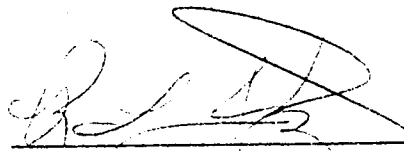


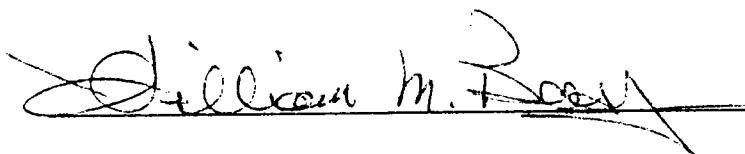
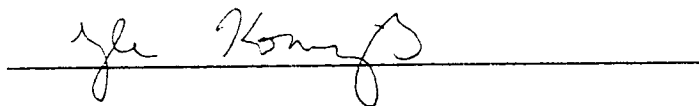
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**THE ROLE OF ADMIXTURE IN THE IDENTIFICATION
OF SKELETAL REMAINS:
A METRIC ANALYSIS OF MEXICAN CRANIA**

**A Thesis
Presented for the
Master of Arts
Degree
University of Tennessee, Knoxville**

**Jennifer J. Prutsman
August 1994**

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ABSTRACT

Skeletal biological studies of crania have allowed physical forensic anthropologists to typically distinguish Caucasoid, Negroid, and Amerindian traits for the identification of racial affinity. In the forensic setting, individuals of admixed heritage pose a challenge to the investigator. For example, persons who identify themselves as Mexican have European, Amerindian, and African ancestry. It is the duty of the forensic anthropologist to investigate, morphologically and metrically, where this group may be viewed in relation to the three parental groups.

A sample of 70 Mexican crania was measured from the Spencer R. Atkinson Cranio-Osteological Collection at the University of Pacific School of Dentistry in San Francisco. Data were analyzed by finite mixture analysis and multivariate discriminant function analysis; results were compared to Caucasoid, Amerindian, Negroid, and Hispanic individuals from the Forensic Data Bank at the University of Tennessee-Knoxville.

The results of the study discuss the ability of current metric analyses to properly identify hybrid individuals; specifically the Mexican group from White, Black, and Amerindian populations. Findings show that Mexicans from the Atkinson Collection to be a hybrid group, and can be discriminated from the three parental groups used from the Forensic Data Bank. The Mexican group seems to be most closely related to the Black ancestral component in the Mahalanobis distance scores and the multivariate canonical analysis.

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LIST OF ABBREVIATIONS

Maximum Cranial Length.....	GOL
Maximum Cranial Breadth.....	XCB
Minimum Frontal Breadth.....	WFB
Bizygomaxillary Breadth.....	ZYB
Biauricular Breadth.....	AUB
Nasal Height.....	NLH
Nasal Breadth.....	NLB
Exterior Palatal Breadth.....	MAB
Exterior Palatal Length.....	MAL
Orbital Height.....	OBH
Frontal Chord.....	FRC
Parietal Chord.....	PAC
OccipitalChord.....	OCC
Foramen Magnum Length.....	FOL
Basion-Bregma Height.....	BABR
Cranial Base Length.....	BANA
Basion-Prosthion Length.....	BAPR
Upper Facial Height.....	UFHT
Orbital Breadth.....	ORBR
Biorbital Breadth.....	BIOB
Interorbital Breadth.....	INTB

CHAPTER 1

INTRODUCTION

A forensic anthropologist faces a challenge each time a case is introduced into the laboratory. Identification of the victim is arrived at by the skeletal remains presented to the scientist. With any luck, the forensic anthropologist will have been able to go to the scene and oversee the complete recovery of the remains. More often, this is not the case, and the scientist is handed a paper bag full of bones. Hopefully this bag will contain the skull, since it is the prime determinant used when assessing the race of an individual.

Skeletal biological studies of the skull have allowed forensic physical anthropologists to typically distinguish Caucasoid, Negroid, and Amerindian traits for the identification of racial affinity. Yet in the real world and in forensic settings, people may have a mixture of ancestral backgrounds. The identification of race in individuals with admixed backgrounds, especially among the major racial divisions mentioned above, poses a challenge to the investigator.

The forensic race identification topic has been well-covered for Whites and Blacks. The famous skeletal collections of Todd and Terry, housed at Case Western Reserve University in Ohio and the Smithsonian Institution respectively, have been extensively studied with regard to every aspect of physical anthropology. These collections consist of mainly Black and White individuals obtained from cadaver studies and are representative of an elderly

population; useful for some physical anthropological studies, but not necessarily indicative of modern forensic cases.

Another group that has been traditionally studied by physical anthropologists in America is Amerindians. This population is extremely variable, due to the number of geographically unique tribes found in North America. To prove this, one need only look at the difference in appearance of an Eskimo compared to a native from South America.

One group of people that has not been widely studied in the realm of forensic race identification are "Hispanics". "Hispanic" is a term that denotes a Spanish-speaking person. "Originally used as a vague 'social race' term, Hispanic is now used as a biological category indicating various combinations of European and Amerindian stocks, in place of the now unpopular term, Mestizo" (Rhine 1990). In addition to European and Amerindian influences, "Hispanics" may claim ancestry from Black groups. The end result of admixture among groups is referred to as a hybrid population, and "Hispanics" are a prime example.

"Hispanics" are a rapidly expanding ethnic group in the United States, and as a result, this hybrid populational group will be appearing more frequently in the forensic record. It is important that the skeletal affinities of "Hispanics" be studied in order to determine their unique identifying characteristics, as have been developed for Whites, Blacks, and Amerindians.

The reader should recognize that the terms "Mexican, Mestizo, and Hispanic" have all been used to describe a hybrid of Caucasian

(i. e. Spaniards), Amerindian, and Negroid (i. e. African-American) groups. Although the term "Hispanic" does conform to some biological reality and is used by forensic anthropologists (Gill 1986), I will refer to the hybrid population in this study as "Mexican", as the place of origin is known for those individuals studied.

Objectives

The most accurate estimation of racial origin is obtained from the skull when dealing with skeletal remains (Giles and Elliot 1962; Bass 1987). Morphological and metric assessments of the cranium are used to determine the racial affiliation of an individual. This thesis will compare a Mexican sample from the Spencer R. Atkinson Cranio-Oseological Collection in San Francisco with the data housed in the Forensic Data Bank in Knoxville. The main objective of this paper is to examine the Mexican skull more closely morphologically and metrically with regard to the forensic record. Proper classification of individuals into their respective racial affinities is of prime importance to the forensic anthropologist. The findings presented henceforth will enable more accurate and consistent classifications of people with admixed (more specifically, Mexican) ancestry in the realm of human identification.

Chapter 2 discusses the concept of race, and how it has been viewed by anthropologists historically and presently. The definition of race is an enormous and sensitive issue in the field of anthropology. This paper will address race from a forensic physical anthropologist's perspective: how race is defined for the purposes of

identification. Chapter 2 also introduces Mexico as a prime example of a hybrid population whose origins are racially diverse.

Chapter 3 consists of a literature review as well as an introduction to previous studies on admixture and hybridity. Physical anthropologists have focused mainly on genetics and disease when studying admixture among populations. Other physical anthropologists, especially those involved in forensics, are also interested in skeletal attributes when examining hybrid populations. Morphology of crania and metric analyses are helpful tools when looking at admixture.

Chapter 4 is a description of the data samples used in the study. The Forensic Data Bank at the University of Tennessee at Knoxville consists of White, Black, Amerindian, and "Hispanic" representatives. The latter group was used as the "control" group for the data from the Spencer R. Atkinson Cranio-Osteological Collection housed at the University of the Pacific School of Dentistry in San Francisco. The history and contents of both collections will be discussed in more detail in Chapter 4.

The fifth chapter discusses the statistical analyses conducted. Finite mixture analysis and discriminant function analysis will be explained in this chapter.

Chapter 6 concludes the work, and further discusses the concept of admixture and hybridity.

CHAPTER 2

THE CONCEPT OF RACE

The Race Issue

Forensic physical anthropologists identify individuals by studying their skeletal attributes. Assessing the race of an individual is perhaps one of the most arduous tasks that a forensic anthropologist can deal with; the task is easier if the individual claims ancestry from one of the major geographical racial stocks (Caucasian, Amerindian, Black, etc.), and is enigmatic if the distinguishing morphological traits overlap.

To begin, a definition of "race" must be clarified. American Heritage Electronic Dictionary defines race as "1) a group of people distinguished by genetically transmitted physical characteristics; and 2) a group of people united by a common history, nationality, or tradition" (1990). There are actually two polar definitions of "race"; one is biological and the other is social. This is why the issue of race has been a heavily debated topic through the history of physical anthropology. Whole books and dissertations can be found in the literature discussing the subject, including comments and criticisms on the use (or misuse) of the term "race". "The term race has become encumbered with contradictory and imprecise meanings, as it has been used in a variety of social and biological contexts" (Molnar 1992). The antagonists in the discussion over the word fall into either the biological or cultural category.

Population geneticists, as well as most physical anthropologists, view race as biological in nature; a word describing breeding populations in terms of geographical areas. Different races of people are populations that have undergone some degree of genetic divergence, becoming phenotypically dissimilar from each other. Races are thus defined and grouped into categories based on morphological similarities, such as skin color, hair color and texture, facial features, and body size and shape. The concept of genetic variability among human populations is the key to understanding race, and categorizes differences between groups.

Other non-biological considerations may be taken into account when defining race from a cultural stance. A cultural definition of race can be especially important from an individual or society's point of view. Remembering that supporting data from social, cultural, and ethnohistorical sources are necessary in assessing the validity of admixture analyses by genetic markers (Chakraborty 1986) will immensely help the investigator in arriving at accurate conclusions. Cultural perceptions and linguistic factors need to be accounted for if the investigator or scientist is to be successful in assessing group affiliation.

While the race issue is truly beyond the scope of this paper, forensic anthropologists need to be aware of the controversy surrounding the topic. One need only have been present at the 1994 American Academy of Forensic Sciences annual meeting in the Physical Anthropology section to be aware of the opinions surrounding "race" in the anthropological community. In a forensic

setting, the scientist needs to put aside the academic discussions, and provide clear and concise descriptions to give investigators simple and direct answers. George Gill (1990) phrases it well when he comments, "Any anthropologist who contends that races do not exist and provides a vague answer as to ancestry of an unidentified skeleton, or launches into a discourse on 'ethnic groups' will likely never be called upon again to assist in solving a case." Moore-Jansen (1989) also realizes that "the forensic anthropologist is burdened with the identification of race in terms of cultural perceptions of racial affiliation sometimes attributed without a biological basis". Forensic anthropologists must realize that our society tends to put people in social categories, and need to give statements to the public in terms with which they are able to identify.

Race and Hybridity

Physical anthropologists have often recognized six groups--- African Negroid, East Asian Mongoloid, American Indian, European Caucasoid, Polynesian, and Australasian---as traditional geographic races of the world. Four of these groups are well described metrically and anthroscopically while Polynesians and Australoids are not (Gill 1986). In North America, physical anthropologists have the most exposure to studies involving African Americans, Caucasians, and native Amerindians.

More and more in the forensic context we find individuals that fit not one major group, but several. Hybrids are individuals that claim ancestry from two or more groups that may be

genetically and culturally diverse. How will these individuals be viewed with respect to racial qualifications? Will one of the parental groups be dominant with regard to structural appearance? Will the admixed individual relate more to one of the parent's social and cultural background than to the other?

Physical anthropology will have to find a way to deal with the changing concept of "race", taking into consideration both biological and social definitions. The background of people of admixed ancestry will need to be investigated if accurate assessments of skeletal identification are to be arrived at.

The population of Mexico is a model illustrator of hybridity, and is chosen in this study to answer the aforementioned questions. The population of Mexico is derived from European, African, and Native American ancestors, recent migrants to the United States, as well as U.S. citizens who descend from colonists in the Southwest and California (Molnar 1992). The admixture that has occurred between groups in Mexico is supported in historical documents as well as being observable in the present day. The nature of the population of Mexico gives an ideal place to begin testing hypotheses on admixture between certain populational groups.

Mexico: A Nation of Hybrids

Perhaps one of the best historically documented cases of admixture is the colonization by the Europeans of the New World, specifically the "Conquest of Mexico" in the early 1500's. Explorers and Conquistadores kept journals of daily life and were observant to

their surroundings. The missionaries that accompanied these men were additional sources of recorded information.

The events that have transpired since the arrival of the Europeans is unprecedented in history with regard to admixture. By the eighteenth century, miscegenation was so advanced in Mexico that there were few individuals of pure race left in the country (Morer 1967). Every variation of crossing has occurred between the main parental groups of Amerindians, Caucasoid, and Negroid.

There are several reasons why mixing among the races was so large in scale and successful in Mexico at the time:

(1) Europeans were already a heterogeneous group. The Spaniards, a group made of many people merging genetically and culturally, consisted of Iberian, Celtic, Phoenician, Greek, Roman, Jewish, Arabic, and Gypsy blood (Morer 1967). These people succeeded as colonizers because of their miscibility.

(2) The Spaniards were Conquistadores, conquerors of land, wealth, and people. Bernal Diaz, "the incomparable chronicler of the Conquest of Mexico, speaking of the Spaniards says on one occasion: '...they formed groups of fifteen and twenty and went pillaging the villages, forcing the women and taking the cloth and chickens as if they were in Moorish country to rob what they found' " (Morer 1967).

(3) Spanish America was settled by single men, in contrast to English America that was settled by families. The rapid race mixture was facilitated by the small numbers of white women in the New World at the time of the Conquest. The satisfaction of a natural instinct after months of abstention was a major proponent to the admixture among the races.

(4) The Conquest of Mexico was inherently the capture of native labor (Harris 1964). Yet, the native Indians were sensitive to the exorbitant labor involved in slavery, as well as diseases brought by the Conquistadores. The Spanish colonists were compelled to look to Africa for slave labor. These people were not protected by colonial rule (as was the native labor), had acquired immunities against the diseases of the Spaniards, and the selective effect of the horrendous journey from Africa tended to weed out the weaker individuals. The introduction of Africans into Spanish America subsequently led to the introduction of African genes, influencing future generations.

Socially, groups separated into Indian and non-Indian. The most important factor in this distinction had to do with the manner in which one lived; i.e. in an Indian community, speaking an Indian language, or wearing Indian-style clothing (Harris 1964). The hybrid individuals, claiming both Spanish and Indian ancestry (termed Mestizo), were never looked upon as a minority, but as a lower peasant class of the non-Indian. The Mestizos were socially aligned with European- and American-born Caucasians, whereas the Africans and American-born Africans (usually admixed with Indian blood) made up the lowest class in the caste system.

There was a great increase in the Mestizo population during the 17th century. The growing numbers of this hybrid filled the vacuum created by the disappearance of the native Indians due to disease and hardship (Morner 1967). Mestizos became the dominant group in Mexico, politically and economically powerful since trading between the New World and Europe had dramatically increased. During the colonial period of the 19th century, the Mestizos wished to break ties

with the Spanish crown, making Mexico a new country independent from Spain in 1830. The success of Mexico as a country was partially due to the influence of the Spanish spirit: after independence the Spanish habit of isolation and exclusiveness was too deeply entrenched in the Mexican people to be changed (Kelly 1947).

The population of Mexico is unique in its history and origin. The mixing of three distinctive racial groups makes this nationality of people a model illustrator of the phenomenon of hybrid groups.

CHAPTER 3

LITERATURE REVIEW

Admixture studies focusing on Mexicans are relatively sparse in the literature. Basically, there are two categories of articles that are of interest to forensic anthropologists on admixture: serological/genetic, and morphological/metric. Serological admixture studies focus on blood marker data and disease susceptibility, and are the most numerous in journal articles. The genetic articles are of interest to the forensic physical anthropologist, yet of prime interest is information regarding the morphometrics of hybrid populations when compared to their parental groups. Morphological and metric information is much more valuable to the forensic anthropologist when faced with the immediate identification of an unknown skeleton.

Serological admixture studies have been of interest to anthropologists in the past (Adams and Ward 1973; Matson et al. 1968; Mourant et al. 1976; Reed 1969; Workman et al. 1963; Crawford et al. 1974). However, such studies are becoming more popular with the increased interest in genetics and the engineering going on in the field. New blood markers are discovered every day. Serological studies may be "truer" to the investigator, since they are less likely to be affected by adaptive pressures of the environment (Chakraborty 1986). Despite their popularity, blood marker and genetic studies are of little utility to the forensic anthropologist when

estimating ancestry on skeletal remains quickly and as accurately as possible in the field.

Serological studies have several other drawbacks for a forensic anthropologist. These studies require living people; the drawing of blood is a medical procedure that needs to be handled by a health-care professional. After the sample is obtained, specialized equipment and knowledge of certain applicable techniques must be carried out to ensure the proper results are acquired. Although these studies are interesting to forensic anthropologists, they are often time consuming, complex, and separate or independent from their area of expertise.

Metric and morphological analyses are old friends of forensic physical anthropologists. These two areas are fundamental in the scientists training, and it is with shapes and measurements that they are most familiar. Most metric and morphological studies are concerned with the differences between the races, not admixture within or among the traditional groups (see Hanna 1962 for a discussion of admixture among Amerindian populations). Some work has been done in this area with respect to racial hybrids; yet the works are few and far between (Kelly 1947; Saksena 1974; Chung et al. 1986).

One other important consideration to realize about anthropometrics and anthroscopics is that the two are very closely related. The quantitative measurement of a skull is directly dependent upon the shape and size of the skull. Measurements and morphological assessments need to be considered together when attempting to describe a skull's ancestral heritage.

Serological and Genetic Methods

Blood Marker Studies

One method of estimating ancestral contributions to a hybrid group is through the use of blood marker data. Biological and physical anthropologists can use serological methods to study parental contributions to an individual through their genetic make-up.

Long et al. (1991) carried out an investigation of Mexican-American genetic structure. They attempted to estimate proportions of genetic contributions from known parental groups. Long et al. state the importance of the research: "Mexican-Americans are one of the fastest growing ethnic groups in the United States, a fact that increases the need for additional characterization of the variability in their gene pool, and application of this information to problems of health and origins".

The authors uses serological methods (through blood typings) to estimate ancestral contributions to the Mexican-American population studied. Any method of admixture estimation requires knowledge of the composition of populations ancestral to the hybrid under investigation, as well as estimates of their allele frequencies. Long and co-authors knew the major contributors of genes to the Arizona Mexican-Americans to be Spanish immigrants and indigenous Amerindians, plus a minor component from African slaves.

Blood was drawn for analysis from 730 Mexican-Americans who were involved in paternity cases in Scottsdale, Arizona.

Individuals were chosen on the basis of a legal action of a paternity petition, an unbiased method that ensured a representative sample of the Mexican-American population. Since the drawing of blood is a medical procedure insisting that the party be in good health, the sample is not biased toward any particular disease.

Blood is typed according to the presence or absence of antigens at certain loci. Loci used in the blood typing included HLA-A, HLA-B, ABO, Rhesus, MNSs, Duffy, Kidd, and Kell. Admixture proportions were then estimated by comparing the sample group of Arizona Mexican-Americans to allele frequencies of the parental reference populations which were obtained from various sources by Long et al.

Statistical methods of maximum likelihood functions and weighted least squares were used to estimate allele frequencies and admixture proportions, respectively. The weighted least squares method has been shown by computer simulation to provide estimates of ancestral proportions most suited to fitting dihybrid and trihybrid models (Long et al. 1991). Admixture results with the dihybrid model split ancestry at 66.9% Spanish and 33.1% Indian. The trihybrid model alters estimates for Caucasian and Amerindian ancestry slightly at 68.3% and 29.2% respectively, with a small African component of 2.5%. Long and colleagues state that the African admixture is not statistically significant but is demonstrated by the presence of the Fy allele in Arizona Mexican-Americans. That allele is known to be restricted to African populations and their descendants.

The authors took the admixture question one step further, in comparing Arizona Mexican-Americans with Los Angeles and San

Antonio Mexican Americans. The admixture proportions from both populations were nearly the same as the Arizona Mexican-Americans. The observations led to the conclusion that Mexican-Americans are a biological entity spanning across geographical areas, and not just a group bound by a cultural or social identity alone.

Long et al. conclude with a brief discussion of the events that led to the hybridization of this Hispanic population. The first hybrids, often termed *mestizos*, were composed of a fifty-fifty mix of Spanish and Amerindian blood. These offspring were accepted back into the Spanish society, which assists in explaining the proportion estimate of 65 - 70% Caucasian in Mexican-Americans. African admixture is historically documented in colonial Latin American terms (such as *negra*, *mulatto*, *morisco*, and *lobo*) which describe different degrees of admixture among groups.

Reed (1969) addresses the topic of Caucasian genes in American Negros. This article is of particular interest because the author points out that American blacks are actually biracial hybrids; 2 to 50% of their genes are from the Caucasian ancestors, received after 1700 (Reed 1969). The work illustrates this fact by estimating the Caucasian contribution to American Negro ancestry through maximum likelihood ("M") estimates. Blood marker data was utilized in this study from previous work by various authors. The most helpful gene in Reed's study was the *Fya* allele from the Duffy blood group to estimate "M" (i. e. admixture rates). It is an ideal Caucasian gene, since the mean frequency in Whites is 0.43, and in Africans it is 0.02. The value for American Negroes would be expected to fall somewhere within this range, and Reed finds this to be a valid

hypothesis in one sample of American blacks in California with an "M" value of .21. Maximum likelihood estimates provide information about genetic heterogeneity among populations. This procedure can be useful when assessing the hybridity of other groups, including "Hispanic" populations.

Lisker et al. (1990) investigated admixture estimates and gene frequencies in four Mexican urban populations. There is little information available regarding the gene frequencies and admixture estimates in Mexico's large urban centers (Lisker et al. 1990). Through their study, a trihybrid model consisting of Whites, Amerindians, and Blacks, was obtained for four locations of Leon, Merida, Oaxaca, and Saltillo.

Blood marker data was gathered from medical students, seminarists, and prisoners located in the above mentioned areas. Admixture estimates were obtained after a maximum likelihood method of Kreiger. Lisker and co-authors found their trihybrid model to result in the following ancestral proportions (in ranges): a White contribution of 15.9 to 42.9%, an Amerindian element of 51.2 to 76.2%, and a Black portion of 1.8 to 15.9%.

Two additional studies focusing on Mexico and admixture estimates by Lisker et al. (1988, 1986) were found in the literature. The 1988 paper focuses on Puebla, Mexico and individuals from the University Hospital there. An interesting result of the admixture analysis was that the authors found a large amount (10.7%) of the African Fy(a) allele. According to the authors, other nearby locations such as Mexico City and Tlaxcala compare to this frequency at 3% and 8%, respectively. One hypothesis on the high rate of African

genes in the Puebla location is offered when the history of the area is looked at. Blacks were of great importance in the early racial composition of Puebla, and towards the end of the sixteenth century, they equaled or surpassed the Spaniards in number (Lisker et al. 1988). After the slave trade ended, the black population slowly mixed with the existing Indian and Mestizo populations. The paper concludes in saying that these estimates are tentative on black ancestry until further investigations can be made.

Lisker et al. (1986) focused on admixture estimates of Mexico City. Blood samples were drawn from individuals at the University Medical School. This investigation into admixture estimates yielded a high Indian component when compared with results obtained by Tiburcio in an earlier study. To test the discrepancies found, a method by Krieger et al. was used. The authors concluded that the differences between the two studies reflected real differences between groups with respect to ancestral contributions.

Lisker et al. admit that it is impossible to investigate a representative sample of the population of Mexico City, which has over fifteen million inhabitants and is constantly increasing by the influx of people from smaller towns. They also note that the city is socioeconomically stratified, with the upper strata having a higher concentration of people with European ancestry. One final observation by the authors is that a high degree of Black ancestry was encountered, at a proportion of 4%, which is clearly higher than "common knowledge" (Lisker et al. 1986). The authors give no explanation for this finding in the 1986 paper.

Williams et al. (1986) are interested in previous work by Bernstein in estimating the amount of admixture (M) in hybrid populations. Bernstein used allele frequency data in the analysis of hybrid and parental populations to estimate accumulated contributions of ancestral stocks and hybrids (Chakraborty 1986).

Data (in the form of pedigree information) was collected from people of the Gila River Indian Community upon entrance to a clinic. Williams and contributing authors found a linear result between the amount of stated admixture and the frequency of alleles based on the blood marker Gm 3; 5, 13, 14.

The authors compared an estimate of M for Caucasian admixture with stated admixture of Native Americans. An ideal genetic blood marker for measuring admixture between European Whites and Amerindians would be one that has a high frequency in Whites, but absent in Amerindians before admixture occurred between the groups. A Gm 3; 5, 13, 14 hybrid population would show an intermediate frequency of the stated marker allele.

Crawford et al. (1974) investigated the genetic relationship of two populations in Mexico in order to assess distances between the groups. This study is of particular interest because it addresses the question asked in this thesis--what is the relationship of hybrid (i.e. Mestizo) versus parental (i.e. Amerindian, Spanish, African) groups?

The authors studied the allelic frequencies through blood specimens of two communities: Tlaxcala, a Mestizo town and San Pablo del Monte, an unhybridized Indian community. Three techniques, Sanghvi's Chi squared, Cavalli-Sforza and Edward's D

squared, and Mahalanobis generalized distance were used to assess genetic distances in addition to blood marker data.

The authors found the San Pablo del Monte group to have little gene flow from the Spanish population, unlike the Mestizo group. Mestizos are intermediate to Caucasians and Indians for certain allelic frequencies, and have been found to resemble Amerindian populations from the southwest United States.

An interesting note on the Tlaxcala Mestizos is that there is substantial evidence of African admixture in the population. One such example was found in the group specific components (Gc) locus. Caucasian and Indian populations have frequencies of 82% and 72%, respectively. However, the Tlaxcala population has a frequency of 87%. The presence of African alleles in the Mestizo gene pool is likely, since the frequency of the Gc allele among african populations is normally greater than 90% (Crawford et al. 1974).

In conclusion the authors state that the primary determinants of gene frequency in Mexico are geographic distance between populations and the degree of hybridity with parental populational groups.

Genetic Studies

While blood marker data is a form of a genetic study, this section takes into consideration genetic studies related to disease incidences, especially the results found in admixed groups.

In 1984, Weiss, Ferrell, and Hanis researched a syndrome of metabolic diseases that affected Amerindian-Caucasian hybrid populations in the Southwest. They termed the epidemic of disease

the "New World Syndrome". Amerindians as well as hybrid types of this group (Mexican-Americans) seemed to be increasingly susceptible to obesity, adult diabetes mellitus, cholesterol gallstones, and gallbladder cancer. Diabetes prevalence in hybrid populations is higher than that reported in Caucasians of Western European origin, yet lower than among Amerindians (Weiss et al. 1984).

New World people are most susceptible to the syndrome. The effects of "westernization" are one of the roots of the problem. Western diets are high in fat, low in fiber and high in carbohydrates. Coupled with a sedentary lifestyle, these factors lead to increased rates of heart disease and cancer. New World peoples may experience a different response to environmental factors, and have an additional susceptibility when exposed to certain factors. The second root to the New World Syndrome is genetic in origin; ancestors of the people associated with the health problems encountered in the New World Syndrome (i.e. Amerindians) had selected against diabetes and obesity in the past. The admixture with groups identified as "western" introduced factors into the hybrids' lifestyles that have resulted in the New World Syndrome health problems mentioned above.

Hanis et al. (1986) also examine the role of disease and admixture estimates in Mexican-American populations. They state that non-insulin dependent diabetes mellitus (NIDDM) and gall bladder disease have been observed to occur in very high frequencies in Amerindians, with intermediate frequency in admixed groups (Mexican-Americans), and the lowest rates in western groups. This article proposes an estimate of individual admixture by

studying a group of Mexican-Americans from Starr County, Texas. Hanis et al. note that there has been little work done in estimating an individual's affinity to an ancestral population by studying the disease susceptibility of that person or group. Relating admixture to individual disease risk could be a useful tool in estimating ancestral contributions. Assessing individual admixture is useful in dividing the population into different risk groups for disease susceptibility.

Chakraborty (1986) gives an overview of methods and models for estimating admixture. Chakraborty states that admixed human populations can be regarded as a natural experiment, and that different methods of estimating admixture rates cannot be formally compared. There are two categories into which admixture studies fall: studies based on gene frequencies or those based on phenotypic trait frequencies. The former heading includes genetic and serologic studies, and the latter is synonymous with morphology and anthropometry.

Chakraborty does not have much comment about morphologic studies, except that they have become less effective in recent years for estimating admixture; genetic markers have taken the lead due to their highly technological nature.

Chakraborty concentrates on the methods for admixture estimation based on gene frequencies. This type of admixture estimation is based on the Bernstein equation, which represents allele frequencies of the hybrid population in terms of admixture components and allele frequencies of parental groups. Some of the well-covered admixture studies address historically controversial unions between certain populational groups: Caucasian genes in

American Blacks, the composition of the Icelandic gene pool, and the admixture of Jewish groups with Gentiles. The author briefly mentions the parental groups of Amerindian and Caucasian mixing to create a Hispanic hybrid, and that the coverage of this group has not been extensive in the literature.

Morphological Studies

There are very few studies in the literature regarding the identification of hybrid populations through the use of measurements on the skull. Some landmark studies on determining racial affinity using measurements and statistical techniques (Giles and Elliot 1962; Howells 1951, 1970; Jantz and Moore-Jansen 1989) have focused on major populational groups (i.e. White, Black, and Amerindian), and have served as a framework for the analysis of Mexican crania. The literature review also found papers that used anthropometric measurements in the study of hybrids (Kelly 1947; Saksena 1974; Chung et al. 1986).

The determination of racial affiliation through the use of measurements of the cranium has been well recognized in the forensic community. In 1951, Howells authored a paper in which he addressed the factors of size and shape on the cranial vault. Howells was most concerned with differences among skulls of similar genetic makeup, rather than differences between populational groups. The author concludes that most of the variation in the cranium is accounted for in those measurements that relate to length, breadth, and height. Howells also mentions other regions of the skull that are important in determining size and shape: supraorbital ridges,

forehead breadth and height, the parietals, fullness of the lower occiput, and the breadth of the base of the auricular meatus.

In 1962, Giles and Elliot co-authored an important paper that was significant in the determination of populational classification through measurements and multivariate discriminant function analysis. In this paper, the authors were interested in determining the racial affiliation of White, Black, and Amerindian skulls. Eight (8) measurements were taken on two-hundred twenty-five (225) crania from the three abovementioned populational groups. Discriminant function formulas were calculated for the future categorization of skulls into one of these populational categories.

Jantz and Moore-Jansen (1988) published new alternative discriminant functions for a contemporary forensic sample of a geographically diverse nature. These new discriminant functions have been adjusted for a modern sample of individuals for racial classification; the worksheets from this publication were widely used in the Forensic Anthropology Class at the University of Tennessee-Knoxville.

Each of these studies have greatly added to our knowledge of differences between populational groups, yet we are still faced with the question of how to handle individuals of admixed ancestry.

The earliest study found to deal with anthropometrics and admixture is by Kelly (1947). The author studied prisoners at Blue Ridge prison of mixed Spanish-Indian ancestry. Anthropometric measurements were recorded for the whole body. A large portion of these measurements were related to the cranium. Kelly states that the individuals of mixed heritage tended to have broader skulls and

smaller face lengths when compared to individuals of unmixed groups.

Hanna (1962) examines the relationships of various Amerindian populations in the Southwest United States using both metric and serological techniques. The measurements used were taken by Hrdlicka in the early part of the century, and included head length, height, and breadth; lower facial height; forehead height; bigonial width; bizygomatic width; and nasal width. Hanna analyzed the measurements using Mahalanobis distance and canonical variates. He compared these results with blood group allelic frequencies, finding a positive correlation among measures of divergence based on the "blood and bones" method. Although this study relates more to biological distance relationships, it discusses the utility of comparing serological analyses with metric analyses to arrive at differences between populations.

An additional study that addresses hybrid individuals is a paper by Saksena (1974). This paper examines to what extent a multivariate discriminant function analysis will reflect morphological patterns of hybridization, using a Black-White admixed sample. In the past, the assessment of cranial morphological characteristics has largely been ignored (Saksena 1974); instead investigators have chosen to study monogenetic traits, as in allele frequencies in blood groups.

Saksena's ancestral groups are as follows: a White sample from Britian, a Black sample and a hybrid Black-White sample from the Todd collection. Nineteen (19) measurements and three (3) angles were used in the multivariate discriminant analysis and Mahalanobis

distances. Major contributors to group separation were upper facial height, cranial breadth, alveolar angle, nasal angle, nasal breadth, nasal length, total facial breadth, cranial base length, and facial height.

Saksena found the hybrid series to be twice as variable as either of the parental groups. The author concluded that morphological methods and serological methods to yield almost identical results with regard to amount of admixture. Assessing the degree of hybridization by the use of a multivariate analysis for morphological characteristics of crania is a reliable tool.

Chung et al. (1986) address the effects of admixture on cephalometric measurements. Racial differences in the morphology of the skull are well recognized, and cranial measurements do conform to genetic influences. This article investigates the effects of interracial crossing on measurements of the skull. Will a hybrid population be intermediate between the parental influences on it?

The data was collected from thirteen public schools in Hawaii; measurements taken were face height, bizygomatic diameter, bigonial diameter, head breadth, and head length. The analysis of racial effects on the cephalometric variables was based on an extended model of diallel cross, in which the race of a child was expressed as a function of parental races (Chung et al. 1986).

The only significant effect of hybridity on the children with regard to cephalometrics was found in bizygomatic diameter. When the hybridity was between the major races, the authors found that the bizygomatic breadth variable in Orientals to behave as a partially dominant trait.

Mexican Admixture Studies

Admixture studies on crania are sparse in the anthropological literature with respect to metric and morphological analyses. Even less abundant are studies on Mexican/Hispanic crania, a known hybrid group. Three unpublished papers have been written by this author addressing the topic of Mexican admixture.

The initial paper discussed a paper by Long et al. (1991) in detail, and compares those results to a multivariate discriminant analysis on crania from the Forensic Data Bank using fourteen (14) measurements. Prutsman predicts that Hispanic crania will behave as a hybrid group in a metric analysis, falling within an area consisting of the parental groups of Whites, Blacks, and Amerindians. Both serological analysis and craniometric analysis were in agreement that the Hispanic/Mexican group was a hybrid, with the highest amount of admixture from the White ancestral group.

A comparison of vault and face size between Hispanics and parental groups was investigated in a second paper by Prutsman. This study was designed as a supplement to the initial paper. Hispanic crania are a mixture of three parental groups (Whites, Blacks, and Amerindians), but tend to have smaller vault and face sizes than the other populations. Again, a sample from the Forensic Data Bank was used in the analysis, using a total of five (5) measurements to arrive at a geometric means equation which was then plotted.

The results of the analysis revealed that Hispanics have smaller vault sizes than the other populational groups, and have smaller face

size than Amerindians and Negroids. The author also mentions that vault and face size for Hispanics is most similar to the Black ancestral group, which may reflect a stronger ancestral relationship.

Each of the previous studies by Prutsman mention a need for further testing of the hybrid hypothesis on a similar sample. The author had the opportunity to measure the Spencer R. Atkinson Cranio-Osteological Collection at the Ward Museum in San Francisco. A portion of this collection originated from Mexico City; unfortunately all other provenience information on these skulls has been lost. This posed a challenge, and an opportunity to test a statistical method known as finite mixture analysis in a third paper.

Finite mixture analysis and discriminant function analysis were used to determine the sex of the seventy (70) Mexican crania from the Atkinson Collection. A visual sexing method was used upon the collection of cranial measurements. This method was compared with the finite mixture analysis results and a discriminant function analysis for sex using White crania from the Forensic Data Bank. Finite mixture analysis split the sample into even groups of male and female. The visual sexing technique showed a similar division between the sexes when compared to the White "control" group, which was skewed toward the female group. This supports the hypothesis that Mexican crania appear more gracile in both sexes.

A fourth paper is in progress for publication that is a condensed form of the three above papers, as well as portions of Chapter 5 discussing more recent statistical analyses of the Atkinson data.

CHAPTER 4

MATERIALS AND METHODS

The study of admixed populations requires an understanding of the ancestral populations that contribute to the formation of that particular hybrid. Without such a foundation, physical anthropologists would have no place to begin to test their hypotheses. In this thesis the hybrid population is Mexican, and the ancestral population consists of White, Black, Amerindian, and Hispanic individuals.

I was interested in studying the hybrid population that is so often termed "Hispanic". Some research into this idea revealed that there is no such biologically defined group! The word Hispanic is a descriptive term used to classify groups of people as Spanish-speaking; most commonly used by the U.S. Census Bureau. This term actually has no bearing on the people's ancestral heritage or genetic make-up. There are many groups that consider themselves "Hispanic", from Puerto Ricans and Cubans in New York City, to Mexican-Americans in Los Angeles, and every variation of ancestry that speak Spanish between the coasts.

I narrowed my study to concentrate on a sample of crania from Mexico City, referring to this population by their place of geographical origin rather than the language in which they spoke. Regardless of what these people are called, I still set out to test the hypothesis that this population is an admixture of three major parental populations of White, Black, and Amerindian.

The Samples

Spencer R. Atkinson Collection

The Spencer R. Atkinson Cranio-Osteological Collection at the Ward Museum contains over 1400 cataloged modern human crania from autopsy or biological warehouse specimens. The crania represent fifteen (15) countries worldwide; a large portion ($n=205$) is listed as originating from Mexico City. This collection bears the name of its founder, Spencer R. Atkinson, a prominent craniofacial growth and development researcher. The crania were collected between the 1920's and 1960's, consisting of autopsy and biological warehouse specimens. A valuable aspect of the collection is that it represents the largest growth series in the United States, ranging in age from fetal to seventeen (17) years (Galloway 1992). Adults in this collection are probably younger than individuals in the Terry and Todd collections, due to the emphasis on retaining people with complete dentitions. The collection is located at the University of the Pacific School of Dentistry in San Francisco.

Unfortunately, no provenience information for these crania is available. In most cases only a place of origin is noted. From the skulls listed as "Mexico", seventy (70) were chosen for this analysis. The following criteria had to be met for a specimen's inclusion in the sample. First, as mentioned above, the skull had to be designated in the cataloging as originating from Mexico. Secondly, only complete skulls with complete dentitions were considered. Finally, an age classification of adult based on the dentition (Steele and Bramblett 1988) was used to separate adults and juveniles, and

maxillary suture obliteration (Mann et al. 1991) was utilized to establish an age range for each individual.

Forensic Data Bank

The Forensic Data Bank at the University of Tennessee-Knoxville is a valuable resource for skeletal biology research. The data base contains over 850 records; approximately 60% are documented forensic cases (Moore-Jansen and Jantz 1989). Data has been received from contributors all around the country, and includes at least six populational groups.

I was interested in four major groups---White, Black, Amerindian, and Hispanic individuals, totaling five-hundred forty-seven (547) specimens from the Data Bank. Provenience information, as well as any other pertinent data is also stored in each individual's record. I was interested in adult males and females who were listed as White, Black, Amerindian, or Hispanic.

The Data

Seventy-five (75) measurements were taken on each cranium chosen from the Atkinson collection, utilizing standard procedures set forth by Howells (1973) and Jantz and Moore-Jansen (1989). University of Tennessee Forensic Data Bank recording sheets (see Appendix) were used for recording data. A rough estimation of age based on maxillary palatine suture closure (Mann et al. 1991), and a visual determination of sex based on morphological characteristics (Bass 1987) was noted for each specimen, plus any anomalies or prominent features that were apparent. The data collected from the

seventy (70) Atkinson specimens are presently stored in the National Forensic Data Bank at the University of Tennessee.

A total of six-hundred and eighty-seven (617) individuals (Figure 1) was analyzed using a core of twenty-one (21) measurements, sometimes known as the "forensic set". A list of these measurements is shown in Figure 2. The data were manipulated using several statistical analyses. Simple summary statistics for each populational group are shown in Tables A-1 through A-11 in the Appendix. A finite mixture analysis was carried out to designate sex for the Mexican group, since this information was unknown for the Atkinson sample. Multivariate discriminant analysis was helpful in separating the individuals into their respective populational groups. Mahalanobis distance scores were also obtained to show relationships among the groups. Lastly, an analysis of vault and face size among the groups further explores similarities and differences. The following Chapter 5 is dedicated to the explanation and discussion of the above stated statistical analyses.

RACE	SEX		TOTAL
	Male	Female	
Amerindian	46	29	75
Caucasian	144	132	276
Negroid	90	79	169
Hispanic	27	---	27
Mexican	35	35	70

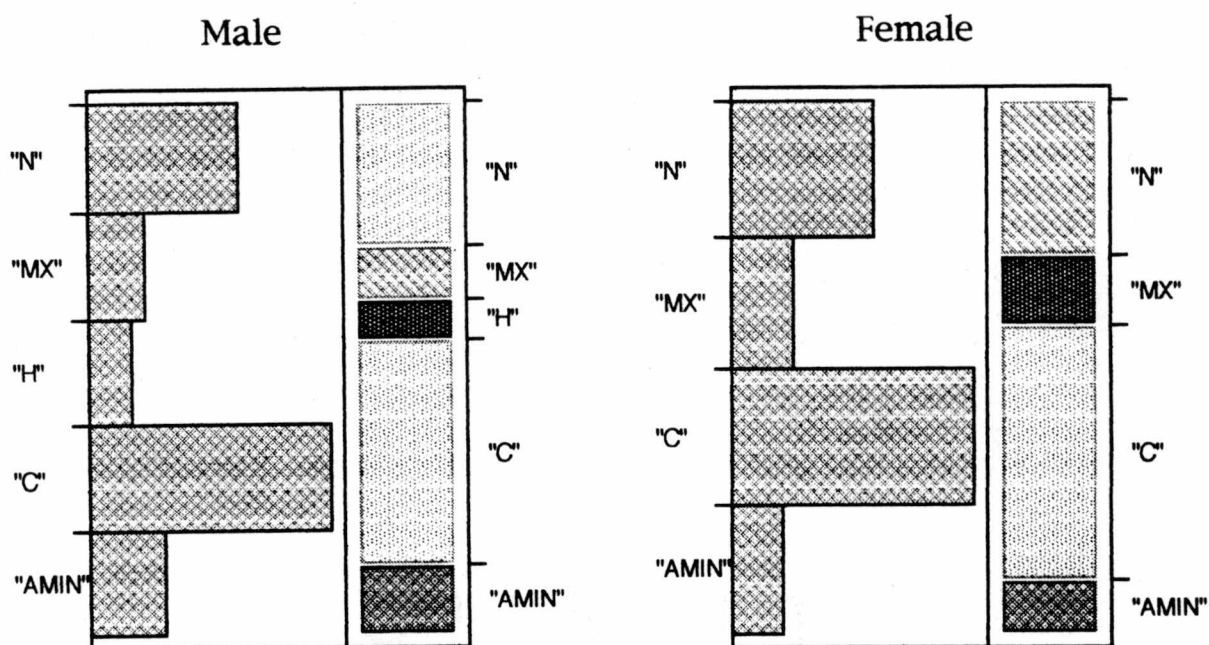


Figure 1. Population samples by group and gender.

*Maximum Cranial Length
 *Maximum Cranial Breadth
 Minimum Frontal Breadth
 **Bizygomaxillary Breadth
 Biauricular Breadth
 Nasal Height
 Nasal Breadth
 Exterior Palatal Breadth
 Exterior Palatal Length
 Orbital Height
 Frontal Chord
 Parietal Chord
 Occipital Chord
 Foramen Magnum Length
 *Basion-Bregma Height
 Cranial Base Length
 Basion-Prosthion Length
 **Upper Facial Height
 Orbital Breadth
 Biorbital Breadth
 Interorbital Breadth

Figure 2. "Forensic set" of cranial measurements.

*Measurements used for vault size

**Measurements used for face size

CHAPTER 5

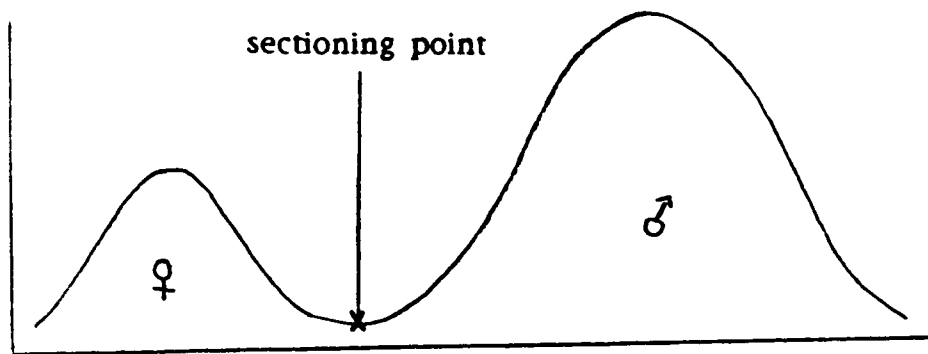
RESULTS

Finite Mixture Analysis

The lack of provenience information for the Spencer R. Atkinson data presented a challenge---the origin of the crania was listed in the cataloging as Mexico, but there was no information available on gender or ancestry. A morphological assessment of sex was made by the observer. However, this issue gave an opportunity to test a technique used in statistics: finite mixture analysis.

Mixture analyses are common statistical procedures, used to create groups among a number of entities where there is no prior information regarding the underlying group structure (MacLachlan and Basford 1988). This is the case when the morphological assessment made by the observer is ignored. It is known that there are two groups, male and female, but there is no prior information about the structure of the groups. Mixture analyses are also referred to as cluster analyses, since the goal of the procedure is to cluster the data into specific groups, making them as distinct and homogeneous as possible (Williams 1976).

The term "finite" comes from the number of groups that is being looked at, in this case, male or female. A "mixture" refers to the combined distributions of the discriminant scores of each observational unit, in this instance, each skull (see below).



In a finite mixture analysis, what is being sought is the sectioning point between the two distributions. The sectioning point, as well as the discriminant scores, are found through a discriminant function analysis. This procedure allows multivariate data on each observational unit to be simplified into one descriptive variable.

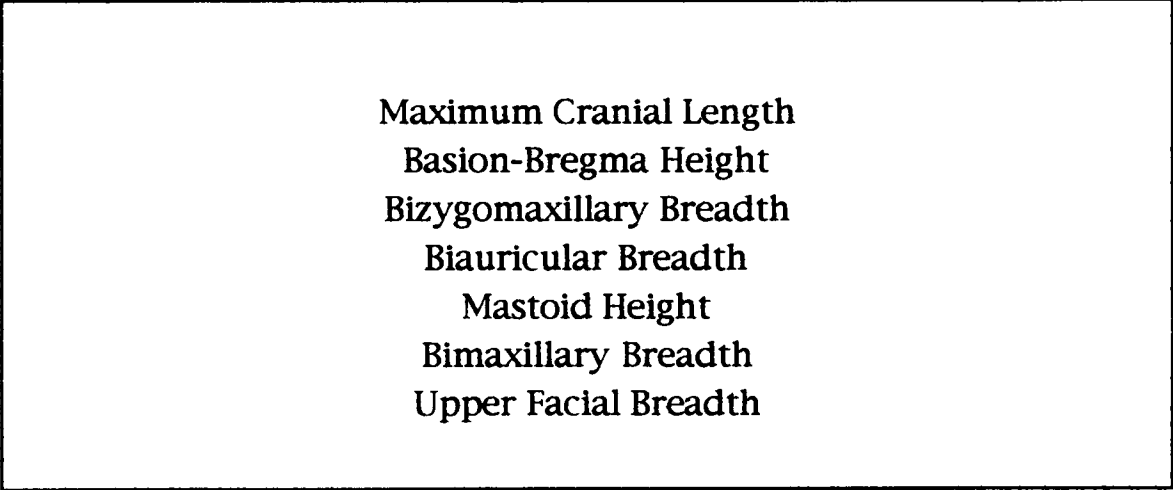
Seven measurements out of the seventy-five recorded for the Mexican sample were chosen for the analysis. These measurements (Figure 3) were selected on the basis of being good discriminators for sexing crania. Through a statistical discriminant analysis of the seven measurements, a discriminant value was calculated for each cranium (see Table 1).

The discriminant function analysis within the finite mixture analysis gave a value of 134.70 to serve as a sectioning point, allowing classification into one of two groups: males were located above the sectioning point with a mean score of 140.81, and females were below the point with a mean score of 128.60 (see below).

Female mean discriminant score: 128.60

Sectioning point: 134.70

Male mean discriminant score: 140.81



Maximum Cranial Length
Basion-Bregma Height
Bizygomaxillary Breadth
Biauricular Breadth
Mastoid Height
Bimaxillary Breadth
Upper Facial Breadth

Figure 3. Measurements used in finite mixture analysis.

A discriminant function analysis using the Forensic Data Bank was carried out for comparison with the Atkinson data finite mixture analysis results. The same procedure of simplifying multivariate data into a single descriptive score was used. Table 2 shows the results of the analysis. Here the sectioning point for sex was based on zero, positive values classify as male and negative values classify as female. The Atkinson crania were compared with the Caucasian reference sample from the Forensic Data Bank. Whites were chosen because they are the most well represented group in the Data Bank, and they have been shown to be the main contributor to the genetic makeup of the hybrid population of Mexicans (Long et al. 1991). Long et al. give admixture estimates of Mexican-Americans using a trihybrid model. According to the authors, ancestral contributions are 68% Spanish, 29% Amerindian, and 3% African for Arizona Mexican-Americans, based on single and multiple locus admixture.

Table 1. Finite mixture analysis results.

Specimen Number	Visual Sexing	Discriminant Score	P(fem)	P(male)
A223	F	139.97779	0.005286	0.994714
A224	F	127.37683	0.999368	0.000632
A225	M	139.10664	0.011573	0.988427
A226	M	139.47331	0.008500	0.991500
A241	F	142.58218	0.000357	0.999643
A245	F	136.74974	0.115040	0.884960
A248	M	137.05864	0.088379	0.911621
A254	F	126.40792	0.999761	0.000239
A255	M	141.47227	0.001133	0.998867
A296	M	144.76998	0.000042	0.999958
A297	F	128.49180	0.997916	0.002084
A301	M	148.04058	0.000002	0.999998
A303	F	128.55691	0.997789	0.002211
B11	F	140.06923	0.004750	0.995250
B118	M	140.54803	0.002850	0.997150
B12	M	130.92217	0.977781	0.022219
B13	M	142.40186	0.000451	0.999549
B177	F	127.89372	0.998900	0.001100
B186	F	129.84209	0.992481	0.007519
B187	F	125.13697	0.999929	0.000071
B189	F	124.79136	0.999952	0.000048
B192	F	122.47134	0.999995	0.000005
B195	F	140.34632	0.003513	0.996487
B196	M	134.88653	0.448318	0.551682
B197	F	123.60316	0.999985	0.000015
B199	M	129.25920	0.995751	0.004249
B201	F	126.25960	0.999788	0.000212
B202	F	129.69307	0.993840	0.006160
B210	F	138.09657	0.033593	0.966407
B216	M	130.25661	0.987621	0.012379
B218	F	129.23837	0.995723	0.004277
B219	F	125.34869	0.999918	0.000082
B220	F	121.87544	0.999997	0.000003
B221	F	128.04148	0.998702	0.001298
B223	F	129.40987	0.995199	0.004801
B224	F	126.13518	0.999808	0.000192
B225	F	142.42089	0.000412	0.999588
B293	M	140.74515	0.002513	0.997487
B310	F	131.30364	0.969998	0.030002
B38	F	138.08572	0.032555	0.967445
B56	F	140.18081	0.004355	0.995645
B59	M	135.49641	0.316969	0.683031
B83	M	148.17808	0.000001	0.999999
B87	F	129.38652	0.995392	0.004608

Table 1 (continued).

Specimen Number	Visual Sexing	Discriminant Score	P(fem)	P(male)
C10	M	143.99046	0.000085	0.999915
C100	M	140.01639	0.004970	0.995030
C11	F	143.79781	0.000114	0.999886
C112	F	123.22474	0.999990	0.000010
C12	M	134.58934	0.530531	0.469469
C127	F	145.19790	0.000028	0.999972
C131	F	130.92274	0.978084	0.021916
C137	F	126.19694	0.999794	0.000206
C144	M	133.33584	0.799456	0.200544
C152	F	128.47417	0.998072	0.001928
C160	F	131.70424	0.954430	0.045570
C166	M	137.38049	0.063776	0.936224
C167	F	146.66966	0.000006	0.999994
C18	M	131.94459	0.940018	0.059982
C189	F	129.29702	0.995848	0.004152
C20	M	129.68708	0.993265	0.006735
C22	F	132.04841	0.937107	0.062893
C26	M	143.55096	0.000142	0.999858
C27	M	142.64513	0.000367	0.999633
C35	M	138.07911	0.035047	0.964953
C38	M	147.35032	0.000003	0.999997
C49	F	136.29112	0.165667	0.834333
C52	F	137.40843	0.062516	0.937484
C59	M	137.37809	0.062019	0.937981
C62	F	129.72912	0.993474	0.006526
C90	M	137.76453	0.045263	0.954737

Table 2. Discriminant function analysis with Forensic Data Bank
Caucasian discriminant functions.

#	Sex	Age	GOL	BBH	ZYB	AUB	MDH	ZMB	UFBR	Score	DFSex
A296	M	30-35	181	142	137	126	32	95	108	8.79	M
CS9	M	30-35	169	142	137	131	31	98	104	7.88	M
A241	F	30-35	173	135	139	131	29	95	106	6.39	M
C35	M	40-50	182	144	131	125	32	100	109	5.84	M
B13	M	20-25	181	135	133	130	31	94	104	5.12	M
B83	M	30-35	181	138	134	121	30	95	104	5.05	M
A301	M	25-30	184	137	135	128	27	95	106	4.45	M
B118	M	30-35	178	136	131	123	32	90	103	4.14	M
B12	M	40-45	168	136	131	127	33	93	103	4.00	M
B59	M	20-30	175	134	130	124	32	93	105	2.63	M
A248	M	35-40	174	135	130	121	32	94	104	2.59	M
C167	F	25-30	180	132	134	123	28	97	106	2.31	M
B195	F	18-25	186	143	123	122	31	87	98	2.29	M
A226	M	30-40	173	127	134	119	32	91	108	2.15	M
A223	F	25-30	176	127	130	122	34	93	102	2.14	M
C11	F	20-30	181	131	131	122	30	94	105	1.7	M
C38	M	40-50	191	141	126	116	29	90	104	1.61	M
A225	M	30-35	177	138	129	123	28	88	102	1.48	M
C166	M	25-30	174	132	130	121	28	93	105	0.88	M
A255	M	30-35	178	136	129	122	28	93	102	0.85	M
C18	M	25-30	168	134	129	122	30	91	103	0.43	M
B216	M	30-35	158	132	134	126	27	92	103	0.4	M
B38	F	40-50	170	129	132	124	29	94	103	0.29	M
C49	F	20-25	168	131	132	122	28	92	104	0.1	M
B293	M	25-30	182	131	127	124	30	97	103	-0.06	F
B225	F	30-35	173	135	131	115	26	86	103	-0.39	F
C26	M	25-30	177	131	129	119	28	93	101	-0.42	F
C90	M	30-35	173	134	127	117	30	93	101	-0.48	F
C10	M	30-35	179	136	133	127	21	91	106	-0.53	F
C100	M	30-35	173	129	131	122	28	97	104	-0.61	F
B11	F	20-25	176	130	130	125	27	98	104	-0.9	F
C27	M	30-35	186	132	124	117	30	88	102	-1.32	F
A245	M	25-30	171	133	127	117	29	93	101	-1.45	F
C22	F	25-30	172	129	128	126	29	96	105	-1.49	F
C12	M	20-25	175	133	123	119	31	87	98	-1.52	F
B87	F	40-50	172	130	126	118	30	91	108	-2.64	F
C62	F	25-30	170	131	125	119	30	93	104	-2.7	F
C152	F	16-25	169	129	123	118	32	85	100	-2.78	F
C144	M	20-25	171	131	125	122	28	93	100	-3.02	F
B223	F	25-30	171	134	121	116	30	90	100	-3.8	F
C131	F	20-25	166	132	124	116	28	93	100	-4.31	F
B199	M	25-30	168	128	123	112	30	89	98	-5.22	F
C160	F	20-25	168	126	124	120	28	95	100	-5.33	F
CS2	F	16-25	170	131	125	116	24	95	100	-5.84	F
B310	F	20-25	174	133	119	112	29	93	101	-5.91	F
B185	F	20-25	160	127	123	120	29	94	96	-5.96	F
B56	F	20-25	185	128	119	116	28	86	100	-6.28	F
C20	M	25-30	160	128	125	112	25	89	101	-7.29	F
C189	F	35-40	171	129	120	114	28	92	103	-7.36	F
B201	F	25-30	166	123	121	113	29	83	100	-7.37	F
B219	F	20-25	164	131	118	112	28	92	98	-8.11	F
B202	F	18-25	175	132	115	112	28	91	97	-8.13	F
A254	F	20-25	171	131	117	116	27	87	100	-8.4	F
C137	F	18-25	171	130	119	112	25	78	102	-8.5	F
B196	M	20-30	168	129	122	114	23	89	98	-8.58	F
C127	F	30-35	171	97	130	121	28	90	99	-8.77	F
B220	F	16-20	163	135	118	117	24	89	99	-8.9	F
C112	F	16-25	177	129	114	112	29	81	104	-9.27	F
A297	F	25-30	164	127	121	116	23	84	98	-9.59	F
B197	F	20-25	161	126	119	113	26	87	99	-10.05	F
A224	F	20-25	171	121	119	113	27	82	103	-10.07	F
A303	F	25-35	165	130	119	111	23	83	98	-10.24	F
B210	F	30-35	170	118	121	110	26	91	97	-10.32	F
B218	F	30-40	166	129	118	115	22	88	96	-11.06	F
B187	F	20-25	161	123	121	116	23	85	100	-11.1	F
B177	F	18-25	167	126	114	112	24	84	93	-12.66	F
B221	F	16-25	170	128	115	109	21	80	99	-13.68	F
B189	F	20-30	162	121	117	112	22	88	99	-14.53	F
B224	F	25-35	159	121	113	105	25	81	90	-14.93	F
B192	F	25-30	153	112	114	109	20	87	93	-19.98	F

Figure 4 shows the results obtained from the finite mixture analysis and the discriminant function analysis by the Data Bank, compared to the morphological observations.

	Visual Sexing Technique	Finite Mixture Analysis	Discriminant Function
Males	29	35	24
Females	40	35	46
Unknown	1		
Total	70	70	70

Figure 4. Comparison of sexing methods.

The Finite Mixture Analysis split the groups evenly with regard to sex. These results are different from the Visual Sexing Technique and the Discriminant Function results. Visual Sexing and Discriminant Function show similar results as both are skewed toward the female gender. To the observer's eye, Mexican skulls appeared more gracile morphologically. The Discriminant Function method utilizing the White reference sample also yields a greater number of females due to the apparent gracility of Mexican skulls.

Finite mixture analysis and discriminant function analysis are two scientific statistical methods that can be utilized to determine sex of an unknown skull. These methods are valuable in that they can be compared to the visual morphological sexing method in order to test that technique's accuracy. Future testing of finite mixture analysis by "blind study" on material of known sex is needed to support this assumption.

Mahalanobis Distance

Mahalanobis distances show degrees of similarity between groups through numerical scores. The D squared statistic of Mahalanobis is used as a measure of biological divergence (Hanna 1962), and was originally designed for applications to continuous variables such as anthropometric measurements (Crawford et al. 1974). Groups that are dissimilar are represented by a high score, while similar groups have a low D squared value.

In Figure 5, the distance scores reveal the relationships between the populations. For males, the Mexican group is closest to Blacks due to the low value of 7.50. The distance of the other groups to the Mexican group can be compared, showing the next closest are Amerindians at 12.64, and finally Caucasians at 15.63. Again, Mexican females are closest to the Black group with the low score of 11.84, Caucasians follow at 15.89, and Amerindians at 15.95.

Multivariate Discriminant Function Analysis

Another statistical procedure that was helpful in my analyses was multivariate discriminant function analysis of craniometric data. This type of analysis is very useful when working with large data sets as it allows many variables to be manipulated and combined into a few very descriptive variables. A multivariate statistical method expresses variation with relation to the total morphological pattern in a single meaningful manner; many observation can be combined into one all-encompassing descriptive statistic (Saksena 1974).

Male

From RACE:	Generalized Squared Distance to RACE:			
	AMIN	C	N	MX
AMIN	0	14.57	11.86	12.64
C	14.57	0	12.73	15.63
N	11.86	12.73	0	7.50
MX	12.64	15.63	7.50	0

Female

From RACE:	Generalized Squared Distance to RACE:			
	AMIN	C	N	MX
AMIN	0	14.88	14.81	15.95
C	14.88	0	14.25	15.89
N	14.81	14.25	0	11.84
MX	15.95	15.89	11.84	0

Figure 5. Mahalanobis distances between populational groups.

Multivariate discriminant function analysis was used for analysis of the Forensic Data Bank sample and the Spencer R. Atkinson sample. Twenty-one (21) measurements (Figure 2) were chosen to assist in separating the skulls into different populational groups. These measurements are sometimes referred to as the "forensic set" (personal communication RL Jantz). The measurements tend to be the most influential in discriminating between populational groups, emphasizing the most important areas when looking for distinct traits that represent ancestral populations.

It is of interest to mention something about the variables (measurements) which separate the populational groups. In a previous study by the author (Prutsman nd), a canonical analysis was carried out using only Forensic Data Bank individuals (n=168). Figure 6 lists the fourteen (14) variables used, and Figure 7 shows the visual representation of the results.

Measurements that were significant in separating Negroids on Canonical Axis 1 were palate breadth, basion-bregma height, interorbital breadth, and basion-prosthion length. These findings agree with general knowledge on the shape of the Negroid skull---a lower and longer vault, a wide nasal aperture and a wider distance between the orbits. Three variables that separated Amerindians on Canonical Axis 2 are parietal chord, cranial base length, and minimum frontal breadth. Amerindian skulls are large, tending to be long and thin in appearance when looking at the frontal view. These results were intended to serve as a guideline for future similar analyses.

Cranial Base Length
Basion-Nasion Length
Basion-Bregman Height
Maximum Cranial Breadth
Minimum Frontal Breadth
Bizygomaxillary Breadth
Basion-Prosthion Length
Nasal Height
Palate Breadth
Orbital Breadth
Interorbital Breadth
Bistephanic Breadth
Parietal Chord
Foramen Magnum Breadth

Figure 6. Cranial measurements used in initial analysis.

A more recent discriminant function analysis was performed combining the Atkinson data (n=70) and the Forensic Data Bank data (n=547). A visual representation of the discriminant function analysis is the centriod plot seen in Figure 8. Two plots were obtained, one for males and one for females. These plots show the results of a multivariate canonical analyses for both sexes. In both plots, the hypothesis that Mexicans and Forensic Data Bank Hispanics are hybrids is supported. These two groups fall in the middle area of the "triangle" formed by the other three parental groups.

The male plot shows the Mexican group is most closely related to Blacks, next to Amerindians, and lastly Caucasians. The Hispanic group from the Forensic Data Bank is an excellent example of a hybrid population; included in this plot to show that they fall almost equidistant from their supposed parental groups of White, Black, and

Hispanic hybridization

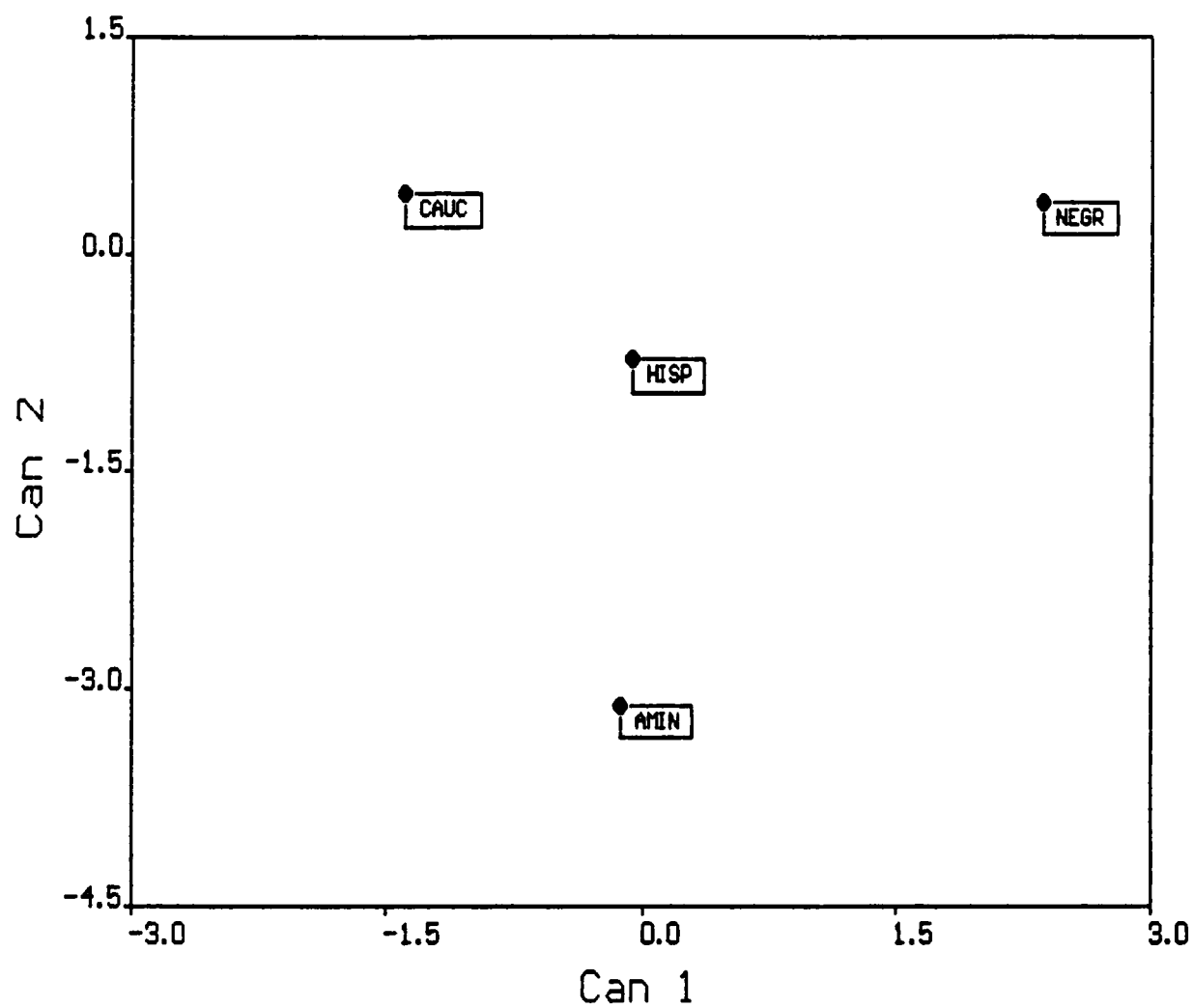


Figure 7. Initial canonical analysis plot, Forensic Data Bank.

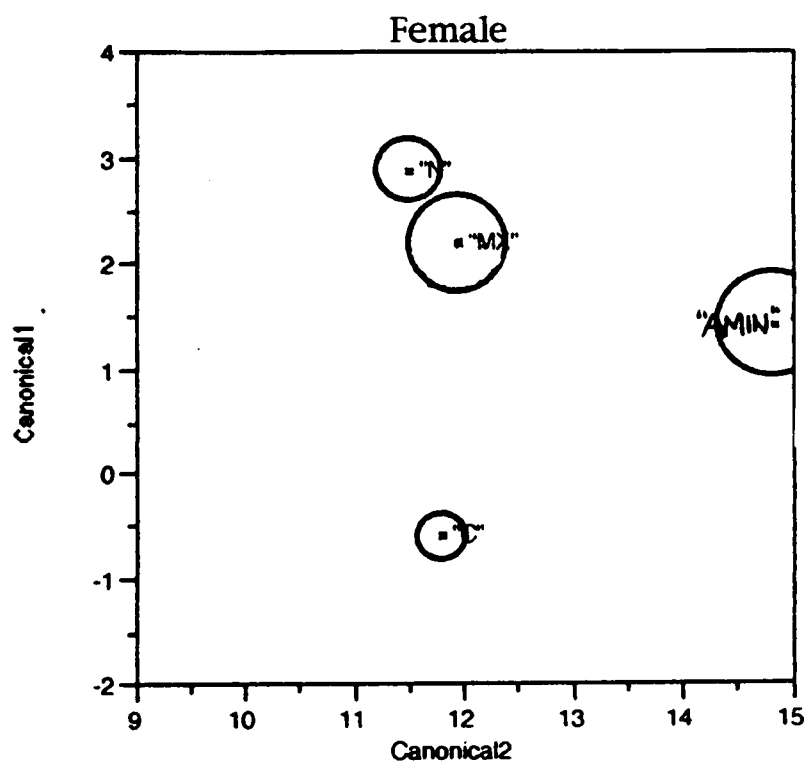
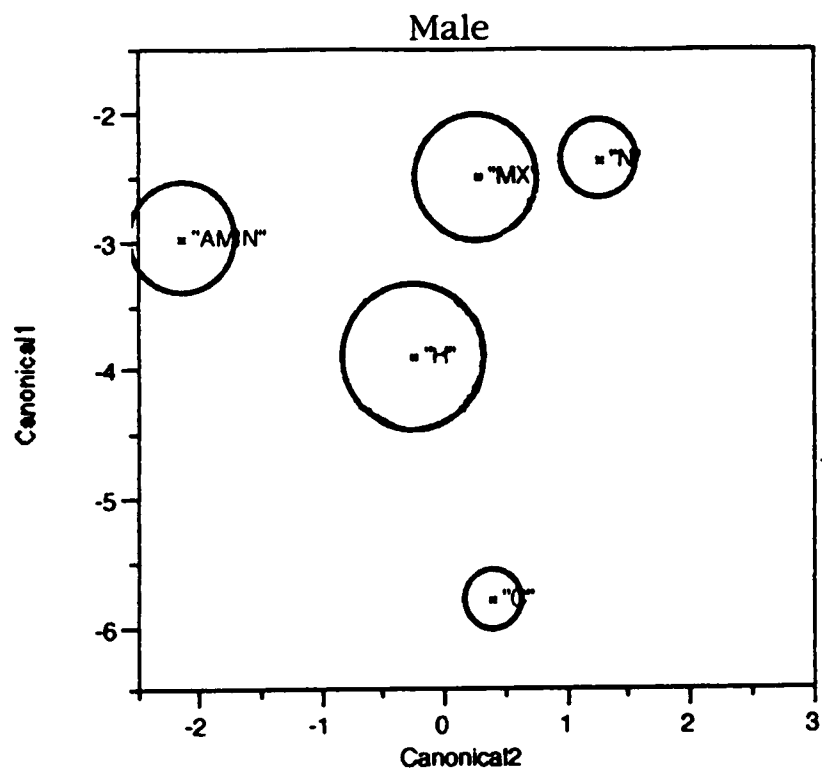


Figure 8. Centroid plots, male and female.

Amerindian. The small Hispanic group in the Forensic Data Bank is solely male, and geographically originates mainly from the southwest United States. The Mexican group shows similar hybrid tendencies, situated between the three ancestral groups, but doesn't represent as strong a hybrid as the Hispanics.

The female plot shows Mexicans are again closest to the Negroid group, then Caucasians, and lastly Amerindians. As mentioned previously, no Hispanic females are present in the Forensic Data Bank.

Figures 9 and 10 give the canonical coefficients of variables and the canonical scores of each population in the analysis. Figure 9 gives the scores for the male centroid plot in Figure 8. Negroids and Caucasians are separated on Canonical Axis 1; orbital height, bizygomaxillary breadth, and basion-prosthion length separate Blacks, maximum cranial length, basion-bregma height, and maximum cranial breadth separate Whites. Canonical Axis 2 shows Amerindians and Negroids on opposite sides of the plot. The variables that separate the blacks are interorbital breadth, foramen magnum length, and biorbital breadth. The variables that influence the positioning of Amerindians are basion-prosthion length, orbital breadth, and auricular breadth.

Figure 10 gives the canonical coefficients and scores for the female centroid plot seen in Figure 8. Again, Blacks and Whites are separated along Canonical Axis 1. Blacks are separated by the high values of basion-prosthion length, orbital height, and exterior palatal breadth. Whites are at the low end of Can 1; biauricular breadth,

Canonical Coefficients

Variable	Can 1	Can 2	Can 3	Can 4
GOL	-4.9407487	0.57356832	19.5702655	-5.9963258
XCB	-4.8630854	0.60199345	19.8073752	-5.0368292
WFB	-4.2456967	0.40989536	18.4256439	-5.5286165
ZYB	-3.2256211	-0.9725142	19.2144998	-6.5057186
AUB	-4.3160571	-0.7679435	17.9928289	-4.9025999
NLH	-4.280717	0.14841416	18.7962182	-4.7867511
NLB	-3.4650551	0.47398994	18.3101395	-5.8892497
MAB	-3.3942623	0.41593766	18.6569355	-5.1454962
MAL	-4.1914028	0.55980477	19.4790425	-4.622147
OBH	-2.6816993	0.4360813	18.3160173	-5.3016453
FRC	-3.5659157	0.17010547	18.6903489	-4.9575022
PAC	-3.8278746	0.60302597	18.7315095	-5.3531417
OCC	-3.5452591	0.44350653	18.1955819	-5.6545851
FOL	-4.342306	0.73025985	18.5139623	-5.4830922
BABR	-4.8854248	0.33026202	18.5127852	-5.4421273
BANA	-4.8119363	0.3027606	19.1766031	-5.5831735
BAPR	-3.0119627	-0.0065201	18.5124427	-4.9621817
UFHT	-3.5705596	0.14108837	18.7101281	-4.7705174
ORBR	-4.2835844	-0.228427	19.6449698	-4.6030918
BIOB	-4.1764338	0.64951849	20.1141448	-6.1645914
INTB	-3.361805	0.87025146	18.7094089	-5.1967083

Canonical Scores

Group	Can 1	Can 2	Can 3	Can 4
"AMIN"	-2.9720567	-2.129725	19.4491087	-5.4473701
"C"	-5.7920994	0.39847411	18.8816555	-5.4057225
"H"	-3.9038143	-0.2383074	17.8844161	-4.2064931
"MX"	-2.5059145	0.27288709	16.8752296	-5.7726105
"N"	-2.3658633	1.27751596	19.4339663	-5.2880028

Figure 9. Canonical coefficients and canonical scores, males.

Canonical Coefficients

Variable	Can 1	Can 2	Can 3
GOL	0.93609221	12.2151384	20.6808688
XCB	0.67873161	11.7756921	20.2411827
WFB	0.64969335	11.3313078	19.2003517
ZYB	1.54391192	13.0291487	19.3769445
AUB	-0.0638311	13.4336218	19.1759211
NLH	0.67012116	11.9295242	18.5919672
NLB	1.55105121	12.3700821	18.9697175
MAB	1.86891931	12.016762	19.0343371
MAL	0.47375289	12.2829765	20.895531
OBH	1.97590352	11.7833435	19.1240576
FRC	1.17186838	12.0619041	19.6751537
PAC	1.06871171	11.6478649	19.4036255
OCC	1.05495686	11.5904125	19.3469552
FOL	0.80225708	12.0861839	19.242273
BABR	0.33022575	11.8132913	18.8726242
BANA	0.12803874	12.6400358	19.4617245
BAPR	2.13707611	11.5401124	19.4676639
UFHT	0.6611931	12.3722235	19.6618297
ORBR	0.90259145	12.5488032	20.6417029
BIOB	0.57974864	12.0344304	20.3209749
INTB	1.5732447	11.9950976	19.5671525

Canonical Scores

Group	Can 1	Can 2	Can 3
"AMIN"	1.4113223	14.8275416	19.7228561
"C"	-0.6010058	11.8066672	19.5055165
"MX"	2.1866092	11.9546305	17.3963879
"N"	2.88177636	11.5073583	20.0822534

Figure 10. Canonical coefficients and canonical scores, females.

cranial base length, and basion-bregma height are the most influential measurements. Canonical Axis 2 separates Blacks and Amerindians as in the male centroid plot. The variables that account for the separation of Blacks are minimum frontal breadth, maximum cranial breadth, and basion-prosthion length. The Amerindian group is influenced by biauricular breadth, bizygomaxillary breadth, and cranial base length.

The contents of each of the lower boxes in Figures 9 and 10 show the canonical scores for each of the populational groups. Can 1 and Can 2 values relate to the positioning of the respective groups on the centroid plots in Figure 8.

Figure 9 and 10 contain additional Canonical Axes that were not discussed in the text above. These Axes exist, but are unable to be graphically depicted in this plot. They are descriptive of the variables, but are to a lesser degree when compared with Can 1 and Can 2.

Cross- validation classification matrix

The cross-validation classifications give an unbiased value for each race by giving the percentage of correctness rate, or the number of individuals that were classified correctly in the analyses. Figure 11 shows 91% of Caucasians were correctly classified for the male group, as well as 84% of Amerindians, 78% of Negroes, and 74% of Mexicans. For females, Figure 11 shows 93% of Whites were correctly classified, followed by 89% of Mexicans, 86% of Blacks, and 82% of Amerindians. These results support that in both sexes Mexicans can be discriminated as well as the other groups, but especially so in the female group.

Male

Percent Classified into RACE:				
From RACE:	AMIN	C	N	MX
AMIN	84.44	4.44	4.44	6.67
C	3.52	90.85	2.11	3.52
N	5.56	8.89	77.78	7.78
MX	8.57	5.71	11.43	74.29

Female

Percent Classified into RACE:				
From RACE:	AMIN	C	N	MX
AMIN	82.14	3.57	3.57	10.71
C	1.60	92.80	1.60	4.00
N	5.13	2.56	85.90	6.41
MX	8.57	0.00	2.86	88.57

Figure 11. Cross-validation matrix, males and females.

Another point to mention about the cross-validation matrix is the percentages of misclassifications in the Mexican group. Mexicans are misclassified as Blacks most frequently in the male group---11% were misclassified. Only 3% of females were misclassified as belonging to the Negroid group. These results show that the Mexican group most closely resembles the Black group (especially so in males), supporting the findings discussed earlier in this chapter.

Vault and Face Size Comparison

An interesting observation became apparent when measuring the Atkinson collection. Mexican crania are much more gracile than the other groups observed in this study. Morphologically, the Mexican group tended to have smaller crania and have gracile features. Mexican crania tend to be smaller and rounder, similar to Black crania, and not especially close to Amerindian or Caucasian skulls. Morphologically, White and Amerindian faces tend to be long and large, while Mexicans, Hispanics and Blacks have smaller, rounder and more gracile crania.

These observations can be supported by the centroid plots and Mahalanobis distances discussed above. In another statistical analysis, vault and face sizes were compared between the Mexican/Hispanic group, Caucasians, Amerindians, and Blacks. The Mexican and Hispanic groups were combined due to the similarity of the groups, and the male-only nature of the Hispanic group.

Geometric Means Equation

The cranio-facial complexes of the skulls can be demonstrated through an analysis of five (5) measurements (see Figure 2) using two (2) log geometric means equations:

$$\text{Log vault size} = \frac{1}{3} (\log \text{ GOL} + \log \text{ XCB} + \log \text{ BBH})$$

$$\text{Log face size} = \frac{1}{2} (\log \text{ ZYB} + \log \text{ UFHT})$$

Maximum Cranial Length, Maximum Cranial Breadth, and Basion-Bregma Height measurements contributed to the determination of vault size, whereas Bizygomaxillary Breadth and Upper Facial Height were used for the calculation of face size. Values obtained for each equation are located in Table 3.

Figure 12 shows the plotted values of the geometric means for each populational group. There is a definite separation among male and female skulls, as males have larger vault and face sizes than females. Also apparent in this plot is the location of the Mexican skulls within each gender cluster. Both male and female Mexican skulls are smaller than the other groups within their own sex.

Overall, Amerindians tend to have large faces and Caucasians have relatively large vaults (see Figure 12). Mexicans, Negroids, and Hispanics have intermediate vault and face sizes: smaller faces and larger vaults than Amerindians, yet larger faces and smaller vaults than Caucasians. These observations continue to demonstrate the similarity of Negroid and Mexican/Hispanic crania.

Table 3. Vault and face size coordinates.

Race	Male		Female	
	Vault	Face	Vault	Face
Amin	5.0150	4.6260	4.9891	4.5758
Caucasian	5.0442	4.5724	4.9969	4.5106
Hispanic	5.0117	4.5826	---	---
Mexican	4.9902	4.5587	4.9509	4.4955
Negroid	5.0164	4.5932	4.9745	4.5720

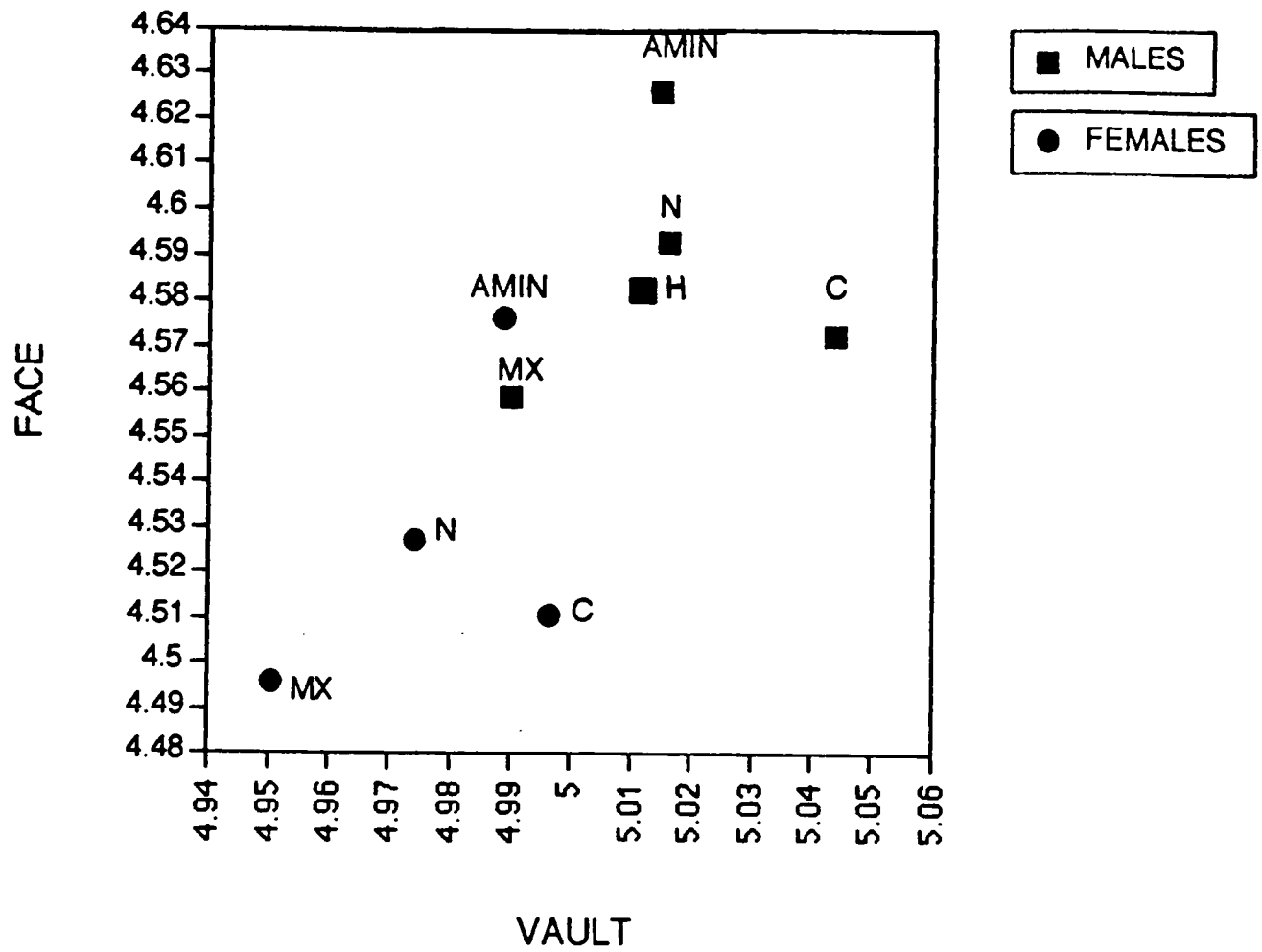


Figure 12. Geometric means plot of vault and face size.

CHAPTER 6

CONCLUSION

Forensic anthropologists have found themselves facing a new challenge in recent years---the identification of individuals that claim ancestry from two or more genetically different populations. Admixture between populational groups with distinct identifying characteristics creates a variable hybrid group.

This thesis has discussed one such group; the well-established population of Mexico. People that claim parentage from Caucasian, Amerindian, and African-American ancestors in varying degrees may have typical features of a Mexican populational group. These people are often described (in the American society) as "Hispanic". This term only serves to identify the populational group by the language that is spoken and tends to overlook actual racial designation.

I have shown that a Mexican sample from the Spencer R. Atkinson Cranio-Osteological Collection and the Hispanic group (as so identified) in the Forensic Data Bank to act as hybrid groups from White, Amerindian, and Black parental groups. The next step in this investigation is to develop a discriminant function for the Mexican group, based on the discriminant functions of the parental groups.

In the finite mixture analysis (Chapter 5), a discriminant function analysis of Mexican crania was carried out with a White discriminant function. This method was sufficient for the analysis;

only two other disriminants were available for use (i.e. Amerindian and Black), and the hybrid group has been shown to contain larger amounts of White ancestry (Long et al. 1991, Prutsman 1991). A conflicting arguement to this statement has become apparent in my canonical analysis of the Atkinson data. The Mexican hybrid group tended to be more similar to the Black ancestral component than to the other groups. Galloway (1992) suggests that there is a large number of crania in the Atkinson Collection (total n=1400) which reflect Negroid ancestry (mostly males). Perhaps the Mexican group does have a higher proportion of Black ancestry than from the other groups. High frequencies of African genes have been found in populations of Mexico (Crawford et al. 1986; Lisker et al. 1986). Lisker et al. (1988) found an uncommonly high frequency of African alleles (10.7%) in the City of Puebla.

These results may point to several conclusions. When assessing the hybridity or estimating admixture of a population, geographical distances from surrounding populations, as well as the history of the population under investigation must be taken into account. It is important to know something about the ancestral/parental influences at work on the hybrid.

Mestizos in Mexico City are not only numerous, but extremely diverse in ancesrty. Varying degrees of Spanish, Amerindian, and African ancestry have been accounted for in this population. Lisker et al. (1986) comment that it may be impossible to investigate a representative sample of Mexico City due to its diversity. Socioeconomic stratifications are another important factor to keep in mind when studying populational groups.

We know not the exact origin of the specimens in the Spencer R. Atkinson Cranio-Osteological Collection. The similarity I found between the Atkinson sample and the Black ancestral component most likely reflects a high degree of African ancestry, similar to results obtained by Crawford et al. (1986) and Lisker et al. (1988, 1986).

The problem of sexing the Atkinson data is another obstacle. There is no way to test the accuracy of visual methods or other statistical means, since no provenience information is available. One way to remedy this situation would be to find a Mexican sample of known sex, age, and place of origin, and compare the Atkinson group to these individuals. This process would also be used in the development of a discriminant function for Mexicans mentioned above.

The previous suggestion therefore necessitates the continued research on Mexican crania. To gain more knowledge on Mexicans would assist in better understanding all hybrid groups, since generalizations could be inferred from population to population.

More individuals await measurement and classification at the Ward Museum at the University of the Pacific School of Dentistry in San Francisco. I was able to measure only seventy (70) out of the two-hundred and five (205) listed as originating from Mexico City, due to time constraints. The inclusion of the rest of this sample into the Forensic Data Bank at the University of Tennessee, as well as having a record of these measurements for the Ward Museum is of great importance to any researcher interested in the collection.

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APPENDIX

Figure A-1. Forensic Data Bank data recording sheets.

H-2/1989 (after P/K - 1986/H-J - 1986)

Record No.: R _ _ _ FDI: _ _ _ _ Ent.: _ _ _

CRANIAL MEASUREMENTS

Skull ID.: _____ Id. name: _____ Sex: _____ Positive Id.: _____
 Collect.: _____ Means Id.: _____ Sista: _____ Place of Birth: _____
 Observer: _____ Site/Loc.: _____ Race: _____ Date of Birth: / /
 Recorder: _____ Ethn/Trib: _____ Rstat: _____ Place of Death: _____
 Date Rec: / / 19 Period: _____ Age: _____ Date of Death: / /

Pts. damaged PR MA BR LA OP BA BK EX ZH NI ZY _____ Deform/Path: _____
 (Spreading Calipers):

1. GOL Glab-occipital l: _ _ _ 33. IML Malar l, inferior: _ _ _
 2. MOL Nasion-occipit l: _ _ _ 34. IML Malar l, maxinus: _ _ _
 3. BML Basion-nasion l: _ _ _ 35. MLS Malar Subtense: _ _ _
 4. BBN Basion-bregma h: _ _ _ 36. WPH Cheek ht, minous: _ _ _
 5. ICD Max Cranial br: _ _ _ 37. SOS Supraorb project: _ _ _
 6. IFB Max Frontal br: _ _ _ 38. GLS Glabella projection: _ _ _

(Sliding Calipers):

7. WFB Min Frontal br: _ _ _ 41. FRC Frontal chord: _ _ _
 8. ZYB Bizygomax br: _ _ _ 42. FRS Frontal subtense: _ _ _
 9. AUB Biauricular br: _ _ _ 43. FRF Frontal fraction: _ _ _
 10. MCB Min Cranial br: _ _ _ 44. PAC Parietal chord: _ _ _
 11. ASB Diasternum: _ _ _ 45. PAS Parietal subtense: _ _ _
 12. BPL Basion-prosthion: _ _ _ 46. PAF Parietal fraction: _ _ _
 13. MPH Nasion-prosthion: _ _ _ 47. OCC Occipit. chord: _ _ _
 14. MLH Nasal height: _ _ _ 48. OCS Occipit. subtense: _ _ _
 15. JUB Bijugal breadth: _ _ _ 49. OCF Occipital fraction: _ _ _
 16. MLD Nasal breadth: _ _ _
 17. MAD Ext. palatal br: _ _ _
 18. PAL Ext palatal l: _ _ _
 19. MDH Mastoid height: _ _ _
 20. MDB Mastoid breadth: _ _ _

(Dial Calipers):

21. ODB Orbital height: _ _ _ 52. MAR Nasion radius: _ _ _
 22. ODB Orbital breadth: _ _ _ 53. SSR Subspinale radius: _ _ _
 23. BKB Interorbital br: _ _ _ 54. PRP Prosthion radius: _ _ _
 24. BKS Nas-dacryon subt: _ _ _ 55. BKR Dacryon radius: _ _ _
 25. WNB Sinoitic chord: _ _ _ 56. ZDR Zygorebit radius: _ _ _
 26. SIS Sinoitic subtense: _ _ _ 57. FNR Frontomalar radius: _ _ _
 58. EKR Ectoconchion radius: _ _ _
 59. ZNR Zygomaxillare rad: _ _ _
 60. AVR H1 Alveolar radius: _ _ _
 61. BRP Bregma radius: _ _ _
 62. VOR Vertex radius: _ _ _
 63. LAR Lambda radius: _ _ _
 64. OSR Opisthion radius: _ _ _
 65. BAR Basion radius: _ _ _

(Coordinate Calipers):

27. ZNB Biaxillary br: _ _ _
 28. SSS Zygo-nas subtense: _ _ _
 29. FNB Bifrontal breadth: _ _ _
 30. MAS Nasio-frontal sub: _ _ _
 31. EKB Biorbital breadth: _ _ _
 32. BKS Dacryon subtense: _ _ _

FORENSIC

DATA BANK MEASUREMENTS:

70. MPR Nasion-prosth: _ _ _
 71. FNT Upper face br: _ _ _

MANDIBULAR MEASUREMENTS:

(Sliding Calipers):

75. GNI Symphysis ht: _ _ _
 78. GDB Bigonial br: _ _ _
 79. CBL Bicondylar br: _ _ _
 80. MRL Min Ramus br: _ _ _

(Handibulometer):

84. IRL Max Ramus ht: _ _ _
 85. MLT Mandibular lt: _ _ _
 86. MAN Mandib angle: _ _ _

COMMENTS:

Table A-1. Summary statistics, total males.

Variable	N	Sum	Mean	Std Dev
GOL	342	63042	184.3333	7.9971
XCB	342	47778	139.7018	6.1055
WFB	342	33070	96.6959	4.9751
ZYB	342	45182	132.1111	6.6150
AUB	342	42323	123.7515	6.3324
NLH	342	17930	52.4270	3.0392
NLB	342	8498	24.8480	2.3481
MAB	342	21961	64.2134	4.9054
MAL	342	18621	54.4474	4.0497
OBH	342	11739	34.3246	2.2608
FRC	342	38332	112.0819	5.4223
PAC	342	39727	116.1608	7.5489
OCC	342	33297	97.3596	6.1279
FOL	342	12546	36.6842	2.5051
BABR	342	46876	137.0643	6.7483
BANA	342	35343	103.3421	5.2507
BAPR	342	33915	99.1667	6.4928
UFHT	342	24686	72.1813	4.2298
ORBR	342	14135	41.3304	2.6014
BIOB	342	33721	98.5994	4.4511
INTB	342	7814	22.8480	2.9413

Table A-2. Summary statistics, Amerindian males.

Variable	N	Sum	Mean	Std Dev
GOL	46	8277	179.9348	8.6956
XCB	46	6579	143.0218	6.7247
WFB	46	4468	97.1304	5.7912
ZYB	46	6531	141.9783	6.0571
AUB	46	6080	132.1740	5.3554
NLH	46	2482	53.9565	3.5712
NLB	46	1196	26.0000	2.0221
MAB	46	3058	66.4783	3.9482
MAL	46	2528	54.9565	3.2319
OBH	46	1627	35.3696	2.8780
FRC	46	5091	110.6739	5.2113
PAC	46	5037	109.5000	7.5535
OCC	46	4314	93.7826	5.5052
FOL	46	1678	36.4783	2.6478
BABR	46	6113	132.8913	5.6420
BANA	46	4745	103.1521	4.9887
BAPR	46	4629	100.6304	5.3763
UFHT	46	3396	73.8261	5.3595
ORBR	46	1975	42.9348	2.1848
BIOB	46	4689	101.9348	3.9463
INTB	46	1037	22.5435	2.8652

Table A-3. Summary statistics, Caucasian males.

Variable	N	Sum	Mean	Std Dev
GOL	144	26960	187.2223	7.4378
XCB	144	20342	141.2639	5.4246
WFB	144	14047	97.5486	4.7802
ZYB	144	18768	130.333	5.1318
AUB	144	17795	123.5764	5.0737
NLH	144	7580	52.6389	2.7523
NLB	144	3421	23.7570	2.0148
MAB	144	8837	61.3681	4.6225
MAL	144	7649	53.1181	3.7276
OBH	144	4845	33.6458	2.0086
FRC	144	16400	113.8889	5.1442
PAC	144	7054	118.4306	6.7333
OCC	144	14315	99.4097	5.7493
FOL	144	5371	37.2986	2.3507
BABR	144	20343	141.2708	5.2799
BANA	144	15183	105.4375	5.0143
BAPR	144	13959	96.9375	6.2893
UFHT	144	10310	71.5972	3.9654
ORBR	144	6029	41.8681	2.5344
BIOB	144	14055	97.6042	3.7252
INTB	144	3129	21.7292	2.3570

Table A-4. Summary statistics, Hispanic males.

Variable	N	Sum	Mean	Std Dev
GOL	27	4848	179.5556	5.6795
XCB	27	3737	138.4076	4.5341
WFB	27	2530	93.7037	4.6560
ZYB	27	3492	129.3333	5.0612
AUB	27	3323	123.0741	5.4556
NLH	27	1436	53.1852	2.6608
NLB	27	643	23.8148	1.9223
MAB	27	1733	64.1852	3.5414
MAL	27	1456	53.9259	2.9991
OBH	27	936	34.6667	2.5570
FRC	27	3012	111.5556	4.6437
PAC	27	3038	112.5185	6.0216
OCC	27	2597	96.1852	6.3187
FOL	27	975	36.1111	2.3425
BABR	27	3680	136.2963	4.9366
BANA	27	2724	100.8889	3.7245
BAPR	27	2623	97.1481	4.1666
UFHT	27	1991	73.7407	3.0076
ORBR	27	1092	40.4444	1.5525
BIOB	27	2560	94.8148	3.1013
INTB	27	573	21.2222	1.8467

Table A-5. Summary statistics, Mexican males.

Variable	N	Sum	Mean	Std Dev
GOL	35	6186	176.7429	5.8074
XCB	35	4713	134.6571	5.9505
WFB	35	3270	93.4286	3.5087
ZYB	35	4543	129.8000	4.5491
AUB	35	4252	121.4857	5.0022
NLH	35	1767	50.4857	3.3552
NLB	35	892	25.4857	1.8848
MAB	35	2272	64.9143	3.3727
MAL	35	1810	51.7143	2.9263
OBH	35	1216	34.7429	1.5594
FRC	35	3807	108.7714	4.7470
PAC	35	3918	111.9429	6.5571
OCC	35	3398	97.0857	5.0198
FOL	35	1249	35.6857	2.6432
BABR	35	4681	133.7429	5.3211
BANA	35	3449	98.5429	3.6890
BAPR	35	3357	95.9143	4.4943
UFHT	35	2438	69.6571	3.8113
ORBR	35	1330	38.0000	1.3504
BIOB	35	3331	95.1714	3.0916
INTB	35	813	23.2286	2.5447

Table A-6. Summary statistics, Negroid males.

Variable	N	Sum	Mean	Std Dev
GOL	90	16771	186.3444	6.1992
XCB	90	12407	137.8555	5.4351
WFB	90	8755	97.2778	4.6472
ZYB	90	11848	131.6444	5.5957
AUB	90	10873	120.8111	5.6487
NLH	90	4665	51.8333	2.6658
NLB	90	2346	26.0667	2.3454
MAB	90	6061	67.3444	4.0144
MAL	90	5178	57.5333	3.7000
OBH	90	3115	34.6111	2.1395
FRC	90	10022	111.3556	5.5004
PAC	90	10680	118.6667	6.4022
OCC	90	8673	96.3667	6.2683
FOL	90	3273	36.3667	2.4747
BABR	90	12059	133.9889	6.6290
BANA	90	9242	102.6889	4.9958
BAPR	90	9347	103.8556	5.8127
UFHT	90	6551	72.7889	3.8730
ORBR	90	3709	41.2111	2.3203
BIOB	90	9086	100.9556	4.1649
INTB	90	2262	25.1333	2.8959

Table A-7. Summary statistics, total females.

Variable	N	Sum	Mean	Std Dev
GOL	275	48588	176.6834	7.4641
XCB	275	37059	134.7600	9.7000
WFB	275	25555	92.9273	4.2967
ZYB	275	33682	122.4800	5.5738
AUB	275	32163	116.9564	5.5255
NLH	275	13478	49.0110	4.2697
NLB	275	6495	23.6182	2.2964
MAB	275	16584	60.3055	4.5548
MAL	275	14221	51.7127	5.0848
OBH	275	9325	33.9091	2.1788
FRC	275	29571	107.5310	4.8940
PAC	275	30897	112.3527	7.4601
OC	275	26169	95.1600	5.8935
FOL	275	9692	35.2436	2.6003
BABR	275	35899	130.5418	5.8373
BANA	275	26779	97.3782	4.5276
BAPR	275	25950	94.3636	6.1619
UFHT	275	18542	67.4255	4.1343
ORBR	275	10807	39.2981	3.2609
BIOB	275	25904	94.1964	3.9823
INTB	275	5941	21.6036	2.5529

Table A-8. Summary statistics, Amerindian females.

Variable	N	Sum	Mean	Std Dev
GOL	29	5144	177.3790	6.4499
XCB	29	4002	138.0000	5.9881
WFB	29	2668	92.0000	3.666
ZYB	29	3835	132.2414	5.4619
AUB	29	3660	126.2067	4.9308
NLH	29	1503	51.8276	2.6196
NLB	29	739	25.4828	1.9932
MAB	29	1829	63.0690	3.7884
MAL	29	1543	53.2069	2.9448
OBH	29	1016	35.0345	1.8989
FRC	29	3133	108.0345	4.7244
PAC	29	3131	107.9655	5.4148
OCC	29	2724	93.9310	5.2572
FOL	29	1051	36.2414	2.6140
BABR	29	3757	129.5517	5.5459
BANA	29	2889	177.3793	3.4060
BAPR	29	2802	96.6207	4.3046
UFHT	29	2052	70.7586	3.3237
ORBR	29	1189	41.0000	2.5071
BIOB	29	2846	98.1379	4.0242
INTB	29	645	22.2414	1.9577

Table A-9. Summary statistics, Caucasian females.

Variables	N	Sum	Mean	Std Dev
GOL	132	23477	177.8561	6.9306
XCB	132	17900	135.6062	12.7793
WFB	132	12342	93.5000	3.9472
ZYB	132	15977	121.0379	3.9874
AUB	132	15399	116.6591	4.0734
NLH	132	6486	49.1364	5.1419
NLB	132	2944	22.3030	1.8614
MAB	132	7608	57.6364	3.8863
MAL	132	6652	50.3940	3.1399
OBH	132	4384	33.2121	2.2310
FRC	132	14347	108.6894	4.6857
PAC	132	14983	113.5076	7.0011
OCC	132	12777	96.7955	5.4685
FOL	132	4693	35.5530	2.6336
BABR	132	17603	133.3561	5.2176
BANA	132	12978	98.3182	4.4401
BAPR	132	12082	91.5303	5.0410
UFHT	132	8835	66.9318	3.9946
ORBR	132	5226	39.5909	3.9712
BIOB	132	12311	93.2652	3.3221
INTB	132	2713	20.5530	2.3616

Table A-10. Summary statistics, Mexican females.

Variable	N	Sum	Mean	Std Dev
GOL	35	5841	166.8857	5.5560
XCB	35	4615	131.8571	5.3420
WFB	35	3147	89.9142	4.0174
ZYB	35	4235	121.000	5.0059
AUB	35	4042	115.4857	4.9430
NLH	35	1690	48.2857	3.3744
NLB	35	858	24.5142	1.9759
MAB	35	2175	62.1428	3.6067
MAL	35	1710	48.8571	3.4483
OBH	35	1199	34.2571	2.0485
FRC	35	3636	103.8857	3.8939
PAC	35	3756	107.3143	6.0913
OCC	35	3250	92.8571	5.0651
FOL	35	1210	34.5714	2.1321
BABR	35	4503	128.6571	4.3110
BANA	35	3271	93.4571	3.5674
BAPR	35	3231	92.3143	5.2958
UFHT	35	2293	65.5143	4.3816
ORBR	35	1286	36.7429	1.5782
BIOB	35	3186	91.0286	3.4083
INTB	35	750	21.4286	1.7199

Table A-11. Summary statistics, Negroid females.

Variable	N	Sum	Mean	Std Dev
GOL	79	14126	178.8101	6.0406
XCB	79	10542	133.4430	4.5028
WFB	79	7398	93.6456	4.6217
ZYB	79	9635	121.9620	4.5388
AUB	79	9062	114.7089	4.6854
NLH	79	3799	48.0886	2.8519
NLB	79	1954	24.7342	1.9329
MAB	79	4972	62.9367	3.6421
MAL	79	4316	54.6329	7.0641
OBH	79	2726	34.5063	1.8665
FRC	79	8455	107.0253	4.9041
PAC	79	9027	114.2658	7.8719
OCC	79	7418	93.8987	6.4502
FOL	79	2738	34.6582	2.5665
BABR	79	10036	127.0380	5.1997
BANA	79	7641	96.7215	4.2994
BAPR	79	7835	99.1772	5.5672
UFHT	79	5362	67.8734	3.8108
ORBR	79	3106	39.3165	1.8366
BIOB	79	7561	95.7088	3.4978
INTB	79	1833	23.2025	2.4981

VITA

Jennifer Jill Prutsman was born in Lackawanna, New York on October 8, 1969. She attended Cattaraugus Central School, and graduated Salutatorian in 1987. She graduated from Wells College in May 1991, receiving the degree of Bachelor of Arts in Anthropology, Environmental Science, and Economics. During an internship with Dr. Janice Ross in Auburn, New York, Jennifer became interested in forensic medicine. After taking a forensic anthropology course with Dr. Kenneth Kennedy at Cornell University, she entered the University of Tennessee-Knoxville in August 1991. She received a Master of Arts degree in Physical Anthropology in August 1994.

Jennifer is a student member of the American Academy of Forensic Sciences, and presented a paper at the 1994 San Antonio meeting. She hopes to pursue a career in some aspect of the forensic sciences.