 1999: 65). Although the epiphyseal ring was still noticeable, they have completely fused to their respective vertebral bodies.
Age Estimation from the Pubic Symphysis

“One of the most widely used indicators of age at death has been metamorphosis of the symphyseal surface of the pubis” (White, 2000: 349). Not only is it the most popular method in ageing, it is also one of the best (Bass, 1995). Unlike the one-time epiphyseal fusion of the limb bones, changes continue to occur in the pubic area throughout adulthood and into old age. In young adults, the pubic symphyseal face “has a rugged surface traversed by horizontal ridges and intervening grooves” (White, 2000: 349), and flattens out as the individual ages, eventually forming a rim around the area. Todd (1920) analyzed the pubic region of 306 males at a known age of death, and paid special attention to the ventral border (rampart), dorsal rampart, superior extremity and the inferior extremity (White, 2000). Todd created a foundation of knowledge in this area with his ten phases of pubic symphysis age, and throughout the years many anthropologists have expanded to include the female sex as well as various ethnic populations. Katz and Suchey (1986) expanded on male and female pubic symphyses ageing studies, and simplified the 10 stages down to six. They even collaborated with France casting to construct casts of the different age categories. Both left and right pubic symphyses were analyzed, and France casts were used as a hands-on age comparison. Results from both methods are below.

The surfaces still have prominent billowing horizontal ridges, however these ridges are becoming filled in with bone near the dorsal limit (on the right side especially), hindering the extremities of these horizontal ridges (Krogman, 1962 in Bass, 1995). This infill of bone on the dorsal side is referred to as a dorsal plateau. Ossical nodules, or tiny bone deposits, are visible on the superior border of both symphyses. Slight ventral beveling is evident on either symphysis. All of these traits fall in to the following categories: Todd- Second postadolescent (20-21 years), Katz and Suchey...
Phase 2 (19-35 years) and Brooks (1955) - Stage II (19.5-21.5). A wide age range from the pubic symphysis is 19-35 and the narrow age range is 19½ - 20.

**Age Estimation from the Auricular Surface of the Ilium**

The auricular surface is the area of articulation between the coxal bones and the sacrum. Signs of aging can be observed in this area, just as in the pubic symphysis. This method is useful in forensic cases, “namely, that this part of the os coxae is more likely to be preserved” (White, 2000: 355), and changes on the auricular surface continue well into old age (White, 2000), unlike the pubic symphysis. Lovejoy et al. (1985) devised a method of ageing the auricular surface of the ilium and categorized it into 8 stages. Steele and Bramblett (1988) provide a better explanation of Lovejoy’s results. A youthful auricular surface exhibits a fine-grained surface; and prominent billows extend transversely (side-to-side) from the middle. As the bones age, the sacroiliac joint bears more stress; billowing disappears and the fine-grained texture becomes coarser. Perforation, or *microporosity* occurs and tiny holes are visible. As age progresses these holes become larger (macroporosity) and the bone becomes dense.

Left and right auricular surfaces of the coxal bones were analyzed.

Results are consistent with Phase I of Lovejoy et al. (1985b), which corresponds to Steele & Bramblett’s (1988) 20-24 age grouping presented in Skelton’s Osteology Lab Manual (2001). The results are consistent with the following statement:

“Age 20-24: The auricular surface exhibits billowing and very fine granularity. Billows are rounded ridges running from side to side (transverse organization). The surface displays fine granular texture, meaning that it is smooth. In this stage, billows are well defined and cover most of the surface. Apex should be distinct, and there should be no roughening or porosity (holes)” (Meindle et al. 1985, Steele and Bramblett, 1988 in Skelton, 2001:81).

It should be noted that three small microposities are visible on the ventral part of the left auricular surface. Bone remodeling is present, so post mortem damage is ruled
out. Although this is not a trait found in Phase I, this anomaly may be due to human variation and/or occupational stress (see Pathology and Trauma). Based on analysis of the auricular surface of the Ilia, age at death falls between 20 and 24 years.

Conclusions Regarding Age

As described above, many methods exist in age determination at the time of death. Luckily in this case the skeleton was nearly complete, and many bones were analyzed to determine age. Some results are less accurate than others, but having a variety of results is better than just having one or two. Bass (1995: 25) references Bedford et al. (1993), stating that multifactoral aging is more reliable than any single indicator because it "helps control for variation in the changes that occur with age in any single morphological indicator.

Using this multifactoral approach, a narrow age range has been accurately determined for Christy Crystal Creek. Based on epiphyseal union of all long bones, the basilar suture closure and eruption of third molars, it can be stated that this individual has reached adulthood (<18). Todd and Lyon’s ectocranial suture method places the individual as >20 years. Todd and Lyon’s endocranial suture gives an age of at least 24. Baker’s endo/ectocranial suture method results in a narrow age range of 22-25.

As for the dentition, Brothwell’s dental attrition charts give results of “about 17-25”, Lovejoy’s attrition phase table gives an age between 16 and 20. Tromly’s dental wear analysis produce a narrow age range of 18-21.

Age estimation from İşcan et al.’s study of the 4th right sternal rib end is between 16-20 years. Age based on Albert and Maples’ vertebral body analysis is “late teenager”- 14-20 years. According to Suchey’s study of the Iliaic crest, the epiphyseal union stage is partial, with an age range of 14-23 years.
Pubic symphysis age results are as follows; Todd- *Second postadolescent* (20-21 years), Katz and Suchey- *Phase 2* (19-35 years) and Brooks- *Stage II* (19.5-21.5). A wide age range from the pubic symphysis is 19-35 and the narrow age range is 19½ - 20.

Lastly, analysis of the auricular surfaces of the left and right ilium, age at death falls between 20 and 24 years.

Combining the results, we get a wide age range of 14-34. The age of 14 comes from the iliac crest epiphyseal union, and the upper age of 35 comes from pubic symphysis analysis results. We can throw out any age younger than 18, as it is evident that this victim has reached puberty. Based on the partial fusion of the iliac crest of the os coxae, it is unlikely that this individual is older than 23 years. Both studies of the 4th sternal rib end and vertebral body fusion resulted in an age of no more than 20. A narrow age range for Christy Crystal Creek at the time of death is between 18-20 years. This age range is somewhat narrow, however, because of multifactoral analysis and the clues presented in the bones, I feel confident in stating this figure.
Literature Review: Parturition Scars on the Os Coxae

Parturition is “the action or process of giving birth to offspring” (Online Source: http://www.mw.com/cgi-bin/dictionary). Childbirth, as any mother will attest to, is an amazing yet traumatic process. The round, broad female pelvic area is fine-tuned specifically for the purpose of carrying a child and allowing room for 9 months of growth. Just as any traumatic experience leaves its marks on the human skeleton, the act of parturition has potential to produce scarring along areas of ligament attachment on the coxal bones. These scars take the shape of pits or extraneous grooves within attachment areas.

During pregnancy, hormonal secretions assist in the formation of these pits and grooves, causing relaxation and hypertrophy of the surrounding ligaments (Putschar, 1976; Kelley, 1979). Body weight changes also add stress to the pelvic area, and “the subsequent tearing and hemorrhaging associated with parturition further contribute to pubic changes” (Kelley, 1979: 544). In the latter months of pregnancy, many women complain of pain in the pelvic joints (Putschar, 1976; Hickey, Personal Communication, 2004). Degree of pelvic damage depends on a variety of factors; dimensions of the maternal pelvic canal, size of the infant, age of the mother, physical activity exerted by the mother, etc. (Putschar, 1976).

This subject would not have been discussed regarding this case had it not been brought up by Dr. Michael Charney, PhD, a diplomate on the American Board of Forensic Anthropology, in his forensic analysis of this case. He seemed quite adamant that Christy Crystal Creek had a full term pregnancy. In his forensic report dated 28 October 1985 he indicated, “both iliac bones show a pre-auricular sulcus. This indicates pregnancy and delivery of at least one child” (Case File, 1985). The pre-auricular sulcus, or pre-auricular groove, is located on the ilium of the os coxae and is defined as “a variable groove along the anterioinferior edge of the auricular surface”
(White, 2000: 227). Its purpose is to mark “the attachment of the inferior part of the ventral sacro-ilaic ligament” (Houghton, 1974: 381).

Upon speaking to Dr. Randall Skelton of the University of Montana Department of Anthropology, he stated that this is not true; a pre auricular sulcus is not a surefire indicator of pregnancy. Because of these conflicting opinions by two prominent forensic anthropologists, my interest was sparked and research ensued.

There are conflicting views regarding the presence of the pre auricular sulcus. Some anthropologists believe it is only found in females (Charney, 1985; Fraser, 1958), however this is not true. Houghton (1974) indicates that males can also have a pre-auricular sulcus, however it is not as pronounced as that of a female who has delivered children. It is also possible that neither sex will exhibit a pre-auricular sulcus (Houghton, 1974).

In his study, Houghton classifies the pre-auricular sulcus by extremity- GP and GL. GP (groove of pregnancy) “gives the impression of being formed by the coalescence of a series of pits, or small craters, in the bone...The floor of GP is uneven, being ridged where adjacent pits, or scoops meet” (Houghton, 1974: 381), whereas GL (groove of ligament) “is more variable. Commonly it is a narrow, short, straight-edged and shallow groove at the antero-inferior margin of the joint...the essential feature of these variations of GL is the even, flat floor to the groove” (Houghton, 1974: 381). As expected, GP is typically found in females who have borne at least one child (Houghton, 1974), whereas GL can be found in both sexes. In Kelly’s (1979) study, “the GL type occurred about 2.5 times more often in nulliparous (having borne no children) women” (Kelley, 1979: 543) than those who had borne children.

There are implications to the pre-auricular sulcus and its relations to pregnancy, however. Kelly’s results indicated that some nulliparous females (20%) exhibited patterns consistent with GP, and some multiparous (borne more than one child) females
did not exhibit GP characteristics (35%). Obviously this information is so variable that more research is necessary to obtain clear results.

Despite the inconsistencies, this knowledge was applied to Christy Crystal Creek. From the observer’s point of view, the pre-auricular sulcus appeared to fall into the GL category. Both sulci were shallow and the groove floor was flat and smooth. The groove is somewhat wide; “extending laterally to the small tubercle situated almost a centimetre from the inferior margin of the joint” (Houghton, 1974: 381). No deep pitting or undulating scarring is evident. Therefore, the determination of full-term pregnancy and childbirth cannot be made based on the appearance of the pre-auricular sulcus.

Unfortunately, very few studies have been made of the pre-auricular sulcus and its relations to pregnancy. Two out of four references were not available for study; one was a paper presented at the 48th annual meeting of the American Association of Physical Anthropologists by S.S. Dunlap, and the other by W.G.J. Putschar (1931) is written in German.

Both Houghton (1974) and Kelly (1979) believe that the pre-auricular sulcus is the most sensitive indicator of parturition, because the sacro-iliaic joint is in the direct line of body weight transfer and the ligaments in this area endure more stress than the rest of the pelvis (Houghton, 1974). However, it is always best to use a multifactoral approach. The pubic symphysis is observed as well.

Analyses of parturition scars on the os coxae seem to have centered on the dorsal surface of the pubic symphysis. The pubic symphysis is located at the anterior portion of the pelvic girdle, where the two pubic bones meet; the dorsal side faces the inside of the pelvic cavity. Just as in the pre-auricular sulcus, ligament attachments are affected by pregnancy and can create abnormalities on the surrounding bony elements. These “abnormalities of the pubic symphysis confined to females must be connected with

Many studies have been made of females of known parity (number of children borne), and all have inconsistent results (Stewart, 1957, 1970; Angel, 1969: Holt, 1978: Suchey et.al., 1979). In Holt’s study, 23.4% of the nulliparous females exhibited “medium to large” pubic scarring (Holt, 1978), and in Suchey’s study, 22 females having from one to five full term pregnancies have an absence of dorsal changes (Suchey, et.al., 1979).

Although parturition research appears to be inconsistent and highly dependent on the individual, two consistencies appear throughout. Females with increased parity (3+ children) tended to reveal medium to large dorsal pitting in the symphyseal region (especially in areas where medical treatment was lacking–prehistoric or otherwise (Stewart, 1957)). “A clearcut development of (bony) changes occurs after more than three births” (Angel, 1969: 432). The second constant is evident in more mature skeletons. As the female body ages, bone remodeling and arthritic lipping take place along the pubic symphysis. According to Kelley’s study results, this action removes scars of parturition and the “visible bony changes associated with pregnancy are slowly obliterated once the childbearing years are over” (Kelley, 1979: 544).

Regarding pubic symphysis and parturition studies, “until better material becomes available and is given more thorough study, it seems best, from the forensic standpoint, to use extreme care in interpreting the evidence in the case of an unknown adult female” (Stewart, 1970: 133).

As for Christy Crystal Creek, there is no dorsal pitting of the pubic symphysis. The dorsal rim is sharp and well defined, and tapers off into a smooth surface of bone. As
one may assume, this does not necessarily mean she did not have a child. Lack of parturition scars could be the result of many factors; her young age, genetic makeup and/or modern medical technology. Based on observation of the pubic symphysis, however, it does not appear that this victim has had a full-term pregnancy and delivery of a child.

Conclusions Regarding Parturition

Although it seems as if evidence of childbirth would be easy to study, human variation throws a wrench in the works. “There is a correlation between pitting of the os coxae and pregnancy or parturition, but the correlation is not strong” (White, 2000: 354). Some anthropologists have found that evidence of full-term pregnancy “is not significantly associated with pelvic pits, cavities and/or depressions. The nulliparous female may have scarring, the multiparous female may have none, and males can exhibit pelvic scarring. Thus the hypothesis that fertility can be determined by skeletal pelvic analysis is rejected” (Anderson, 1987). Pubic scarring may just be the result of the kind of life an individual led as well as their personal makeup. Anderson (1987) states, “tightly articulated pelvic girdles show significantly less scarring than the more loosely articulated pelves”.

Another factor in the problems with parturition studies is advances in modern medical technology. It has not been studied “Whether modern obstetrical procedures reduced the amount of bone scarring that apparently can occur in females living in a natural state.” (Stewart, 1970: 128).

Trauma other than childbirth can affect the coxal bones. For example, a broken pelvis as a result of a car accident or the like may cause scarring comparable to that of parturition.
It is my interpretation based on visual analysis of the pre-auricular sulcus and the dorsal rim of the pubic symphysis that Christy Crystal Creek has not experienced childbirth. I knew going into this study that there is not enough substantial evidence to prove or disprove Charney’s (1985) hypothesis. However, using the methods described above, there is no evidence of parturition on the os coxae.
Determination of Ancestry

Throughout history, people from various areas of the world have been categorized into different racial groupings in order to better understand their origin. For forensic anthropologists, this classification also assists in identification of individuals.

Because of the widespread human interracial marriages and individual human variation, most people in this world are comprised of many ethnicities. Many people have “absorbed the message that races are, somehow, not quite what they used to be. Far better, then, to avoid the word and substitute ‘ethnicity’ or some similar term that comfortably conflates cultural and physical variety” (Leroi, 2003: 338). This debate extends beyond physical appearances and delves into the realm of national, religious and sociocultural backgrounds (Stewart, 1979). “In spite of the likelihood that mankind in the past exhibited clear-cut subdivisions by appearance, today such as state of panmixia exists that subdivisions by appearance can be defined only very broadly” (Stewart, 1979: 227).

Depending on the nature and outcome of their research, anthropologists use different terms to describe the background of the people they study, i.e. cultural affiliation, ethnicity, race and ancestry. Deciding which term to use has become quite an issue. “Forensic anthropologists do not have the luxury of debating this issue; rather they must arrive at an assessment of this demographic characteristic to aid the police in their identification process” (Byers, 2002: 150). To conform to forensic anthropological terminology, the term “ancestry” will be used in this section.

Over the years anthropologists have attempted to determine separate categories in order to classify ancestral origin. The plethora of groups is somewhat confusing- at least to the author. Today, it seems that three predominant ancestral groupings have adopted by most forensic anthropologists (Bass, 1995). These categories are White (Caucasoid), Black (Negroid) and Asian/Native American (Mongoloid). “Racial taxa
such as white, black or American Indian have clear meaning to both the scientists and
to law enforcement personnel” (Gill, 1998: 295).

Without soft tissue or cultural items present, determining the race or ancestry of an
individual is an arduous task, however a variety of methods exist to assist us. For the
forensic anthropologist, skeletal analysis of ancestry determination falls into two
categories. The first method is based on “morphological and anatomical variations of
the bone structure” (Bass, 1995: 86) and the second is based on anthropometric
measurements. Morphological traits are determined by the observer’s perception of the
presence or absence of a particular trait. Below is a compilation of key morphological
traits categorized by ancestry and put into one table. Traits (according to the author)
demonstrated by Christy Crystal Creek have been highlighted in boldface type.

Twenty-eight features of the skull were observed.

Table 14: Non-metric (Morphological) Ancestry Determination from the Skull

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mongoloid</th>
<th>Caucasoid</th>
<th>Negroid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial sutures</td>
<td>Complex, with Wormian bones</td>
<td>Simple</td>
<td>Simple</td>
</tr>
<tr>
<td>Skull length</td>
<td>Long to short</td>
<td>Long to short</td>
<td>Mostly long</td>
</tr>
<tr>
<td>Skull breadth</td>
<td>Broad</td>
<td>Narrow to broad</td>
<td>Narrow</td>
</tr>
<tr>
<td>Skull height</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Coronal contour</td>
<td>Round</td>
<td>Long to round</td>
<td>Long</td>
</tr>
<tr>
<td>Sagittal contour</td>
<td>Arched</td>
<td>Round</td>
<td>Flat</td>
</tr>
<tr>
<td>Cranium</td>
<td>Low, sloping</td>
<td>High</td>
<td>Low, with post bregmatic depression</td>
</tr>
<tr>
<td>Profile</td>
<td>Moderate alveolar prognathism</td>
<td>Little prognathism, orthographic</td>
<td>Strong alveolar prognathism</td>
</tr>
<tr>
<td>Frontal bossing</td>
<td>Females only</td>
<td>Females only</td>
<td>Both sexes</td>
</tr>
<tr>
<td>Face breadth</td>
<td>Broad</td>
<td>Narrow</td>
<td>Narrow</td>
</tr>
<tr>
<td>Face height</td>
<td>High</td>
<td>High to medium</td>
<td>Low to medium</td>
</tr>
<tr>
<td>Orbit shape</td>
<td>Rounded</td>
<td>Angular to round</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Feature</td>
<td>Medium</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Interorbital distance</td>
<td>Medium</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>Nasal aperture width</td>
<td>Medium</td>
<td>Narrow (h=2xw)</td>
<td>Wide (h=w)</td>
</tr>
<tr>
<td>Nasal bones</td>
<td>Low, “tented” nasals</td>
<td>High and arched with nasion depression</td>
<td>Low, flat, shallow arch shaped</td>
</tr>
<tr>
<td>Nasal bones width</td>
<td>Medium</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>Nasal sill</td>
<td>Intermediate</td>
<td>Sharp</td>
<td>Smooth, guttered</td>
</tr>
<tr>
<td>Nasal spine</td>
<td>Medium, tilted</td>
<td>Large, long</td>
<td>Little or none</td>
</tr>
<tr>
<td>Ruggedness</td>
<td>Medium</td>
<td>Gracile</td>
<td>Rugged</td>
</tr>
<tr>
<td>Palatal shape</td>
<td>Elliptic</td>
<td>Parabolic</td>
<td>Hyperbolic</td>
</tr>
<tr>
<td>Palatal suture</td>
<td>Straight</td>
<td>z-shaped</td>
<td>Arched</td>
</tr>
<tr>
<td>Incisors</td>
<td>Shovel shaped</td>
<td>Blade-form</td>
<td>Blade-form</td>
</tr>
<tr>
<td>Dentition</td>
<td>Not crowded</td>
<td>Crowded</td>
<td>Not crowded</td>
</tr>
<tr>
<td>Zygomatics</td>
<td>Robust and flaring with malar tubercle*</td>
<td>Small, retreating</td>
<td>Small, retreating</td>
</tr>
<tr>
<td>Zygomaticomaxillary suture</td>
<td>Angled</td>
<td>Jagged or S-shaped</td>
<td>Curved or S-shaped</td>
</tr>
<tr>
<td>Chin</td>
<td>Blunt median chin</td>
<td>Square, projecting chin</td>
<td>Retreating chin</td>
</tr>
<tr>
<td>Ramus</td>
<td>Wide ascending ramus</td>
<td>Intermediate ramus</td>
<td>Narrow ascending ramus</td>
</tr>
<tr>
<td>Hair form</td>
<td>Straight round cross section</td>
<td>Wavy oval cross section</td>
<td>Curly or kinky flat cross section</td>
</tr>
</tbody>
</table>


*Not necessarily “robust and flaring”, but projection is evident. Slight malar tubercle on left zygomatic.

**Results of Anthroposcopic Analysis**

Ancestry group expressed by the author’s observation of morphological traits is in parentheses. Starting with features of the skull, cranial sutures are complex; with two Wormian bones present. “Wormian bones are more common in people of Asian origin” (Byers, 2002:160). Although noted as an indicator of Mongoloid ancestry, some anthropologists (Schwartz, 1995; Skelton, 2001) have their doubts. “Although the presence and frequencies of sutural ossicles within skeletal populations have long been recorded, the etiology of these supernumerary sutures is still debated” (Schwartz, 1995:...
264). For example, Wormian bones have been noted to occur in over 80% of skulls, depending on geographical origin (Byers, 2002). For more information, please see Inventory Section, page 12.

Skull length is long to short (Mongoloid and Caucasoid), skull breadth is narrow to broad (Caucasoid), skull height is high (Caucasoid), coronal contour is long to round (Caucasoid), sagittal contour is arched (Mongoloid), cranium is high (Caucasoid), the profile exhibits moderate alveolar prognathism (Mongoloid) and frontal bossing is evident (Mongoloid and Caucasoid).

Regarding the face, the breadth is narrow (Caucasoid), height is high to medium (Caucasoid), eye orbit shape is angular to round (Caucasoid) and interorbital distance is narrow (Caucasoid).

The nose and mouth are the best in ancestry determination (Byers, 2002 and Gill, 1998). Nasal aperture width is narrow, as height = 2x width (Caucasoid), nasal bones are high and arched with a nasion depression (Caucasoid), nasal bones width is narrow (Caucasoid), the nasal sill is sharp (Caucasoid), and the nasal spine is medium and tilted (Mongoloid). The zygomaticomaxillary suture is slightly angled (Mongoloid)- the widest diameter is at the base of the suture, however it is not a dramatic angle. The zygomatic bones are not small and retreating, but cannot be described as “robust and flaring”- nothing on this skeleton is robust. From a profile view, the lower border of the eye orbit (or beginning of zygomatics) projects as opposed to retreats (Byers, 2002), a Mongoloid trait. However the zygomatic bones are not the widest breadth of the cranium as in some typical Mongoloid skulls.

Regarding the palate and dentition: palatal shape is parabolic (Caucasoid), and the palatal suture is intermediate between straight (Mongoloid) and Z-shaped (Caucasoid). The suture is relatively straight across with the exception of two jagged uplifts near the maxillary suture. Incisors are blade form (Caucasoid and Negroid) and dentition is
slightly crowded (Caucasoid). The determination of a slightly crowded dentition is partly based on the fact that tooth #32 (RM₃) has been extracted premortem.

On the mandible, the chin is blunt and median (Mongoloid) and the ascending ramus is intermediate in size (Caucasoid).

Luckily, there was a wad of brown curly hair recovered at the crime scene and possibly associated with this case. The hair in question is consistent with a person of Caucasoid ancestry.

Of the twenty-eight morphological features noted above, ten are consistent with Mongoloid ancestry and nineteen traits are characteristic of Caucasoid ancestry. Two traits—skull length and frontal bossing—are characteristic of both Caucasoid and Mongoloid ancestry. According to the author, the palatal suture is intermediate between straight (Mongoloid) and Z-shaped (Caucasoid). Therefore both traits were reflected in bold.

Although visual identification of ancestral traits is the main method of determining ancestry (Byers, 2002), the subjective nature of this analysis has its pitfalls. These anthroposcopic traits are “not measured on a continuous scale (e.g.) millimeters, centimeters), their expression is divided into discrete categories, which also can be difficult to identify...these ambiguities make the identification of ancestral group the most difficult attribution to be made by forensic anthropologists” (Byers, 2002: 152-153).

Anthroposcopic analysis of the skull yielded nineteen traits consistent with Caucasoid ancestry and ten consistent with Mongoloid ancestry. With the exception of bladed incisors, a trait of both Caucasoids and Negroids, no Negroid traits were observed. Therefore I feel comfortable concluding that based on morphological analysis, Christy Crystal Creek exhibits predominantly Caucasoid traits with the presence of substantial Mongoloid characteristics.
Ancestry from Discriminant Function Analysis

One of the earliest methods of metric analysis of the skull is Giles and Elliot’s (1962) method of discriminant functions analysis (Bass, 1995). Just as in their discriminant function analysis for determining sex, various measurements are taken of the skull (see Appendix A, page ) and applied to an equation. There are two categories in which the measurements are to be applied; White/Black and White/Indian. Results of each landmark’s equation are added up and then plotted on a two-dimensional graph. The following measurements were obtained from Christy Crystal Creek: Basion-Prosthion height (ba-pr), 95mm; Glabella-Occipital or Maximum Cranial Length (g-op), 153mm; Maximum Width (eu-eu), 121mm; Cranial Base Length (ba-n), 91mm; Basion-Bregma (ba-b), 127mm, Maximum Diameter (zy-zy), 115mm; Prosthion-Nasion (pr-n), 57.1mm; Nasal Width (al-al), 21.1mm. These measurements were plugged into an equation with the coefficients provided below.

Table 15: Discriminant Function Worksheet

<table>
<thead>
<tr>
<th></th>
<th>White/Black</th>
<th>White/Indian</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basion-Prosthion (ba-pr)</td>
<td>x +1.74</td>
<td>x +3.05</td>
</tr>
<tr>
<td>2. Glabella-Occipital (g-op)</td>
<td>x +1.28</td>
<td>x -1.04</td>
</tr>
<tr>
<td>3. Maximum Width (eu-eu)</td>
<td>x -1.18</td>
<td>x -5.41</td>
</tr>
<tr>
<td>4. Basion-Bregma (ba-b)</td>
<td>x -.14</td>
<td>x +4.29</td>
</tr>
<tr>
<td>5. Cranial Base (ba-n)</td>
<td>x -2.34</td>
<td>x -4.02</td>
</tr>
<tr>
<td>6. Maximum Diameter (zy-zy)</td>
<td>x +.38</td>
<td>x +5.62</td>
</tr>
<tr>
<td>7. Prosthion-Nasion (pr-n)</td>
<td>x -.01</td>
<td>x -1.00</td>
</tr>
<tr>
<td>8. Nasal Width (al-al)</td>
<td>x +2.45</td>
<td>x -2.19</td>
</tr>
</tbody>
</table>

From Giles and Elliot (1962) worksheet for race identification from cranial measurements (Bass, 1995: Figure 2-35).
As shown in the table below, the sectioning point on the White/Black scale is 92.20. The White/Black ancestry scale yields a score of 82.464, therefore the results fall within the White (Caucasian) range. The sectioning point for the White/Indian scale is 130.10, and the results are 198.021—this figure clearly falls into the Indian (Mongoloid) range. Discriminant function analysis tells us that Christy Crystal Creek exhibits both Caucasoid and Mongoloid traits.

Figure 4: Discriminant Function Worksheet and Reference Chart

<table>
<thead>
<tr>
<th>Specimen:</th>
<th>Date:</th>
<th>Measured by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>b[d]-[e] Basion-Prosthion Ht.</td>
<td>x</td>
<td>-3.06 x</td>
</tr>
<tr>
<td>g-op Glabella-Ocuap. Lp.</td>
<td>x</td>
<td>+1.60 x</td>
</tr>
<tr>
<td>m-op Maxitum Width</td>
<td>x</td>
<td>-1.90 x</td>
</tr>
<tr>
<td>g-n Basion-Bregma Ht.</td>
<td>x</td>
<td>-1.79 x</td>
</tr>
<tr>
<td>g-n Basion-Nasion Ht.</td>
<td>x</td>
<td>-4.41 x</td>
</tr>
<tr>
<td>zy-zy Mx Diam Br-ryg</td>
<td>x</td>
<td>-0.10 x</td>
</tr>
<tr>
<td>n-ids Maxill.-Nasion Ht.</td>
<td>x</td>
<td>+2.59 x</td>
</tr>
<tr>
<td>a[e]-a[e] Nasal Width</td>
<td>x</td>
<td>+10.56 x</td>
</tr>
</tbody>
</table>

*aThese measurements are used for calculating sex.*

From Skelton (2001: Figure 11.1, page 40), after Giles and Eliot (1962).

Ancestry from FORDISC Analysis

FORDISC 2.0 is an “interactive DOS computer program that uses discriminant function analysis of skeletal measurements to classify unknown human remains” (Burns, 1999: 228). Stephen Ousley and Richard Jantz developed this program to assist forensic anthropologists in identification of human remains using statistics from known
modern skeletal samples. These samples are of predetermined ancestry because they “might have been a self-designation, i.e. hospital records for the decedent filled out, a designation by close relatives, as in a missing person report, or a classification by law enforcement officials” (Ousley and Jantz, 1996: 20).

Ousley and Jantz offer a few words of precaution in using their method. The program may not provide accurate results with the following situations; ethnic groups not represented in the reference samples, hybrid groups of people, hybrid individuals and aberrant values affected by disease, disuse, treatment or trauma (Ousley and Jantz, 1996).

Two sets of statistical results ensue from FORDISC analysis; posterior probabilities and typicality probabilities. Posterior probabilities “evaluate the probability of group membership under the assumption that the unknown belongs to one of the groups in the function” (Ousley and Jantz, 1996: 7) and typicality probabilities “represent how likely the unknown belongs to any particular group, based on the average variability of all the groups in an analysis” (Ousley and Jantz, 1996: 7).

Figure 5 below displays the results of Christy Crystal Creek.

Using the appropriate measurements of the skull found in Appendix A, the results yielded a classification closest to Japanese Female (see table 17 below). Posterior probability is .997, and the typicality probability is .048. Although this result is somewhat consistent with the morphological traits and determined by the author as well as discriminant function analysis, it is always advisable to use a multifactoral approach when determining ancestry and any other identification method.
### Discriminant function results using 17 variables:

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Number</th>
<th>WF</th>
<th>BF</th>
<th>AF</th>
<th>JF</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>WF</td>
<td>132</td>
<td>121</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>91.7%</td>
</tr>
<tr>
<td>BF</td>
<td>107</td>
<td>5</td>
<td>92</td>
<td>2</td>
<td>8</td>
<td>86.0%</td>
</tr>
<tr>
<td>AF</td>
<td>28</td>
<td>1</td>
<td>24</td>
<td>2</td>
<td>8</td>
<td>85.7%</td>
</tr>
<tr>
<td>JF</td>
<td>100</td>
<td>5</td>
<td>11</td>
<td>7</td>
<td>77</td>
<td>77.0%</td>
</tr>
<tr>
<td>Total</td>
<td>367</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>85.6%</td>
</tr>
</tbody>
</table>

**Multigroup Classification**

<table>
<thead>
<tr>
<th>Group</th>
<th>Classified into</th>
<th>Distance from</th>
<th>Probabilities</th>
<th>Typicality</th>
</tr>
</thead>
<tbody>
<tr>
<td>WF</td>
<td></td>
<td>40.9</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>BF</td>
<td></td>
<td>40.5</td>
<td>.002</td>
<td>.001</td>
</tr>
<tr>
<td>AF</td>
<td></td>
<td>45.0</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>JF</td>
<td>** JF **</td>
<td>27.7</td>
<td>.997</td>
<td>.048</td>
</tr>
</tbody>
</table>

**is closest to JFs**

### Group Means

<table>
<thead>
<tr>
<th>Group</th>
<th>WF</th>
<th>BF</th>
<th>AF</th>
<th>JF</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOL</td>
<td>153</td>
<td>177.9</td>
<td>178.5</td>
<td>177.6</td>
</tr>
<tr>
<td>XCB</td>
<td>121</td>
<td>135.9</td>
<td>133.6</td>
<td>137.9</td>
</tr>
<tr>
<td>ZYB</td>
<td>115</td>
<td>120.8</td>
<td>122.7</td>
<td>132.5</td>
</tr>
<tr>
<td>BBH</td>
<td>127</td>
<td>133.5</td>
<td>127.5</td>
<td>129.4</td>
</tr>
<tr>
<td>BNL</td>
<td>91</td>
<td>98.5</td>
<td>96.9</td>
<td>99.8</td>
</tr>
<tr>
<td>BPL</td>
<td>95</td>
<td>90.9</td>
<td>98.4</td>
<td>96.9</td>
</tr>
<tr>
<td>MAB</td>
<td>57</td>
<td>57.9</td>
<td>63.2</td>
<td>63.2</td>
</tr>
<tr>
<td>AUB</td>
<td>114</td>
<td>116.5</td>
<td>115.6</td>
<td>126.3</td>
</tr>
<tr>
<td>UFHT</td>
<td>57</td>
<td>67.0</td>
<td>68.0</td>
<td>71.0</td>
</tr>
<tr>
<td>WFB</td>
<td>81</td>
<td>93.5</td>
<td>93.8</td>
<td>92.1</td>
</tr>
<tr>
<td>NLH</td>
<td>45</td>
<td>49.3</td>
<td>48.0</td>
<td>51.9</td>
</tr>
<tr>
<td>NLE</td>
<td>21</td>
<td>22.2</td>
<td>24.8</td>
<td>25.5</td>
</tr>
<tr>
<td>OBB</td>
<td>35</td>
<td>38.3</td>
<td>37.7</td>
<td>41.0</td>
</tr>
<tr>
<td>OBH</td>
<td>31</td>
<td>33.2</td>
<td>34.4</td>
<td>35.1</td>
</tr>
<tr>
<td>FRC</td>
<td>101</td>
<td>108.7</td>
<td>106.8</td>
<td>108.0</td>
</tr>
<tr>
<td>PAC</td>
<td>98</td>
<td>113.5</td>
<td>113.7</td>
<td>108.1</td>
</tr>
<tr>
<td>OCC</td>
<td>93</td>
<td>96.7</td>
<td>94.4</td>
<td>93.6</td>
</tr>
</tbody>
</table>

*Figure 5: Results from FORDISC Analysis (Ousley and Jantz, 1996)*
Ancestry from Analysis of the Dentition

Forensic anthropologists also examine unique features of the dentition, as some characteristics tend to appear only in certain ancestral types. For example, shovel shaped incisors exhibit a “relatively high frequency of occurrence in Mongoloid racial groups” (Bass, 1995: 297). Shovel shaped incisors are not present within Christy Crystal Creek’s dentition.

Carabelli’s Cusp, however, is prevalent on both upper first molars. “Georg von Carabelli (1842) described an accessory mesiolingual cusp on the upper molars that was quite common in European dentitions” (Scott and Turner II, 1997: 5). Carabelli’s trait is “always located on the lingual surface of the protocone (mesio-buccal cusp) of the upper molars present in the form of an almost imperceptible elevation associated with a small furrow”, or “can also be a large cusp that rivals the hypocone in size (Scott and Turner, 1997: 24). For this case, they are slightly pronounced, probably in the middle range of elevation.

“At the time, von Carabelli had no idea he would achieve a degree of immortality on the basis of this obscure accessory cusp that bears his name to this day” (Scott and Turner II, 1997: 5). This trait is consistent with those of Caucasoid ancestry.

Ancestry from Hair Samples

“One characteristic of hair that makes it particularly useful to forensic anthropologists is its resilience,” and hair “may provide valuable additional information concerning the ancestry of decedents” (Byers, 2002: 167). As noted in the inventory, a clump of hair was recovered at the crime scene, and is assumed to be associated with the skeletal remains. If this is correct, than an estimation can be made by analysis of the visual properties of the hair. Usually, microscopic analysis is used in this analysis (Stewart, 1979), but was not employed in the research.
Byers (2002) references Brues’ (1977) studies to categorize the well-known differences in hair form and color between Caucasoids, Negroids and Mongololoids. “In Whites, it is straight to slightly wavy with dark to light color (e.g. blond or red). Blacks have a naturally curled (and in some cases tightly curled) form and black or dark brown color. Finally, in Asians (including Native Americans and Hispanics), hair is black (with occasional red highlights), coarse and straight (i.e. little or no wave)” (Byers, 2002: 167).

Analysis of the hair associated with this case is as follows: the color is dark brown (not black), relatively thin and has a moderate curl to it. Length is approximately 6 inches. This observation is consistent with hair of peoples of European descent in that it is not kinky (as in Negoids) nor is it coarse, dark and straight (as in Mongoloids).

Of course, individuals of a certain ancestry may or may not exhibit characteristic hair types. For example many African American blacks remove the curl from their hair, and hair dyeing (especially with females) is prevalent in all ancestral groups (Byers, 2002). Also, due to mixed ancestries, many individuals do not represent any clear-cut hair type. “Most stereotypic American blacks, whites and mongoloids can be distinguished by their hair” but goes on to state “I have no way of knowing to what extent this holds true of the hybrids between these groups” (Stewart, 1979: 229).

Ancestry From Metric Analysis of the Scapula

In order to obtain an assessment of race from the scapula, measurements must be made of the bone and then plugged into a formula. Maximum breadth, “from the middle of the dorsal border of the glenoid fossa to the end of the spinal axis on the vertebral border” (Bass, 1995: 122) is multiplied by 100 and then divided by the maximum length- “the maximum straight line distance from the superior to the inferior border” (Bass, 1995: 122). The resulting number is known as the scapular
index. This scapular index is then compared to Hrdlička's (1942) chart in Bass' *Human Osteology: A Laboratory and Field Manual* (1995). Due to postmortem damage on the inferior border of the right scapula, only the left scapula was used in this analysis. Maximum breadth of the left scapula measures 88mm, and maximum length is 141.9mm.

\[
\text{Scapular Index} = \frac{\text{maximum breadth} \times 100}{\text{maximum length}}
\]

\[
\text{Scapular Index} = \frac{88 \times 100}{141.9} = \frac{8800}{141.9} = 62.02
\]

When length and breadth of the scapula are plugged into the formula for scapular index, the resulting number is 62.02. This figure is consistent with the category of “Eskimo”, the lowest number in the scapular index of any other racial category. This low number may be a result of the gracility of Christy Crystal Creek, and not related at all to her racial affiliation. However, this information should not be thrown out of the analysis. Although not the most reliable method for determination of ancestry, results from scapular index calculations may assist in identification of the individual.

**Ancestry from Metric Analysis of the Sacrum**

Bass (1995) describes a formula proposed by Wilder (1920) for assessing ancestry from measurements of the sacrum. Maximum anterior breadth, “the greatest distance across the wings (lateral masses) of the first sacral vertebra” (Bass, 1995: 113) is multiplied by 100, then divided by the maximum anterior height- (the sacral promontory to the middle of the anterioinferior border of the last sacral vertebra” (Bass, 1995: 113). The resulting number is called the sacral index. This sacral index is then compared to Wilder’s Racial Index chart, and placed into the according racial category. For Christy Crystal Creek, the maximum anterior breadth of the sacrum is 105.4mm and the maximum anterior height measures 87.2mm.
Sacral Index = \frac{\text{maximum anterior breadth}}{\text{maximum anterior height}} \times 100

\text{Sacral Index} = \frac{105.4 \times 100}{87.2} = \frac{10540}{87.2} = 120.87

The sacral index of Christy Crystal Creek is 120.87. This figure is not within any of Wilder’s proposed racial indices, in fact the closest (and highest number) index is that of the European female, which is 112.4. All other racial indices fall well below this number. In this case, the sacral index may provide information leaning towards European Ancestry. However, due to the uncharacteristic curvature of the sacrum (see Pathology and Trauma, page), the results may be skewed. Luckily there are other, more reliable elements of the skeleton that can assist in the multifactoral analysis of race determination.

**Ancestry from Analysis of the Femur**

Of the postcranium, the seemingly most reliable bone to analyze is the femur in relation to ancestry. Unfortunately, some of these studies require instruments that were not available to the author. Such studies include intercondylar shelf angle proposed by Craig (1995), using radiographs of the femur to measure the angle of two points on the distal end, as well as Stewart’s (1962) anterior femoral curvature studies. Stewart used a “periograph”, a contraption consisting of a board and a sliding caliper, to determine the rate of torsion applied to the bone. Stewart obtained a measurement that could have possibly have been used on Christy Crystal Creek had the entire distal femur been present. Measuring the greater trochanter-lateral condyle length assisted in his analysis of race. However, the lateral condyle has suffered postmortem damage and an accurate measurement could not be obtained.

Although metric analysis was not possible, proximal-distal curvature of the femur as a whole was observed by placing the bone on a flat surface. Stewart (1979) has
"presented evidence that American Blacks, at least in so far as some of the less admixed individuals are concerned, have femora which in comparison with those of American whites are less curved anterioposteriorly, more flattened anterioposteriorly in midshaft, and have less anterior twist (torsion) at the upper end" (Stewart, 1979: 232). In other words, the femora of Caucasoids are generally more curved than are those of a Negroid. No reference is given for a typical Mongoloid femur.

Only the left femur is available for analysis. This bone exhibits slight curvature when placed posterior side down on a flat surface, and therefore throws out the possibility of Negroid ancestry. Curvature of the femur appears to be consistent with that of an individual of Caucasoid or Mongoloid Ancestry.

Conclusions Regarding Ancestry

“To be effective today, the forensic anthropologist must like never before, be fully aware of advances in skeletal race (and even the many political ramifications)” (Gill, 1998: 293). Anthroposcopic analysis of the skull yielded nineteen traits consistent with Caucasoid ancestry and ten consistent with Mongoloid ancestry. Discriminant functions analysis quickly threw out the possibility of Negroid ancestry with “white” results on the White/Black scale. On the White/Indian scale, however, results fell well into the “Indian” range, which also takes Asians into account. Using the FORDISC computer program with all possible female categories into account, the closest match was Japanese female, with a posterior probability of .997, and the typicality probability is .048.

As for the dentition, the Mongoloid trait of shovel-shaped incisors is not expressed. However, Carabelli’s cusp, a Caucasoid trait, is. The hair sample present with the case is dark brown and curly hair and relatively fine. This is consistent with Caucasoid ancestry.
Metric analysis of the scapula yielded a scapular index of 62.02, falling into the “Eskimo” category. As for the sacral index of 120.87, this result is off the charts- the closest figure is 112.4: European female. Femoral curvature is present, once again throwing out the possibility of Negroid ancestry.

In summary, it appears that Christy Crystal Creek has a combination of Caucasoid and Mongoloid traits. Morphological analysis points more strongly to Caucasoid ancestry with Mongoloid expressions, and metric analysis is exactly the opposite- Mongoloid with Caucasoid expressions. Observer error and subjectivity may likely play a part in visual analysis.

“If races don’t exist, then why does a moment’s glance at a stranger’s face serve to identify the continent, perhaps even the country, from which he or his family came?” (Leroi, 2003: 338).
Pathology and Trauma

"It may represent nothing more than a passing annoyance as in a well-healed long bone fracture, or it can indicate the termination of life as in minute cut marks on a cervical vertebrae produced during decapitation" (Merbs, 1989: 186, Isçan and Kennedy, ed.).

Just as indicators of sex, race and age are preserved in a skeleton, pathology and trauma leave their distinctive traces on every bone they affect. Generally, pathology and trauma can aid the forensic anthropologist in identification of an individual. Any pathology or trauma that occurred to the victim in life would show up in medical records (if the victim had any), and X-rays showing unique injuries and anomalies are especially helpful in the process of identification. Repetitive movements of a certain area of the body (i.e. occupational stress) can help determine what the individual may have done for a living. Most importantly, pathology and trauma can assist the forensic anthropologist in cause and manner of death.

"Pathological conditions vary by causative factors, from endocrine disturbances and nutritional deficiencies to congenital deformities and infectious diseases" (Byers, 2002:328). All forms of pathology are readily distinguishable on the bone they affect. These diseases leave their mark in the form of pitting (bone porosity), cloacae (pus drainage sites), bone deformation or inconsistency in size when compared to a normal specimen. Aside from the extensive dental pathology exhibited in this case, no obvious forms of pathology are visible on the rest of the skeleton. However, I am not a medical doctor and it is not within my expertise to make conclusive statements regarding pathologies. I can only state what I see and its consistency with known diseases.

There is a large case file associated with this victim; professional anthropologists, dentists and firearms specialists have all viewed the evidence, and provided their analysis and input. I feel comfortable with this decision partly because the
professionals that have previously analyzed Christy Crystal Creek have not indicated any sign of pathology affecting the postcranial skeleton.

Any type of physical damage that occurs to the skeleton is known as trauma. Trauma affects the skeleton in numerous ways, leaving telltale defects behind. Forensic anthropologists have classified human traumas as fractures, dislocations, crushing injuries, wounds from sharp objects (such as a knife or axe), wounds from blunt objects (such as a baseball bat or rock), circular defects (such as gunshot wounds), deformation, trephination, pregnancy problems, etc. Medical surgery is also considered a form of trauma (Merbs, 1989). These traumas can be categorized as premortem, perimortem or postmortem.

"The acid test for determining that a skeletal lesion is antemortem is evidence for bone remodeling" (Sauer, 1989. in Reichs, ed.). Immediately after trauma impacts bone, blood clots form in the area, thus beginning the healing process. Defects left behind by premortem trauma can help immensely in the process of identification of an individual. Evidence of injury observed on the bones by the forensic anthropologist can be compared to x-rays, dental and medical charts or even family testimony (Burns, 1999). Premortem trauma can also provide “insight into who the person was, what they did for a living, and what type of life they led” (Incillo, 2003: 72). For example, it was determined that this individual was right handed based on premortem trauma experienced on the right glenoid fossa.

Perimortem trauma has “far greater implications” (Burns, 1999:159) for anthropologists- as it is, directly related to, the cause of death, or has “occurred close enough to death that the healing process was not recorded on the skeleton” (Sauer, 1989: 322-323, in Reichs, ed.). Perimortem trauma is evident in fresh, not dry, bone and therefore the color is consistent with surrounding bone (Burns, 1999). Obviously, the two gunshot wounds to the skull are examples of perimortem trauma in this case.
Postmortem trauma is a part of the *taphonomic* process—"the events that affect an organism’s remains (particularly in its skeleton) after death and deposition" (Sauer, 1998: 321 in Reichs, ed.). Extended exposure to the elements, whether they are animal, vegetable, mineral or just plain weathering, leaves distinctive evidence on bone. Bleaching by the sun, staining from surrounding soils, carnivore damage and general wear and tear ("coffin wear") are all examples of postmortem damage. Christy Crystal Creek has suffered predominantly from postmortem trauma.

However, there are prime examples of pre-, peri- and post mortem trauma involved in this case. Because it is so extensive, a separate section on dental pathology and trauma is covered. Only those bones present that have endured some sort of trauma are discussed. For a complete listing of bones present, see inventory section.

**Dental Pathology and Trauma**

"The enamel which covers a tooth crown is the ‘hardest’ part of the body... teeth show excellent preservation in most taphonomic contexts" (Scott and Turner II, 1997: 2). Tooth anatomy is a study in itself, and many professional anthropologists have specialized in this field (Brothwell, 1963, Scott and Turner II, 1997). In a nutshell, the crown, or upper portion of the tooth is covered with enamel. Each tooth has at least one cusp on the occlusal, or upper, surface. Enamel stops at the cervicoenamel line—"the line encircling the crown which is the most rootward extent of the enamel (White, 2000: 112). Under the cervicoenamel line lays the root, which is usually firmly anchored into an alveolar socket within the mandible or maxilla. The outer surface of the root is composed of dentin- the core tissue. Inside the root of the tooth is a root canal, complete with a pulp chamber at the top.

The human dentition consists of 32 teeth- 16 each in the maxilla and mandible. Dentists have devised a universal method of numbering these teeth, #1 starting at the
maxillary right third molar (RM₃), moving along the upper dental arcade to #16 (LM₃), then down to #17 at the lower left third molar (LM₃) and across the mandible to #32- (RM₃). Dental pathology is both described in this manner as well as the abbreviated version of the individual tooth.

Almost every tooth included in the dentition has undergone some sort of pathology and/or trauma. All teeth present with the case are permanent teeth. Extensive dental work was performed on this individual. A wisdom tooth was removed relatively soon before the victim died. Later in life, proper dental hygiene was ignored and rapid tooth decay prevailed. At the location of the crime, nine teeth were recovered on the ground after the skull had been removed from the scene. These teeth have since been glued into the appropriate alveolar sockets (Case File).

Premortem Dental Pathology and Trauma

Caries, or cavities are a result of poor dental hygiene. Plaque bacteria mixes with ingested carbohydrates and begins to ferment. This process produces acids, which alters the pH of the plaque matrix surrounding the dentition and initiates a demineralization process. Too much demineralization erodes the enamel coating on the teeth and forms tooth decay. Caries are cavernous holes etched from the tooth as a result of this process (Schwartz, 1995). When recognized and treated early, cavities can be removed and replaced with fillings, halting further decay to the surrounding tooth. In this case, multiple cavities were filled using amalgam, the “most common filling material, also known as "silver fillings", containing mercury (app 50%), silver, tin, copper and zinc used for fillings” (Internet source, http://www.dentistry.com/glossary2.html).

The dentition of Christy Crystal Creek also contains two very unique types of root canals. “Root canal treatment, also known as endodontic treatment, is a dental
procedure in which the diseased or damaged pulp (core) of a tooth is removed and the inside areas (the pulp chamber and root canals) are filled and sealed... the canals are slightly enlarged and shaped to receive a filling material called gutta percha, an inert (non-reactive) latex-like substance used for filling root canals” (Internet Source: http://www.healthatoz.com/healthatoz/Atoz/ency/root_canal_treatment.html). “Root canal therapy is generally necessary when the pulp, which contains the nerves and blood supply of the tooth, is diseased or damaged” (Internet Source: http://www.toothtalk.com/rootcanaltherapy.htm).

Dr. Edward McGreevey, an endodontist (endo- inside; dont- tooth) in Missoula, Montana provided pertinent information regarding the root canal work performed on tooth #9 and #12. The root of tooth #9, the first left upper incisor (LI¹), has been infilled with gutta percha, as is evident in the X-rays. Dr. McGreevey also stated that a composite (tooth colored) filling was placed on the lingual surface of the tooth to seal the hole from the root canal. Composite fillings, because they are tooth colored, are used on the teeth in the front of the mouth for cosmetic purposes.

X-rays also show that tooth #12 (LP¹) has undergone a double root canal. Because there are two roots in an upper premolar, the process appears a bit more complicated than with the incisor. This root canal is unique in that it is “a screw-in type, it was not cast” (Johnson, 1986: Case File), and can also be seen in the X-rays. McGreevey indicated that because of the extensive decay on this tooth, the dentist that performed this procedure inserted the stainless steel threaded post atop the gutta percha infill. The majority of the occlusal surface, although damaged post mortem, exhibits an amalgam filling, and not a crown. This amalgam continues interproximally along the distal side of the tooth. It is Dr. McGreevey’s belief that this was a temporary procedure, to be made permanent at a later time. Obviously the victim never returned to the endodontist.
Fillings- Two amalgam fillings are located on the occlusal surface of tooth #2 (RM²). Two fillings are also on the occlusal surface of tooth #3 (LM¹), one towards the lingual side and the other located centrally. A filling is located on the occluso-distal side of tooth #13 (LP²), and even ventures interstitially- or between the teeth (Schwartz, 1995). Finally, an occluso-lingual amalgam is present on tooth #15 (LM²).

Teeth #17, #18 and #19 (LP², LM¹ and LM₂, consecutively) all have large occlusal/interproximal amalgams running mesio-distally, as the X-rays display. It was thought that these fillings were all connected- dental floss would not fit through the gaps between the teeth. When this was mentioned to Dr. McGreevey, he indicated that was not possible, as it defies any idea of good dental hygiene. These three teeth must have been found outside the cranium postmortem and included with the teeth glued back into the dentition.

Tooth #30 (RM₁) exhibits an amalgam centrally on the occlusal surface. Dr. McGreevey provided unique information regarding this tooth as well. Apparently the cavity on tooth #30 was so extreme that after removing the decayed tooth matter, the pulp was exposed and needed protection from further decay. An indirect cap had to be placed on top of the pulp chamber. A “pulp cap” consists of “ZOE”- a zinc oxide eugenol concoction that acts as a filling material and protects existing tooth matter (McGreevey, personal communication 2004). An amalgam filling was placed over the top to seal the tooth off from further decay. Tooth #31 (RM₁) contains a smaller, centrally located amalgam on the occlusal surface.

Multiple caries untreated by dental care are located throughout the dentition. These caries have been categorized according to size by the author as pinpoint, medium (~2mm in length) and large (>2 mm in length). Tooth #1 (RM³)- one large on buccal side, one pinpoint distally and one pinpoint lingually. Tooth #2 (RM²)- one medium on
buccal surface, #15 (LM²)- one large on buccal surface, #16 (LM³)- one medium on buccal-distal side (appears to also have been chipped postmortem based on color).

Continuing on with the mandible: #17 (LM₃)-a large carious lesion spans the occlusal, distal and buccal side. Tooth #22 (LC) has some pitting towards the apical portion near the neck, near the termination point of the enamel.

Periodontal disease is evident in varying degrees throughout the maxillary and mandibular dentition. According to modern forensic anthropologists, periodontal disease is the end of a process (Schwartz, 1995). “Usually periodontal disease begins with simple plaque, followed by calculus formation. Calculus is rough and porous. It harbors bacteria easily. The result is irritation and inflammation of the surrounding gingival tissues. Underlying alveolar bone is affected by the inflammation in the gingiva and the bone resorbs and remodels. The result is pocket formation around the teeth” (Burns, 1999: 130-131), therefore accumulating more bacteria and continuing the decay cycle. Too much decay can lead to massive destruction of the alveolar margins supporting the teeth, leaving attachments non-existent, and tooth loss is common.

On the maxilla, bone porosity is concentrated on the rear of the mouth towards the molars. The mandible exhibits a similar pattern, with increased porosity of alveolar bone towards the rear of the mouth. At tooth #17 (LM₃), extreme porosity is centered along the bucco-distal side of the tooth, and it appears as though a deep pit has formed due to the bone loss. With the exception of the extreme porosity of tooth #17, periodontal disease of the dentition is greater on the right side than the left.

Advanced stages of periodontal disease, as mentioned above, can lead to “destruction of tooth attachment and subsequent tooth loss” (Schwartz, 1995: 255). It is wise to remember this throughout the recovery process in a forensic environment, because “sometimes teeth which in life would have had little to tether them in place
will be shed postmortem and should not be overlooked in excavating around the skull” (Schwartz, 1995: 255). This was exactly the case with Christy Crystal Creek. Remember that nine teeth were recovered on the ground after the skull was removed from the scene. Based on alveolar bone loss around the dentition, it is not hard to believe that these vulnerable teeth would have easily fallen out of their sockets after the remaining connective tissue had decomposed.

Dental staining, although not a disease, is worth pointing out and can be another factor in victim identification (Burns, 1999). Tobacco has extremely effective properties as a staining agent. “A cigarette smoker will have an overall staining that intensifies on the lingual surfaces” (Burns, 1999: 132). Generally, a cigarette is smoked using the dominant hand and placed on that side of the mouth (personal experience). Dr. Johnson’s analysis of Christy Crystal Creek indicated the staining is more predominant on the right side. Brown staining is evident on the lingual surface of tooth #6 (RC1), on the interproximal surface of #9 (RI1), on the lingual surface of tooth #27 (RC1) and the interproximal surfaces of #28 (RP1) and on the buccal surfaces of all mandibular molars. Unfortunately, three teeth on the right side of the dentition were not recovered with the case (#7 (RI2), #26 (RI2) and #28 (RP2). Based on the evidence present, it is very likely that these teeth also exhibited brown dental staining.

Postmortem Dental Trauma

Four teeth were lost postmortem and never recovered with the remains, as indicated by the open alveolar sockets with no sign of resorption. These teeth are: #7 (RI2), #9 (LI2) of the maxilla and #26 (RI2) and #29 (RP2) of the mandible.

A few teeth are fractured postmortem as well. This is probably due to general wear and tear caused by the exchanging of this case to various analysts throughout the years. The buccal portion of tooth #12 (LI1) is chipped away, leaving the extensive amalgam
exposed. The lower left wisdom tooth #17 (LM₃) is broken away, probably spurred by
the sizeable cavity on the occlusal surface. Tooth #25 (RI₁) is bisected in half, only the
mesial portion remains. Although tooth #27 (RP₁) is complete, it is fractured at the
cusp down to the buccal surface. Both upper first incisors- #8 (RI¹) and #9 (LI¹) have
fracture lines and show evidence that they have been glued. Teeth #6 (RC) and
#11(LC) both have hairline fractures running from the occlusal surface posteriorly, as
do #22 (LC), #23 (LI₂), #24 (LI₁) and #25 (RI₁).

As mentioned above, nine teeth had fallen out of the dental arcade and were
recovered after the skull had been removed from the crime scene. These teeth were
later glued into the corresponding alveolar sockets (Case File). It is difficult to
determine exactly which teeth had been recovered and glued, because it wasn’t
indicated in the police report. However, it is evident that teeth #17-#19 were glued
into their alveolar sockets after recovery.

**Post-Cranial Premortem Trauma**

Evidence of possible premortem trauma was observed mainly in the form of
occupational stresses to the body. On the atlas, or cervical vertebra #1, fusion has not
taken place on the right transverse process and indications of scar tissue on the bone
exist. On the 5th thoracic vertebra, the spinous process is “deviated to the left,”
(Charney, 1985). Spurring is prevalent on the laminae of thoracic vertebra 11 and 12.
These may indicate some form of back injury earlier in life, and could very well be
related. The earliest indications of vertebral lipping are evident on the 4th and 5th
lumbar vertebrae, indicating a form of occupational stress.

On the sacrum, adjacent to the third nodule of the median crest, or spine a smaller
nodule lies on the right side. “The last two sections of the spinal canal on the sacrum
are open,” (Charney, 1985). White (2000) describes the median spine as “highly
variable” (White, 2000:220). The openness of the median spine is probably due to human variation, however pathologies such as Spina Bifida were not discounted. Ortner and Putschar (1985) include an extensive section on this debilitating disease describing it as “complete lack of closure of the neural canal” (Ortner and Putschar, 1985:355). They elaborate by stating, “Incomplete bony fusion of one or several spinous processes...is common, especially in the sacral area. Lateral or dorsal hemivertebrae occur, causing abnormal curvature of the spine” (Ortner and Putschar, 1985: 355). Some vertebrae may even fuse together, especially in the cervical area and between the fifth lumbar vertebra and the sacrum. Because the entire vertebral column is generally upright and exhibits no substantial form of deformation, the possibility of Spina Bifida is thrown out. It is my belief that the sacrum, however obviously female, is unusually curved. The curvature of the sacrum may possibly be linked to an occupational stress as the atlas and 5th thoracic vertebra. Charney reminds the observer that these anomalies should show up on any X-rays this victim may have had in life (Charney, 1985).

Perimortem Trauma

“While a forensic anthropologist may make recommendations as to the cause and manner of death based on his or her interpretation of skeletal trauma, it is ultimately the medicolegal responsibility of the forensic pathologist to make the final determinations” (Steadman, 2003: 129). In the case of Christy Crystal Creek, however, it is highly unlikely that there was any other cause of death than two gunshot wounds to the head.

“There are distinguishing characteristics of both entry and exit wounds in soft tissue and bone, as well as the fractures that radiate from these wounds” (Smith, Pope and Symes: in Steadman, 2003”: 138). Following the laws of physics, ectocranially,
entrance wounds of gunshots are beveled internally (and therefore smaller) and usually characterized by a sharp round border, whereas the exit wounds are externally beveled (and therefore larger) and exhibits a ragged, cone shaped border (Smith, Pope and Symes, in Steadman, 2003:139). There is no evidence exit wounds on the skull of Christy Crystal Creek. Both defects exhibit external beveling endocranially, and are characteristic of entrance wounds and two bullets were found within the cranium at the time of X-ray analysis (Case File).

Bullet entry wounds can be either round, oval, keyholed or irregular in shape (Byers, 2002). The shape of the entry wound depends on angle of the gun aimed at the head. If the angle is perpendicular, a clean, circular hole will result. Oval, keyholed and irregular shaped defects result in any angle less than 90 degrees.

Two types of fracture lines typically branch out from the point of impact. “Fractures radiate away from the bullet entrance site. The bullet slows, giving up its energy, as it enters the brain and increases intercranial pressure...Plates of bone produced by radiating gunshot fractures are elevated or levered out of the vault. As a result, concentric fractures...develop perpendicular to the radiating fractures” (Berryman and Symes, in Reichs, ed., 1998, 344-345). In other words, radiating fractures have a point of origin directly at the gunshot wound, and concentric fractures form perpendicular to the radiating fractures.

The first bullet hole to be discussed is located on the frontal bone, 47.9mm superior to the supraorbital notch of the right orbit. It measures 12.3mm x 13mm at its widest point. The border of the wound on the frontal bone is rounded medially and has grazed the bone on the lateral side. This is considered a keyhole defect- it looks like an old fashioned keyhole because it is “the result of a tangential strike by a bullet that produces beveling of bone inward and chipping outward. The shape is created by the
shallow entry of the bullet that produces an oblong opening, followed by a fan-shaped outward beveling of bone” (Smith, Pope and Symes, in Steadman, 2003:142).

Three radiating fracture lines branch out from the circular defect as a result of the traumatic impact. A 42mm fracture runs posteriorly at the lower right side of the defect to the coronal suture. A 22.3mm fracture line runs from the superior border of the circular defect, and dissipates before hitting the coronal suture. The final radiating fracture is 78.3mm in length and runs medio-posteriorly from the inferior portion of the defect to where the sphenoid meets the coronal suture.

As for concentric fractures, two originate from the latter radiating fracture. One is located 23mm medially from the onset of the former fracture and is 70mm in length, and runs posteriorly to its termination point at the coronal suture. A smaller, less intrusive concentric fracture is located 28mm inferiorty from the previous concentric fracture and goes for 37mm anteriomedially until its junction with said fracture. At the point of union of these two fractures, two very minor concentric fracture lines form a “V” shape, heading laterally. The anterior-most fracture measures 19mm in length while the posterior-most fracture measures 14mm.

The second entrance wound straddles the lambdoidal suture, therefore affecting both the occipital and right parietal bone. At its widest point, it measures 15mm X 11mm. It is centered 42mm inferio-laterally from the point of union of the lambdoidal and sagittal sutures. A keyhole shape is also evident on this wound. The inferior border of the wound is distinctly rounded while the superior border is “levered from the outer table” (Berryman and Symes, in Reichs, ed., 1998, 349). This bullet wound only exhibits one major radiating fracture line, which runs anterio-laterally from the upper rim of the defect, at the keyhole. The fracture measures 27mm in length. A much smaller radiating fracture lies laterally to the first and is only 7mm in length.
As a general rule, the larger bullet hole, the larger the caliber of bullet (Byers, 2002). These bullet holes appear to be medium-sized. William Newhouse, Firearms and Toolmark Examiner, studied the bullets that came from the endocranium of Christy Crystal Creek. His determination was “The two bullets...are .32 caliber bullets” (Newhouse, 1985, Case File).

Two additional fractures are visible on the cranium, possibly a result of impact after the victim was shot. A 33mm fracture line starts at the lower medial portion of the right eye orbit and parallels the zygomaticomaxillary suture. Another fracture line is on the left temporal 7mm posterior to the zygomaticomaxillary suture.

Because the possibility of surviving two separate gunshot wounds to the head is extremely slim, and because the staining of the bevels caused by the gunshot are consistent with the stain of the rest of the cranial bones, it is more than likely that this person died as a result of these bullet wounds. However, it needs to be stated that I am not trained as a forensic pathologist, and it is not within my jurisdiction to make assumptions.

We must not forget that “many skeletons are incomplete and it is always possible that the missing bones may have had evidence of perimortem trauma” (Steadman, 2003: 129). However, in this case, there is sufficient evidence with the skeleton to determine perimortem trauma.

**Postmortem Trauma**

Despite perimortem trauma, Christy Crystal Creek has suffered the most damage post mortem. The depositional environment in which the victim was discovered is laden with rich mineral soil, and subsurface water is common. Brown, gravelly silty loams compile the surface with a clay-like subsurface (LSI, 1989). This soil type is conducive to staining of surrounding objects. These minerals leach into the porous bone in the
wet environment and therefore stain the surface. All elements included with this case are stained a similar muddy brown color, with no clean breaks. All forms of postmortem damage appear to have occurred within a similar time frame.

Starting with the cranium, all delicate bones of the sinus cavity have been obliterated. Both nasal bones are partial, having suffered to post mortem damage. At the longest points, both left and right nasal bones measure 21mm. As for the left lacrimal, a 5.7mm fracture runs supero-inferiorly, 1.5mm behind the lacrimal groove.

Only the groove is present on the right lacrimal. The sphenoid has a 22mm fracture line moving anterior-posteriorly on the right lateral ptergoid plate. The ethmoid is shattered in both the left and right orbits and the vomer is shattered interiorly in the nasal cavity. The left maxilla is partially complete; a 6.7mm fracture extends from the palatine suture into the palate. The left palatine bone has a 3.5mm fracture that runs posterior-anteriorly through the length of the bone, and extends into the palate of the right maxilla (mentioned above). No carnivore damage is visible on the cranium.

As for the postcranial skeleton, the greatest post mortem trauma has occurred in the form of rodent damage and coffin wear. Wild animals thrive on the mineral content of bone and the fat of the marrow. “Mice, squirrels, porcupines and other rodents will gnaw bones for calcium” (Skelton, 2001: 116), also “rodents occasionally will chew on bones with the apparent purpose of keeping their incisor teeth worn down” (Byers, 2002:363). Typically, because of the nutrient content, the cancellous, or spongy bone parts will be damaged the most. Carnivores and rodents leave distinctively different marks on the bone- rodents “leave straight grooves with relatively flat floors” (Byers, 2002:363) and carnivores leave punctures and pits (punctures that don’t penetrate). Most tooth scrape marks are smaller than two millimeters; therefore it is probable that
smaller rodents such as mice, rats and squirrels have done the most damage (Byers, 2002). There are a few medium-sized tooth puncture marks on cortical areas of bone.

Of the shoulder girdle, the left scapula exhibits two semi-lunar fractures at the thinnest part of bone, 39.5mm above the inferior angle. Measurements of the fractures are as follows: 12.5mm superior, 10.5mm inferior. These fractures are placed 18.5mm apart. The right scapula is also partially complete, with all bony projections damaged by carnivores. The tip of the coracoid process has been gnawed off, and the bell-shaped acromion is gnawed away, leaving just the scapular spine. Small carnivore tooth punctures are evident at the superior angle. Two, 4.3mm rodent tooth puncture marks at medial portion of infraspinus fossa below the scapular spine. The inferior angle has been scavenged to oblivion.

Both left and right clavicles suffer carnivore damage at the costal tuberosity medially and the conoid tubercle laterally. Small tooth puncture marks are located on the medio-posterior end of the left clavicle as well.

The right humerus is missing the head posterior to the greater tubercle. Small tooth punctures are visible along what remains of the humeral head. A medium-sized tooth puncture as well as exfoliation is visible medially from the lesser tubercle.

Only the ribs on the left side suffer from post mortem damage. Left rib #1 has been gnawed at the sternal end, giving it a stringy appearance. The 2nd left rib is also damaged at the sternal end with a non-puncturing tooth mark on the inferior border. Both the sternal and vertebral end of left rib #3 has been gnawed away. The sternal end of the 7th left rib has been bitten off to the tubercle. Finally, the 9th left rib has endured carnivore damage at the very tip of the head.

As for the vertebral column, cervical vertebra #6 is missing the body and transverse processes. Minute tooth scrapings are visible on the remains of cervical vertebra #6. Carnivores have destroyed the transverse processes of thoracic vertebra #8; a small
tooth puncture is on the anterior portion of the body. Minor coffin wear has occurred at the inferior portion of the body anteriorally. Lastly, the inferior portion of the anterior body of lumbar vertebra #2 has succumbed to carnivore damage on the inferior portion of the anterior body. The right transverse process has been eaten away as well as the tip of the spinous process.

Postmortem trauma has also affected the os coxae. Carnivores have marred the anterio-lateral portion of the iliac crest, as is evident by a small tooth puncture on the medial side. The left coxal bone exhibits rodent gnawing on the posterior superior iliac spine, and a “greenstick” puncture is evident on the medial side.

The femur also exhibits postmortem trauma in the form of carnivore scavenging. The greater trochanter has been nicked off, and two medium sized puncture marks are observed in this area. The entire medial epicondyle as well as the posterior lateral epicondyle is obliterated. One small tooth puncture is visible above the damage on the lateral epicondyle.

Only the shaft remains of the left tibia; as carnivores have damaged this bone as well. The proximal end above the tibial tuberosity and the distal end are not present. Two small tooth punctures are visible - one at the tibial tuberosity and one proximally on the anterior portion of the shaft.

The same remains for the left fibula - the proximal and distal ends have been eaten by scavengers. The proximal end has greenstick fractures caused by gnawing action and the distal end. One small tooth puncture is visible proximally on the distal end.

Concluding the post mortem trauma, it appears that only smaller carnivores (i.e. any kind of rodent) had access to the remains of Christy Crystal Creek. Only small tooth punctures are observed on the bones, and the scraping marks left along the bones are evident of a smaller rodent such as a mouse, rat or squirrel. If a larger animal such as a coyote or wolf had discovered this victim, larger tooth punctures would show on the
bone. Also, if a canine would have scavenged on this victim, it is probable that there
would be less of the skeleton remaining due to the fact that larger animals need more
food to support their energy requirements.

"Humans are able to use their superior hands and brains to create their own
trauma-producing instruments, ranging from crude crushing and cutting weapons to
the sophisticated ultradestructive weaponry of modern warfare. Conversely, humans
unitize trauma, primarily in the form of surgery as a medical procedure" (Merbs, in

Conclusions Regarding Pathology and Trauma

In conclusion, this individual is someone who was generally healthy in her younger
years and had extensive dental work completed with enough time to pass for the
healing process to ensue. Because of the curvature of the sacrum, she may have broken
her tailbone. At one point, this individual stopped caring for her teeth and decay
rapidly ensued. Unfortunately, Christy Crystal Creek met her fate in the form of two
gunshot wounds to the head. After her death, she was deposited in a forested
environment and the decomposition process endured long enough to completely
skeletonize and stain her remains. During this process, small carnivorous animals
found nourishment in the form of calcium and bone marrow located within the
cancellous bone, and these rodents were able to sharpen their rapidly growing teeth.
Stature

In a skeletal forensic case, length of individual long bones can assist the anthropologist figure out how tall the person was in life. “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” (White, 2000: 371). This mathematical method “rests on the proportion of certain bones to the height” (Stewart, 1979: 190).

Trotter and Gleser’s stature studies are “the best now available for use on the long limb bones of specific elements of the American population” (Stewart, 1979: 201). Maximum length of long bones are obtained and then plugged in to a regression equation, producing an average height range. “The lengths of the lower-limb long bones are more highly correlated with stature than are the lengths of the upper-limb bones” (Stewart, 1979: 202). The only lower limb bones present in this case are the left femur and tibia, both partial.

Using an osteometric board, maximum length was measured of all long bones present with this case- the right humerus as well as the left and right ulnae and radii. Due to postmortem damage, partial measurements were taken of the left femur, tibia and fibula. Despite post mortem damage to the femur and humerus, complete measurements were attained. Measurements are below. Because of the variation of right and left radius lengths, bones on both sides were incorporated in analysis.

<table>
<thead>
<tr>
<th>Table 16: Long Bone Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right humerus</strong></td>
</tr>
<tr>
<td><strong>Left ulna</strong></td>
</tr>
<tr>
<td><strong>Left radius</strong></td>
</tr>
<tr>
<td><strong>Right ulna</strong></td>
</tr>
<tr>
<td><strong>Right radius</strong></td>
</tr>
<tr>
<td><strong>Left femur</strong></td>
</tr>
<tr>
<td><strong>Left fibula</strong></td>
</tr>
</tbody>
</table>

* The lateral right humeral head posterior to the greater tubercle is obliterated. A partial measurement was taken.
**both medial and lateral epicondyles of the left femur are obliterated from post mortem damage. A partial measurement was taken.
***Both proximal and distal ends of the left fibula were not present with this case. A partial shaft measurement was taken.

It is advisable to know sex and race of the individual, as the formulae for stature are classified as such. it is determined that the victim is female and most likely Caucasian (see previous chapters on sex and race), equations used in this case correspond with the category of white female.

The right humerus measures 277mm with a corresponding stature of 151cm or 4'11¾". The left radius measures 204mm in length, giving a corresponding stature of 151cm or 4'11". The right radius measures 216mm with a corresponding stature of 157.5cm or 5'2". The left ulna measures 223mm in length, with a corresponding stature of 153cm or 5'1¼". The right ulna measures 225mm with a corresponding stature of 154cm or 5'1½". The left femur is the only lower long bone available for analysis. Maximum length is 404mm, with a corresponding height of 154cm or 5'2/3¾".

Complete long bone lengths were then plugged into Trotter and Gleser’s formulae:

- Right humerus - 3.36(27.7-length in cm)+57.97 = 151.04±4.45cm
- Left radius - 4.74(40.4cm)+54.93 = 151.63±4.24cm
- Right radius - 4.74(21.6cm)+54.93 = 157.31±4.24cm
- Left ulna - 4.27(22.3cm)+57.76 = 152.98±4.30cm
- Right ulna - 4.27(22.5cm)+57.76 = 153.84±4.30cm
- Left femur - 2.47 (40.4cm)+54.10 = 153.88 ±3.72

The narrow height range for this individual according to Trotter and Gleser’s table in Bass (1995) is 151cm-157.5cm or 4'11¾"-5'2¾". By plugging the lengths into a regression formula, a wider height range of 146.6cm-161cm or 4'9¾"-5'3½" was obtained.

Some forensic cases contain only fragmentary long bones due to post mortem wear such as exfoliation or carnivore damage. Steele (1970) comprised a method to obtain
approximate stature from portions of long bones. The bone is divided into segments, and those segments present are measured and then plugged into an equation.

The segment available for analysis of the left tibia is segment 3-4, or the “distance from the confluence of the lines extending from the lower end of the tuberosity to the point where the anterior crest crosses over the medial border of the shaft” (from Steele, 1970, in Byers, 2002: 249). Segment 3-4 measures 128.7mm, or 12.9 cm. The equation follows:

\[
\text{Segment length} \times 100 = \text{approximate length of tibia}
\]

\[
\text{Percentage on chart}
\]

\[
12.9\text{cm} \times 100 = 27.7\text{cm}
\]

\[
46.46
\]

The figure 27.7 is then applied to Steele’s equations used previously:

Left tibia- 2.90(27.7)+61.53 = 141.9±3.66

This figure skews the results dramatically; making the lower range of stature less than 56 in, or 4’8”. It should be advised that this method “should be avoided unless they are the only osteological material available” (Byers, 2002: 247). Because there were complete long bones (albeit only one lower, more reliable limb bone) available for analysis, this result is not included in the final stature estimate. Fragmentary fibulae have not been studied to determine stature.

**Weight**

Determining an individual’s weight in life by examining their skeletal material is “extremely difficult to estimate reliably because it is so variable” (Skelton, 2001: 101). For example, two individuals may have measured 5’3” in life, however one could have weighed 105 lbs while the other weighed 175 lbs. If no physical evidence exists with the case (i.e. pant-size label or belt with worn in loopholes), pronounced muscle
attachments on the bones or the lack thereof may be the only way the analyst can estimate weight.

The Metropolitan Life Insurance Company comprised a standard height-weight chart that is reasonably accurate for non-industrial populations (Skelton, 2001). The chart is broken down by sex, stature and bone size (gracile, medium and robust). We know the victim is female, between the ages of 19-21 and stood between 4’9 ¾” and 5’3½” in height. Skeletal material is gracile in appearance. For the purpose of this analysis the average of the established age (20) and height (5’½”) are used. The instructions indicate “for females younger than 25 subtract 1% for each year under that age” (Skelton, 2001: 110).

For a female 5½” the corresponding weight for a gracile person is 101.5 ±15 lbs. However, one more step must be taken because the determined age is below 25. Since the average age for this individual is 20, 5% must be deducted from the total. The result is 96.4 ±14.25lbs.

**Conclusions regarding stature and weight**

In summary, this gracile individual stood approximately 5’ in life, and weighed about 96 pounds. However, human variation allows for a height range of 4’9¾”-5’3½” and a weight range of 96.4 ±14.25lbs.
Handedness

Knowing whether a victim is right or left handed may assist in their identification. Although it seems a valuable clue for forensic anthropologists, not many studies have been compiled regarding handedness. The reason for this is “indications of handedness in a skeleton are not of much help in leading investigators to the initial identification of a decedent, because the records of missing persons almost never include information on this subject” (Stewart, 1979: 240). Stewart further states, “the disregard of handedness in personnel, hospital, military, and other records has retarded the study of this subject” (Stewart, 1979: 240).

Hand dominance creates occupational stress markers on the shoulder girdle bones. Observing stress markers on the scapula, handedness can be estimated based on which side has more prominent beveling of the dorsal margin of the glenoid cavity, and “also a tendency for the plane of the (dominant side) cavity as a whole to be more dorsally inclined, and for the proximal end of the (dominant side) humerus to show more torsion” (Stewart, 1979: 240). The glenoid cavity as a whole tends to be shallower on the dominant side (Terry, 1942, in Stewart, 1979). Right and left scapulae were available for analysis in handedness. Because of post mortem carnivore damage, the head of the humerus was not available for analysis.

Observations of the glenoid fossae of both right and left scapula tend to lean towards right-handedness. Characteristics that lead to this conclusion are; shallowness of the right glenoid cavity compared to the left, wider angle of the right glenoid cavity and slight arthritic lipping along the dorsal rim of the right glenoid fossa. Also, the glenoid fossa (articular surface) is distinctively smaller on the right side. Terry completes the thought by stating “the inequality of the two articular surfaces, the shallowness of the glenoid cavity and the looseness of the articular capsule combine to
make the shoulder joint most free in range of movements” (Terry, 1942, in Stewart, 1979: 244).

Stewart (1979, in Burns, 1999) proposes another method of testing handedness by glenoid fossa analysis. It involves using the flat end of a piece of chalk and outlining the rim of the fossa. “Hold the right scapula in your right hand and the left scapula in your left hand while looking at the glenoid fossa. Compare the dorsal rims of the left and right glenoid fossa. Look for a distinct bevel outside the dorsal rim of the glenoid fossa. If one rim is beveled and the other is not, the person probably did more reaching with the arm on the beveled side” (Burns, 1999:158). In this context, the term “reaching” indicates dominance of that particular side. When observed in this fashion, a bevel was clearly observable on the right glenoid fossa.

Additionally, the case report accompanying the skeleton includes a complete forensic analysis compiled soon after recovery by the esteemed Dr. Michael Charney PhD, DAFBA of Fort Collins, CO. Regarding handedness of the victim, Charney indicates “The apical portion of the right glenoid fossa and the dorsal rim of this fossa are decidedly flatter and broader than the one on the left scapula. This would indicate more activity of the right arm” (Charney, 1985).

Dr. David Johnson, DDS of Great Falls, MT conducted a dental analysis on the victim, and suggests that based on tobacco stains primarily on the right side of the dentition indicates right-handedness. In his report to the Sheriff, he states, “notice the brown stain along the gingiva of the teeth, particularly on the right side. This individual was probably a moderate smoker and was probably right handed” (Johnson, 1986, Case File).

All characteristics of the right glenoid fossa coincide with Terry’s notes on handedness; therefore it is more than likely that Christy Crystal Creek was right handed in life. In his forensic report dated 28 October 1985, Charney confirms, “the apical
portion of the right glenoid fossa...suggests to me over-development of the shoulder muscles on the right”, and even ventures to guess that the victim was “a waitress, perhaps?” (Charny, 1985).
**Time Since Death**

Rate of decomposition varies by climate and depositional environment. For example, a body in the hot, humid areas of the southeast will decompose quite differently than one found in the dry heat of Arizona or a montaine climate such as Montana. It is very important for a forensic anthropologist to know where the victim was located, for each climate type can yield different results.

The remains of Christy Crystal Creek were recovered in a seasonal drainage in western Montana. This area is considered the northern Rocky Mountain Region; west of the continental divide under a modified maritime climate (LSI, 1989). The average elevation of the area is 3,150 feet Mean Standard Locator (MSL). “Average daily temperatures in Missoula from the years 1951 to 1978 ranged from 22° F in the in the month of January to 67 ° F in the month of July” (LSI, 1989: 4). Over two thirds of the precipitation received falls as snow, which covers the ground for about 4-5 months of the year in the area described.

With the exception of a small amount of dried ligament on the distal femur and proximal tibia, no fleshy material exists on the skeleton. Byers (2002) uses Rodriguez and Bass’ (1985) decompositional rate chart to categorize time since death. Christy Crystal Creek falls into the oldest stage: Completely skeletonized-No soft tissue recovered, giving a range of 2 months to 8 years since death. (Byers, 2002:112).

However, one small detail can assist in narrowing down the gap between life and death of this individual. Before she died, Christy Crystal Creek had her lower right third molar (RMs) removed. Doctor David W. Johnson, DDS (1986) Based on this spongy cortical bone that filled in the alveolar socket, the “extraction was probably done within the last year” (Johnson, 1986: Case File).

It is difficult to complete this section without using the knowledge that this victim was discovered in September of 1985. However, clues on the skeleton have assisted in
an approximation of time since death (TSD). The lack of any fleshy material, rate of
skeletonization, depositional environment in which the victim was recovered and
observation of the "spongy area" (bone remodeling) in the location of RM₃ are
consistent with the belief that she was deceased for about a year prior to her discovery.
Conclusions Regarding Christy Crystal Creek

This case was intriguing for me to work with. Although as a forensic anthropologist I am not supposed to get emotionally involved with cases, I certainly formed an attachment with Christy Crystal Creek.

Based on the methods employed in this analysis, the victim is a female and was between the ages of 18-21 at the time of death. Her ancestry appears to be a mixture of Caucasoid and Mongoloid traits. FORDISC analysis revealed her as being Japanese, although the thin, curly hair sample included with the case, if hers, is certainly not characteristic of Asian people.

This individual was very petite, probably not much more than 5’ tall, and weighed somewhere around 96 pounds. At one time, she was well taken care of, with extensive dental work applied to various teeth. Two root canals have occurred and a wisdom tooth was removed about a year before she died. Somewhere around that time, she stopped taking care of her teeth and rapid decay ensued. There is a slight possibility of a full-term pregnancy.

Perimortem trauma consists of two gunshot wounds (both entrance) to the head. Her body was deposited in a drainage in the Rocky Mountains and left to completely skeletonize. Carnivorous rodents had the opportunity to gnaw on the nutritious bones before authorities recovered her remains.
Appendices
Appendix A: Anthropometric Points on the Skull

Figure 1: Craniometric Points of the Skull, Frontal View (Bass, 1995: 69)
Figure 2: Craniometric Points of the Skull, Lateral View (Bass, 1995: 70)
Figure 3: Craniometric Points of the Skull, basilar view (Bass, 1995: 71)
**Appendix B: Christy Crystal Creek Cranial Measurements**

**Anthropometry of the Cranium**

Craniometric measurements were taken using spreading and sliding calipers.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Craniometric Point</th>
<th>Size (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cranial length</td>
<td>(g-op)</td>
<td>153mm</td>
</tr>
<tr>
<td>Maximum cranial breadth</td>
<td>(eu-eu)</td>
<td>121mm</td>
</tr>
<tr>
<td>Bizygomatic breadth</td>
<td>(zy-zy)</td>
<td>115mm</td>
</tr>
<tr>
<td>Basion-Bregma height</td>
<td>(ba-b)</td>
<td>127mm</td>
</tr>
<tr>
<td>Cranial base length</td>
<td>(ba-n)</td>
<td>91mm</td>
</tr>
<tr>
<td>Basion-apex height</td>
<td>(ba-ap)</td>
<td>123mm</td>
</tr>
<tr>
<td>Basion-prosthion</td>
<td>(ba-pr)</td>
<td>95mm</td>
</tr>
<tr>
<td>Maxillo-alveolar breadth</td>
<td>(ecm-ecm)</td>
<td>57mm</td>
</tr>
<tr>
<td>Maxillo-alveolar length</td>
<td>(pr-alv)</td>
<td>49mm</td>
</tr>
<tr>
<td>Biauricular breadth</td>
<td>(au-au)</td>
<td>113.7mm</td>
</tr>
<tr>
<td>Upper facial height</td>
<td>(n-pr)</td>
<td>57.1mm</td>
</tr>
<tr>
<td>Minimum frontal breadth</td>
<td>(ft-ft)</td>
<td>81.2mm</td>
</tr>
<tr>
<td>Upper facial breadth</td>
<td>(fmt-fmt)</td>
<td>84.2mm</td>
</tr>
<tr>
<td>Nasal height</td>
<td>(n-ns)</td>
<td>44.9mm</td>
</tr>
<tr>
<td>Nasal breadth</td>
<td>(al-al)</td>
<td>21.1mm</td>
</tr>
<tr>
<td>Orbital breadth</td>
<td>(mf-ek)</td>
<td>35mm</td>
</tr>
<tr>
<td>Orbital height</td>
<td>(obh)</td>
<td>31mm</td>
</tr>
<tr>
<td>Biorbital breadth</td>
<td>(ec-ec)</td>
<td>88mm</td>
</tr>
<tr>
<td>Interorbital breadth</td>
<td>(d-d)</td>
<td>17.5mm</td>
</tr>
<tr>
<td>Frontal chord</td>
<td>(n-b)</td>
<td>100.8mm</td>
</tr>
<tr>
<td>Parietal chord</td>
<td>(b-l)</td>
<td>97.6 above Inca bone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>106.9 below</td>
</tr>
<tr>
<td>Occipital chord</td>
<td>(l-lo)</td>
<td>93.8mm</td>
</tr>
<tr>
<td>Foramen magnum length</td>
<td>(ba-o)</td>
<td>28.3mm</td>
</tr>
<tr>
<td>Foramen magnum breadth</td>
<td>(FOB)</td>
<td>27mm</td>
</tr>
<tr>
<td>Mastoid length</td>
<td>(po-ms)</td>
<td>27.7mm</td>
</tr>
<tr>
<td>Chin height</td>
<td>(id-gn)</td>
<td>27.4mm</td>
</tr>
<tr>
<td>Height of mandibular body</td>
<td>N/A</td>
<td>27.7mm</td>
</tr>
<tr>
<td>Breadth of the mandibular body</td>
<td>N/A</td>
<td>11.3mm</td>
</tr>
<tr>
<td>Bigonial width</td>
<td>(go-go)</td>
<td>84.9mm</td>
</tr>
<tr>
<td>Bicondylar width</td>
<td>(cdl-cdl)</td>
<td>99.9mm</td>
</tr>
<tr>
<td>Minimum ramus breadth</td>
<td>N/A</td>
<td>32.1mm</td>
</tr>
<tr>
<td>Maximum ramus breadth</td>
<td>N/A</td>
<td>43.8mm</td>
</tr>
<tr>
<td>Maximum ramus height</td>
<td>N/A</td>
<td>55.8mm</td>
</tr>
<tr>
<td>Mandibular length</td>
<td>N/A</td>
<td>89.8mm</td>
</tr>
<tr>
<td>Mandibular angle</td>
<td>N/A</td>
<td>Undetermined*</td>
</tr>
</tbody>
</table>


* A mandibulometer, an instrument required for this measurement, was not available. Therefore no angle is recorded.
Appendix C: Christy Crystal Creek Postcranial Measurements

Maximum length of the long bones was measured using the osteometric board, and calipers were used for the clavicles, scapulae, os coxae and sacrum. Landmarks on individual bones were measured using both spreading and sliding calipers as well as a metric tape. Only bones present in the case are listed in the table below. Those bones absent from this case are not included.

<table>
<thead>
<tr>
<th>Bone</th>
<th>Element</th>
<th>Length (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left clavicle</td>
<td>Maximum length</td>
<td>129.8mm*</td>
</tr>
<tr>
<td></td>
<td>Sagittal diameter at midshaft</td>
<td>9mm</td>
</tr>
<tr>
<td></td>
<td>Vertical diameter at midshaft</td>
<td>8.2mm</td>
</tr>
<tr>
<td>Right clavicle</td>
<td>Maximum length</td>
<td>122.7mm*</td>
</tr>
<tr>
<td></td>
<td>Sagittal diameter at midshaft</td>
<td>8.9mm</td>
</tr>
<tr>
<td></td>
<td>Vertical diameter at midshaft</td>
<td>7.7mm</td>
</tr>
<tr>
<td>Left scapula</td>
<td>Maximum height</td>
<td>141.9mm</td>
</tr>
<tr>
<td></td>
<td>Maximum breadth</td>
<td>88mm</td>
</tr>
<tr>
<td>Right scapula</td>
<td>Maximum height</td>
<td>125.1mm</td>
</tr>
<tr>
<td></td>
<td>Maximum breadth</td>
<td>81.9mm</td>
</tr>
<tr>
<td>Right humerus</td>
<td>Maximum length</td>
<td>277mm</td>
</tr>
<tr>
<td></td>
<td>Epicondylar breadth</td>
<td>53.8mm</td>
</tr>
<tr>
<td></td>
<td>Vertical diameter of head</td>
<td>32 mm**</td>
</tr>
<tr>
<td></td>
<td>Max. midshaft diameter</td>
<td>7.5mm</td>
</tr>
<tr>
<td></td>
<td>Min. midshaft diameter</td>
<td>4.4mm</td>
</tr>
<tr>
<td>Left radius</td>
<td>Maximum length</td>
<td>204mm</td>
</tr>
<tr>
<td></td>
<td>Sagittal dia. at midshaft</td>
<td>8.9mm</td>
</tr>
<tr>
<td></td>
<td>Transverse dia. At midshaft</td>
<td>10.2mm</td>
</tr>
<tr>
<td>Left ulna</td>
<td>Maximum length</td>
<td>223mm</td>
</tr>
<tr>
<td></td>
<td>Dorso-volar diameter</td>
<td>10mm</td>
</tr>
<tr>
<td></td>
<td>Transverse diameter</td>
<td>13.4mm</td>
</tr>
<tr>
<td></td>
<td>Physiological length</td>
<td>191mm</td>
</tr>
<tr>
<td></td>
<td>Min. circumference</td>
<td>29mm</td>
</tr>
<tr>
<td>Right radius</td>
<td>Maximum length</td>
<td>216mm</td>
</tr>
<tr>
<td></td>
<td>Sagittal dia. at midshaft</td>
<td>10.6mm</td>
</tr>
<tr>
<td></td>
<td>Transverse dia. At midshaft</td>
<td>11.3mm</td>
</tr>
<tr>
<td>Right ulna</td>
<td>Maximum length</td>
<td>225mm</td>
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<tr>
<td></td>
<td>Dorso-volar diameter</td>
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<td></td>
<td>Transverse diameter</td>
<td>12.8mm</td>
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<tr>
<td>Measurement</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Physiological length</td>
<td>194mm</td>
<td></td>
</tr>
<tr>
<td>Min. circumference</td>
<td>30.0mm</td>
<td></td>
</tr>
<tr>
<td>Sacrum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior height</td>
<td>87.2mm</td>
<td></td>
</tr>
<tr>
<td>Anterior breadth</td>
<td>105.4</td>
<td></td>
</tr>
<tr>
<td>Transverse diameter of sacral segment 1</td>
<td>37.4mm</td>
<td></td>
</tr>
<tr>
<td>Left coxal bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>184mm</td>
<td></td>
</tr>
<tr>
<td>Iliac breadth</td>
<td>137mm</td>
<td></td>
</tr>
<tr>
<td>Pubis length</td>
<td>69.6mm</td>
<td></td>
</tr>
<tr>
<td>Ischium length</td>
<td>74.4mm</td>
<td></td>
</tr>
<tr>
<td>Right coxal bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>183mm</td>
<td></td>
</tr>
<tr>
<td>Iliac breadth</td>
<td>134mm</td>
<td></td>
</tr>
<tr>
<td>Pubis length</td>
<td>70.0mm</td>
<td></td>
</tr>
<tr>
<td>Ischium length</td>
<td>74.5mm</td>
<td></td>
</tr>
<tr>
<td>Left femur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum length</td>
<td>404mm***</td>
<td></td>
</tr>
<tr>
<td>Bicondylar length</td>
<td>N/A***</td>
<td></td>
</tr>
<tr>
<td>Epicondylar breadth</td>
<td>N/A***</td>
<td></td>
</tr>
<tr>
<td>Diameter of femoral head</td>
<td>39.5mm</td>
<td></td>
</tr>
<tr>
<td>Max. antero-posterior subtrochanteric diameter</td>
<td>22.0mm</td>
<td></td>
</tr>
<tr>
<td>Transverse subtrochanteric diameter</td>
<td>26.6mm</td>
<td></td>
</tr>
<tr>
<td>Antero-posterior diameter at midshaft</td>
<td>24.6mm</td>
<td></td>
</tr>
<tr>
<td>Transverse diameter at midshaft</td>
<td>22.0mm</td>
<td></td>
</tr>
<tr>
<td>Circumference at nutrient foramen</td>
<td>70.0mm</td>
<td></td>
</tr>
<tr>
<td>Left Tibia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum length</td>
<td>258mm****</td>
<td></td>
</tr>
<tr>
<td>Max. epiphyseal breadth of proximal tibia</td>
<td>N/A- proximal tibia not present</td>
<td></td>
</tr>
<tr>
<td>Max. epiphyseal breadth of distal tibia</td>
<td>N/A- distal tibia absent</td>
<td></td>
</tr>
<tr>
<td>Max. diameter at nutrient foramen</td>
<td>29.1mm</td>
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</tr>
<tr>
<td>Transverse diameter at nutrient foramen</td>
<td>18mm</td>
<td></td>
</tr>
<tr>
<td>Circumference at nutrient foramen</td>
<td>76mm</td>
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<tr>
<td>Left fibula</td>
<td></td>
<td></td>
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<tr>
<td>Maximum length</td>
<td>275mm*****</td>
<td></td>
</tr>
<tr>
<td>Diameter at nutrient foramen</td>
<td>12.5mm</td>
<td></td>
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</table>


* both sternal and vertebral ends of the clavicles were not present. A partial measurement was taken.
** The lateral right humeral head posterior to the greater tubercle is obliterated. A partial measurement was taken.
both medial and lateral epicondyles of the left femur are obliterated from post mortem damage. A partial measurement was taken.

Proximal and distal ends were not present with the case. A partial measurement was taken.

Both proximal and distal ends of the left fibula were not present with this case. A partial shaft measurement was taken.
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