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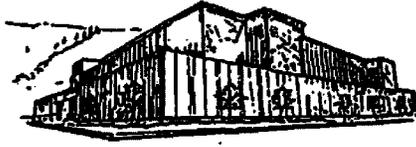
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The Ancestry of North America

A statistical craniomorphic comparison
of paleoindian skulls

by

J. Chad Jones

B.A. Denison University, Ohio. 1996

Presented in partial fulfillment of the requirements

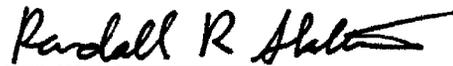
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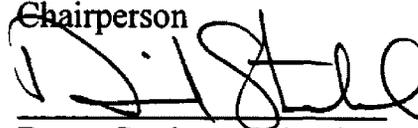
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The Ancestry of North America: A statistical craniomorphic comparison of paleoindian skulls.

Chair: Dr. Randy Skelton *RS*

The relationship between prehistoric skull measurements, the 9,500 year-old remains of Kennewick Man, Buhl Woman, Spirit Cave Man, Skull 101, and numerous skulls from the Windover Site in Florida, the Ainu and Jomon populations all dating to about the same time period, is explored. Based on approximately 16 measurements, an attempt to find out how closely related these skulls are, is made. A multivariate analysis (One-sample Hotelling T^2 test and Neighbor Joining Euclidean distance tree) will show that these specimens may or may not be from the same ancestry. Data is extrapolated and used to make assumptions about the peopling of North America. By comparing the measurements of skulls from the same time period separated geographically an attempt to discover if these skulls were from one major migration into North America or if unrelated, they were part of separate small migrations that lead to the peopling of North America. Previous results have shown that these skulls are dissimilar to current Native American populations and that the Paleo-Indian skulls studied most likely died or intermixed with current populations. New evidence shows that while these skulls are not the oldest or "first Americans" we can still learn much about the way North America was populated. This study will provide insight into the question that has plagued anthropologists and archaeologists for over half a century: "Who were the Paleoindians?" and "Did they populate North America in one major migration or successive waves of smaller migrations during the late Pleistocene."

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come see me when I could not make it back to West Virginia to see them. They have shared the burden of this research and have kept me on track with it. Thanks, I love you guys.

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Introduction

For years anthropologists, archaeologists, and scientists alike have pondered over an important question. “Who were the first people to populate North America?” More importantly, “Where did they come from and when did they get here?” There has probably never been a more controversial topic within the anthropologic community. These questions are studied and disputed at great length to this day, and have been for years, with still no resolution or agreement within the field.

Craniometric analysis by using multivariate statistical methods is a common tool in attempting to answer these questions. Previous studies have shown that cranial morphology can be used to show biological affinities among groups with surprising accuracy. Most studies, such as Howells (1966, 1973, 1989, 1995), or Brace (1990) attempt to show biological relationships between two or more different populations. Studies such as Powell and Rose (2000) are also used in attempts to find biological affinities of individuals, such as Kennewick Man, to known populations. These studies are extremely important in physical anthropology, but previous research has attempted to compare ancient individuals or populations to modern groups.

Most current research follows the trend of comparing “ancient” individuals to modern populations. Research that involves comparisons of “ancient” cultures to other prehistoric biological groups is few and far between. The problem with current research and the comparison of modern to prehistoric is the time-scale. Modern populations when compared to specimens, such as Kennewick Man, that are approximately 9,500 years old, are dealing with effects of microevolution. It has been shown that skull shape is directly affected by the environment as well as genetics. Therefore, as a population moves to

different regions the overall characteristics of the skull, will change over time depending upon environmental stresses, and other forces such as genetic mutation, this is evolution. This can seriously affect the results of a study by skewing the data, and providing either spurious correlations with groups that should not be related or failing to find relationships within related populations.

Individuals with shared heritage, often share the same traits. Ergo, people that look alike with regard to facial features, are most likely related somewhere down the line. The more similar, statistically speaking, a group or cluster of individuals is, then the “higher” the relatedness is (Freid, 2000). By performing statistical analysis based upon facial measurements, scientists can formulate a general theory of how closely linked populations are. This is called craniometrics and the theories it provides are used, among other things, to trace the peopling of the New World (Brace, 1990), and the dispersion of modern *Homo sapiens* (Howells, 1989).

A Brief History of Craniometrics

The metric analysis of the skull has been used in anthropology for a number of years. Early studies unfortunately, typically looked for ways to differentiate and establish “racial” groups among human populations. Scientists understand that today, race does not exist as a biological concept, instead it is a surface adaptation, and should not be used in classification of the human species. Race is used to classify human variability, and unfortunately has been overused to explain these differences. By definition it is used to explain certain typologies within humans, i.e. hair or blood types that is found to be characteristic of a certain region. This means that these traits are not found in any other

group of humans (Livingstone, 1964). We know this today, to be entirely untrue. Anthropologists do not study race, nor does it exist in the science of anthropology, instead scientists see human variability or clines within the human population (Livingstone, 1964).

As science and culture progress away from racial typologies, craniometrics are used to address a wider range of problems. Today, craniometrics for instance, can be used to establish links between human remains and archaeological evidence. These relationships between skull shape and cultural artifacts can prove the origin of artifacts and the populations from where they came. It has been proven that craniometrics is as accurate in finding ancestry, as genetics, blood groups and cultural artifacts. Skull shape is used extensively in the field of forensic anthropology to determine ancestry and sex for unidentified human remains (Freid, 2000).

As mentioned above, previous craniometrics were used to prove racial typologies and unfortunately inequities between races. Carleton Coon (1962) talks extensively of the origin of modern races. Coon (1962) breaks down the world's populations into five racial groups, "Caucasoid," "Mongoloid," "Australoid," "Congoid," and "Capoid." This is work that today is widely recognized, by many as offensive. Coon divided the populations into these groups using early assumptions based upon skin color, linguistics and early craniometrics. These measurements included facial flatness, the shape of the nasal bones, as well as overall skull size. Early craniometrics was not what it is today, much of it did not involve actual measurements, instead it involved comparing the skulls purely on looks. With these features there was no discriminate analysis, just comparisons from afar, between the individual specimens. This means a researcher would compare

two specimens solely on how they compared to each other, instead of measuring different points upon the cranium. This method left much to be desired since the decisions were based on what the researcher thought, not what was actually happening. Early researchers would find skulls of people that they believed typified their external skin color. These skulls would then be used to compare all other skulls found against. This practice was used on many other animals before humans, and was adapted to the human genera. Researchers would periodically kill an animal species, skin it and use it to compare all others against if it became the definitive specimen. Near the turn of the century, a skull was selected to be the typology of the Caucasian. This skull was found in the European Caucasus Mountains, from which the word “Caucasian” is derived, and was originally used as the holotype of the *Caucasioids* (Coon, 1962).

This early form of craniometrics, while not refined in any matter, did however lead to modern techniques. Early researchers, such as Coon (1962) and Hrdlicka (1906), while rudimentary in their approach did help to form modern craniometric studies. They began by comparing skulls side by side to check for obvious differences in appearance and then comparing them to “racial” typologies already available. While this method is not practiced any longer, scientists adapted their approaches and craniometrics today is an objective study that helps to dispel the racial stereotypes that were earlier embedded in the field.

More recently the study of craniometrics has been used in response to the demands of Native American Graves Protection and Repatriation Act (NAGPRA). Since its approval by Congress in 1990, NAGPRA has directed all museums to evaluate their human remains collections, determine those remains which can be linked to existing

tribes, and then follow the wishes of the tribes involved (Buikstra and Ubelaker, 1994). In most cases, this involves repatriating the remains to the tribes for reburial.

NAGPRA has affected not only modern craniofacial studies, by creating an entire new field for the application of these methods, but has sparked bitter debate within the scientific community. Most physical anthropologists and archaeologists have trouble establishing a balance between being sympathetic to Native American's concerns and coping with the possible loss of irreplaceable data. Nowhere is this more obvious than with the case of Kennewick Man, discussed in the following pages.

Without the early beginnings of craniometrics though, physical anthropology and all the related fields would be at a standstill. The study of craniometrics today is also used to test relationships between heritability and environments and the changes in facial morphology (Jantz and Owsley, 2001, Sparks and Jantz, 2003). However, in today's modern world the most widespread use of such techniques are in statistical analysis. These studies were not possible until very recently since they rely heavily on the use of computer software.

Perhaps the most famous of all researchers within the field of craniometrics is William White (W.W.) Howells. Howells' numerous studies (1966, 1973, 1989, 1995) look at biological distances between populations based on multivariate discriminant analysis of cranial measurements. In his (Howells, 1966) study he looked at the relationship between Ainu and Jomon skulls and modern Japanese skulls. This study was a first attempt at finding these relationships. Howells expanded his 1966 study to involve numerous measurements and 17 populations from across the world. Within each population, Howells attempted to measure 50 males and 50 females of known age, sex

and ancestry, creating a database of thousands of measurements and numerous populations. This study was conducted to look at the variability of modern *Homo sapiens*, and objectively compare them with confidence to skull shapes of other human populations. Howells set up this experiment as well, to test the reliability of discriminant analysis in a study of this magnitude. In 1989, Howells, with *Skull Shapes and the Map* further extended his study represent populations from around the world and compare their skull shapes, to “search for specific distinctions between the populations of different major regions” (Howells, 1989:1). He found that modern *Homo* is limited in its variation of crania and that no group differed in a statistically great way from the others.

Finally in his last study, Howells, (1995) included his previously studied populations with recent prehistoric human populations, and compared the skull changes over time, in an attempt to find relationships with the modern populations of today. Within his studies Howells produced a database of well over 2,500 skulls and the measurements of numerous points on each. This database has been used by numerous researchers, including myself, and continues to be an irreplaceable source of data.

Another champion of craniometric analysis is C. Loring Brace. Brace studied under Howells and no doubt was influenced and intrigued by his population studies. Brace has authored many multivariate analyses using craniofacial morphology. His 1990 study, *A Nonracial Craniofacial Perspective on Human Variation: A(sustralia) to Z(uni)*, looks at dental and craniofacial measurements from 57 sample populations. Brace created many new measurements within his studies in an attempt to establish ones not “under the control of specific selective forces” (Brace 1990: 341). Brace wanted to

establish relationships between clusters of populations by using traits that are non-adaptive in nature and ignoring those that are basically adaptive, i.e. skin color. Distance dendrograms were set up to show the actual relationship of the clusters, and the results compared with tooth measurements to gather information on brain-size, tooth-size relationships (Brace, 1990).

Brace (1990) has also looked at craniofacial data of modern populations and compared it with data from prehistoric populations, in an attempt to find New World origins. Modern Native American populations were compared with prehistoric populations such as the Ainu and Jomon of Asia to find their relationship, and to see how strong the ties between both groups are. It was found that modern Native American cultures show strong affinity to mainland populations of East Asia, not the Ainu or Jomon, but that the earliest inhabitants of North America, i.e. paleoindians, while not related to mainland populations, do show ties to the Ainu and Jomon (Brace et al., 2001).

Furthermore, the Kennewick Man controversy has been a very recent and publicized example of craniometrics. From initial non-discriminant analysis, Kennewick Man was thought to look European, not Native American. Multivariate analysis of craniometrics was applied to compare Kennewick Man to modern Native American cultures and the results yielded a conclusion like Brace's (et.al) 2001 study. Kennewick Man due to his antiquity is statistically similar to the Ainu of Asia, not modern Native American tribes.

Finally, Donna Freid of Florida State University (2000) used multivariate analysis to explore the crainiofacial variations within a population at the Windover Site in Southern Florida. Freid looked at 63 individuals and established subgroups of variation

within a population that should be based upon the results share genetic heritage. Freid's study shows that it is possible to use discriminant analysis to study variations within a population, not just interpopulation differences, and within that population identify "genetic lineages through craniometric analysis" (Freid, 2000:91).

The above examples are just a few of the numerous ways in which multivariate analysis using craniometrics can be applied to numerous studies. The above listed studies have all either compared prehistoric populations with modern populations in an attempt to find similarities, or compared variations within a population. In the course of this study I am comparing prehistoric populations to prehistoric individuals in an attempt to find patterns of heredity within different populations that were living during the same time periods. This analysis will determine whether the prehistoric populations in question originated from similar ancestry and then spread out to populate the New World, or they moved into the New World from different genetic lineages.

ARCHAEOLOGICAL HISTORY

The following sections include a brief history of the specimens and their discoveries. Some of these histories are shorter than others do to lack of published information, and/or the age of the discovery. Initially this project was to contrast and compare Kennewick Man with individuals from the Windover Site. For this reason the majority of time is spent defining and explaining these finds. The majority of the information refers to Kennewick Man and is in part due to the enormous media coverage and numerous published reports on him. I feel it is necessary to provide the readers with as much background as possible on these subjects, since I am using other researchers'

published data and did not have a chance to personally view and study any of the following specimens. Each cases history shapes the way it was studied and presented and can affect the data in the end. Therefore, with a discovery such as Kennewick Man, I have included a brief history of both the DOI investigation and Dr. James Chatters' investigation, since they yielded somewhat different results. In the case of the Kennewick data I have chosen to use the information gathered by the DOI investigation since it is more widely accepted as valid.

The Windover Site provides an overview of the finds and the impressive preservation found at the site. The history of Skull 101 is only a short summary because of the antiquity of the find and the initial analysis was published in Chinese. The Buhl discovery and Spirit Cave Man were both studied by researchers that published extensive material in popular archaeology magazines. Finally, Howells Jomon/Ainu data sets were extremely difficult to find any more than a few entries about their history and how they were acquired.

Kennewick Archaeological History

Kennewick Man was found in July of 1996, on the Columbia River, below the surface of what is called Lake Wallula. Lake Wallulla is a still portion of the Columbia River behind McNary Dam. Two college students attempting to sneak into a boat race on the Columbia River found the remains. The two students unfortunately moved the skull from its present location to protect it and after the race notified the police and Dr. James Chatters, the local coroner. The remains were found below the surface of the water, but near a river terrace known as Columbia Park. Archaeologists believe that increased boat

traffic and varying water levels in Lake Wallula caused the riverbank to slough into the river exposing the remains. Furthermore, the wave action then disarticulated, and scattered the remains in an area of more than 300 square feet and in 18 inches of water (McManamon, 1999).

Kennewick Preliminary Investigation

The initial phases of the investigation had two goals. The first was to document and study the remains; the second was to provide insight into whether the remains would fall under “Native American” and therefore NAGPRA jurisdiction (McManamon, 2000). Because of the Native American Graves Protection and Repatriation Act (NAGPRA) any remains that are thought to be Native American are placed under the jurisdiction of the federal government, for their study and repatriation. NAGPRA was passed in 1990 by an act of Congress and was formed in order to provide Native Americans the opportunity to reclaim all Indian remains that were held in museums and research facilities and properly rebury the remains. NAGPRA also allowed Native Americans to claim and remove all human remains from land if they can prove the land as ancestral. Unfortunately for scientists, NAGPRA does not make any exceptions for studying and researching finds, no matter how scientifically valuable they are thought to be (McManamon, 2000)

Determining the ancestry, and age of human remains can be accomplished in many ways. These methods, such as radiocarbon dating and DNA analysis, are simple and provide valuable results; however they are destructive to the remains. Because Kennewick Man remains were thought to be Native American, these destructive methods of study could not be used in the determination of ancestry or age. Tribal representatives

strictly prohibit any means of study that may be destructive to the bones, no matter how slight that destruction is. The Department of the Interior (DOI) was put in charge along with the Army Corps of Engineers, and organized into non-destructive phases of the investigation. The non-destructive investigations are a reasonable first step in any investigation, and on their own it is possible that they may answer the necessary questions (McManamon, 2000).

James Chatters, at this time had already begun his own initial investigations as well. He was able to make casts and photographs of most of the bones and to take measurements accordingly. However, he also sent some bone to be destroyed for carbon dating and DNA analysis. Chatters, chose some small bone fragments for these tests he thought would not only be uncontaminated, but also the least destructive. Although Chatters knew that these remains could be Native American, he ordered these tests to arrive at a definitive answer, to the ancestry and age of the remains. Chatters arranged these tests before the Department of the Interior and Army Corps of Engineers took over. He believed that these tests would provide necessary insight and resolution into the mysteries of Kennewick Man. When the tribal council, a group of leaders from local Native American tribes, found out of Chatters actions they were outraged, this led to further deterioration of relationships between tribes and scientists and further complicated an already delicate matter (Chatters, 2001)

The DOI investigation followed standard procedures for an archaeological investigation, and required careful measuring, recording, photographing and examination of the remains. To carry out these procedures the DOI formed a team of scientists consisting of experts in archaeology, geology, lithics and physical anthropology. Most of

DOI initial investigations consists of field notes and preliminary results about the find and documents the recovery (Chatters, 2001)

The DOI investigation did not necessarily coincide with Chatters' initial investigation and Chatters' methodology was criticized not only by the DOI but by the tribal council as well. During the first months of the Kennewick discovery Chatters performed basic metric measurements and reconstruction, but his results were not considered valid by the DOI because he apparently glued, temporarily, some portions of the bones back together. This method, according to the DOI, may have caused a wide margin of error and Chatters' results to be skewed. The DOI was unable to replicate and check many of the tests and measurements that Chatters' had already performed because of his apparent "lack of description of the method and techniques used" (McManamon, 2000). Metric analysis requires that extremely precise and documented definitions be provided for each measurement taken. This is necessary so that other scientists can check the results of earlier work, because of the lack of recording necessary data; the DOI was not able to make decisions of the ancestry based on this part of the initial investigation, as they had hoped (Chatters, 2001).

Examination of Skeletal Remains

Chatters himself conducted extensive examination of the remains, while he was in possession of them. However when they were overturned to the DOI, specific teams were put into action in order to physically examine the remains and modify and check the inventory conducted by Chatters, and the team of scientists that received the remains after Chatters, but prior to the DOI. Dr. Joseph F. Powell and Dr. Jerome C Rose conducted

the examination and the remains were confirmed to be those of a single individual. This was an important fact since the bones were discovered in various contexts and over a period of several days (Powell and Rose, 1999).

Powell and Rose next performed cranial, dental and skeletal measurements. Using several databases, Native American and non-Native American, their findings were compared with the results of previous studies. Databases for Native Americans exist for some regions of the country and are used with a high success rate to determine ancestry. It is well known that because of genetic variability no one individual will meet all the criteria, but these databases can be used as a starting point to determine Native American ancestry (Powell and Rose, 1999).

The third phase carried out by Powell and Rose was the investigation and study of non-metric skeletal, dental and cranial morphology. This approach looks at patterns that have been established within different ethnic groups. Interpretations of these patterns can be extremely useful in determining ethnic affiliations based on a given set of morphological traits. For instance, Native Americans very often have shovel-shaped incisors. While the presence of shovel-shaped incisors does not mean definitively that remains are Native American, it can be an indicator. Dental wear and other skeletal and cranial patterns can also exist. If an individual has a number of these patterns that are congruent with any given ethnic group then this can be used to help determine ancestry. These patterns are compared with other known ethnic groups to determine ancestry.

Drs. Powell and Rose, after careful study of the Kennewick remains concluded that a determination of Native American Ancestry could not be made. Utilizing metric and non-metric characteristics and of known populations from throughout the world, and

comparing them with the Kennewick data, Powell and Rose found the remains were unlike most modern populations, although most similar to the Ainu, in shape (McManamon, 2000).

Further comparisons were made using a limited Pre-Columbian database, which yielded closer mathematical results, when compared with Siberian and Northern Japanese peoples. Although, the end result was still the same, and no determination to Native American ancestry was made (Powell and Rose, 1999).

Soil samples were collected, but because the skeleton was not found in its original place of rest, the samples could not be accurately dated. Furthermore, since it is unaware to scientists whether the Kennewick remains were naturally buried, or buried in a grave, the soil embedded in the skeleton may lead to inaccurate dates. If the remains were buried and soil matrix was mixed, earlier dates could be returned. The soil samples unfortunately could not be used to determine Native American ancestry (McManamon, 2000)

The final portion of the non-destructive investigation focused on the projectile point embedded in the right ilium of the Kennewick Man remains. The projectile point was analyzed in situ using CT scans. These provide a three dimensional view of the point and allowed Dr. Fagan to conduct accurate measurements of the point. Based upon other points in collections Fagan found the point to most likely be a Cascade Point. However these characteristics, size, shape, and raw material, are not exclusive to Cascade points. Furthermore, the Cascade point typology while found in the Pacific Northwest ranges in time from 7,600 years ago through more recent times (Powell and Rose, 1999).

Chatters' Initial Findings

Chatters was aware that this skeleton may be Native American and despite its antiquity may be repatriated. Chatters began the study as a normal forensics and archaeological investigation he catalogued, identified and arranged the bones in their skeletal positions. Chatters also attempted to keep soil samples along with the bones and attempted to set up a soil profile and are map of the deposition of the remains. As he started the pathology and trauma he quickly realized that Kennewick man was somewhat of an anomaly. Conflicting information made this study difficult and because the initial non-metric analysis of the remains had placed Kennewick man of Caucasian or European ancestry, the discovery of the projectile point was a shock. The radiocarbon dates came back as being around 9,400 years old. Both Kennewick Man and the point appeared to be older than initially thought. As news of the great antiquity spread, Native Americans called for the remains repatriation immediately. Because of the projectile point and Kennewick Man's age, Chatters, as well as many other scientists felt that modern Native Americans had no cultural affiliation with the Kennewick remains. Michael Moratto, author of a text on California archaeology states in Chatter's book, *Ancient Encounters*,

As a specialist in the prehistory of western North America, I can assure you that *no* living society, native American or other can credibly claim biologic or cultural affiliation with archeological remains 93 centuries old. This time span represents nearly 500 generations. During this time, peoples entered the New World, moved extensively within it, evolved culturally, intermarried and sometimes died out. The true descendant of people represented by [Kennewick Man] might be living in Central or South America, or might be extinct. To link them with historic or modern Indians near Richland is without substantive or legal merit (Chatters, 2001).

Statements such as the above, added fuel to the NAGPRA fire, but scientists believed turning over the skeleton without study was entirely wrong. Without study Kennewick

man could be turned over to the wrong descendents or perhaps even the relatives of his enemies (Chatters, 2001)

As tests and studies returned, more insight was gained into the life of Kennewick Man. Kennewick Man lived in North America shortly after the end of the last glacial episode. As the glaciers receded the tundra they created changed to rich grasslands where bison and elk roamed. The rivers, initially thick with glacial silt and run-off, eventually stabilized their flow and fish, such as salmon returned to colonize them by around 9,500 years ago (Chatters, 2001). We know from archaeological evidence that the peoples of this time period hunted elk and bison, and set up fishing camps along the rivers as well (Chatters, 2001).

Around the time of Kennewick Man, the climate in the Columbia Basin became increasingly drier. Sagebrush prairies soon replaced the rich grasslands as the climate became more arid. The land could no longer support the large fauna such as bison and elk and as the animals left the prairies the peoples of the region moved towards the rivers for food. Unfortunately, as the climate warmed and dried so did the waters, and fish, especially Salmon, activity decreased (Chatters, 2001)

The dates of Kennewick Man's life were further confirmed with soil dates that once calibrated matched Chatter's radiocarbon dates. However, during this time period in the Pacific Northwest numerous changes were taking place. The above mentioned climate changes were altering people's lifestyles and they were forced to adapt to survive. Around this same time we also see a shift in tool technologies, this can mean a number of things; A new population is entering the region and bringing with it new ideas and new

technologies, or the climate change is forcing people to completely change their lifestyles (Chatters, 2001)

After the Department of the Interior took control of the Kennewick remains Chatters was still able to study the remains based on the amount of information he had acquired while the skeleton was under his control. Using the X rays, CT scans, photographs videotapes and extensive measurements, Chatters was able to continue doing research on the remains, the following is based upon his initial and subsequential research (Chatters, 2001)

Chatters and Powell and Rose, used several methods for determining the age of Kennewick man. These included tooth eruptions, skull suture closures, changes in the rib and pelvic cartilage and others. Ultimately Chatters figured Kennewick Man was somewhere in his forties when he died. Powell and Rose interestingly enough found in their investigation that the remains were most likely between forty-five and fifty-five, but believed Kennewick Man to be closer to his mid-forties (Chatters, 2001)

Next, Chatters attempted to estimate Kennewick Man's stature. This can prove rather difficult because it is based on not only bone length, but cartilage and skin thickness as well. Chatters used the crural index to determine the appropriate ratio of tibia to femur length in figuring stature. This index varies with latitude and helped Chatters figure out which geographic group to place Kennewick Man in and then used the ratio to figure a height range of between 5 feet 7 inches and 5 feet 10 inches tall (Chatters, 2001).

Chatters used the diameter of the head of Kennewick Man's femur to determine his weight. With a femoral head diameter of 1.9 inches, his estimated weight came to

approximately 159 pounds. Using an equation that figured the statistical relationship between height and body mass, worked out by a mathematician friend of Chatters. He found Kennewick man to be of medium build (Chatters, 2001).

Kennewick Man's teeth and bones affirm his good health. During his formative years his bones and teeth show little evidence of being nutrient deprived. Like trees bones and teeth grow with ringed patterns and their development can be slowed by ill health or poor nutrition. In bones these nutrient interruptions are called Harris lines and show up on X rays as portions of increased bone density that run across the bones long axis. In the tooth these interruptions are called hypoplasias and show up as narrow horizontal grooves in the tooth enamel. With the teeth it is also possible to correlate the age the interruption occurred. Chatters found two small hypoplasias that may have been caused by late-weaning, but found no other signs of ill-health (Chatters, 2001).

Windover Site

Windover is a cemetery site that is located in central Florida, near Titusville, a small town approximately 8 km west of Cape Canaveral. Windover pond (8Br246) is a 5400 m² peat deposit and is a persistent but submerged pond. The site was identified in 1982 during construction of the Windover Farms housing development when human remains were discovered within the peat soils being moved for road construction (Freid, 2001). Fieldwork and investigation began in 1984 and continued over the next three field seasons on 1984, 1985, and 1986. Well-preserved human skeletal remains were recovered from the loosely consolidated peat sediments (Freid, 2001). The human remains had been intentionally buried and had been submerged in the peat of the bottom

of the pond at the time of death, many were held in place by wooden stakes. A total of 168 human skeletons were recovered from the site along with five lithic artifacts, 87 specimens of textiles and other perishables, and tools of bone, antler, marine shell and wood (Tuross et. al., 1994). The preservation of these remains was phenomenal, insomuch that 91 of the recovered crania produced samples of preserved saponified brain tissue. According to radiocarbon dating, the burial occurred between approximately 7,000 ybp and 8200 ybp (Freid, 2001).

Paleodietary studies (Tuross et al. 1994) have shown that the main source of food for inhabitants of the Windover region was a combination of terrestrial and aquatic species. Due to the proximity of their habitation sites and the Windover burial site to both freshwater and seawater they were well adapted to both fresh and salt water species as well as the terrestrial flora and fauna in the area. Studies also show that sea levels at the time of habitation were rising and fluctuating rapidly so the inhabitants needed to adapt strategies for food acquisition rapidly and often (Tuross et al, 1994).

Previous research has been conducted with the Windover site due to its large number of well-preserved specimens. Many researchers have used the specimens for craniometric analysis and comparative studies, but past research has focused on the Windover population's distance from modern groups or its intrapopulation variations. Within this study I plan to use the Windover database to compare its population to other populations, geographically separated but of similar age from across the Northern Hemisphere.

Windover Skeletal Sample Descriptions

The sample measurements gathered from the Windover site consists of 63 total crania. These specimens were evaluated for completeness and number of cranial elements present. Donna Freid paid close attention to facial elements such as nasal, orbital, zygomatic and maxillary bones. These particular bones are important for analysis and comparisons with other populations. “All crania used in the study are considered “complete” according to Buikstra and Ubelaker (1994) in at least 75% of the bones are present in each cranium (Freid, 2001). As mentioned before, due to the excellent state of preservation of the remains most crania were recovered intact or reconstructed shortly thereafter. Freid reconstructed crania that were not badly damaged and that with the reconstruction would add to the number of possible measurements. Freid (2001) also states that skulls with reconstruction are noted for possible skewness of results.

The population under study consists of 24 adult males, 22 adult females and 17 unsexed specimens ranging from 4-17 years old. Age and sex determinations were made before Freid’s 2001 study, with the majority of specimens being middle aged (30-50 years old) and male (Freid, 2001).

Skull 101

Skull 101 was discovered inside the lower chamber of a site called “Upper Cave” at Zhoukoudian, nearly 50 miles outside of Beijing, China in 1933 and 1934. The cave sits on a small hill of limestone known as “Dragon-bone Hill.” The hill over looks the Hunhe River, and houses several well-preserved human remains. This locality is famous

for its discovery of “Peking Man”, the remains of a *Homo erectus* dating to about 460,000 ybp were found. This specimen is a nearly complete crania and mandible, and is known as “old man” (Kamminga and Wright, 1988). It was believed, even in the 1930s, that Skull 101 was unlike modern Asian peoples, and more like the Ainu. Radiocarbon dates within the lower chamber of the cave has produced results of around $10,470 \pm 360$ BP. It has been suggested that this skull is that of an elderly male that exhibits both European (Caucasoid) traits and East Asian traits. This skull is typical of fully modern *Homo sapiens sapiens*. The cranium and mandible are complete and the cranial capacity is around 1500cc. The vault of the forehead is low and moderately receding, and the facial height is low compared to modern Asians, and the upper face is not prominent (Xinzhi, 1985).

Skull 101 shows no evidence of incisor shoveling although his teeth are heavily worn indicating a hunter-gatherer lifestyle. Turner places Skull 101 in the sinodont category, and believes that sinodont dentition derives from a north China beginning between 20,000 and 40,000 years ago (Kamminga and Wright, 1988).

Skull 101 had sustained a perimortem crushing-type impact on his left temporal region of his skull. Radiating cracks from this blow criss-cross the skull although it is not known if this was the cause of death. A 25mm section of the right zygomatic arch is missing and the left is cracked and pushed back in towards the brain case (Kamminga and Wright, 1988).

With Skull 101 at least four adults and three juveniles were also, although the other skulls of the other remains were found to be damaged beyond repair or deformed. This deformation most likely comes from being strapped and carried on backboards as

infants. Numerous cultural artifacts were found with Skull 101 and the other burials dating to the same time period. Perforated animal teeth, shells, bone artifacts of unknown function and a large bone needle, most likely for sewing animal skins, along with lithic material were all found with the burials in the Upper Cave. The stone artifacts unfortunately were not able to be tied to any cultural tradition and therefore are undateable. Rodents or the collapse of the roof possibly moved these tools and artifacts into their positions within the cave (Kamminga and Wright, 1988).

Pollen samples from the area have shown that numerous lakes and swamps were formed during the transition from the Pleistocene to the Holocene (12,000ybp). The surrounding areas were most likely cold and consisted of grasslands and woodlands with meadows. This phase lasted nearly 4,000 years and pollen records indicate that the forests consisted of birch, elm and even some oak (Kamminga and Wright, 1988).

Upper Cave excavations have yielded as many as 48 different faunal species remains. These include large hunting and scavenging animals such as the spotted hyena, red dog, lynx, tiger, also found were rodents, deer, gazelle, pig and bear. All of these species of fauna indicate, along with the pollen studies that the habitat around Upper Cave was predominately woodland (Kamminga and Wright, 1988).

The above information provides an overview of Skull 101 and the environment it was discovered in. The habitats described above coincide with the habitats found in central North America around the end of the Pleistocene and beginning of the Holocene periods. Because much of the environment is the same, the inhabitants of Upper Cave, and peoples such as Kennewick Man, and the Windover population may have been experiencing many of the same environmental and economic challenges.

The mixing of both European and Asian traits leads many researchers to believe that like, Kennewick Man, Skull 101 is classified as Paleo-Indian. Skull 101 provides an interesting tie to North American specimens, since it was found within China it could provide a link between North American Paleo-Indian and perhaps the ancestors of peoples such as Kennewick Man and the individuals at the Windover site. The further research of the study will provide more clues to the links between North America and Eastern Asia. Many scientists already feel that the movement of the first peoples of North America originated in Eastern Asia and Siberia and moved northward across Beringia into Northern Alaska (Kamminga and Wright, 1988)

Buhl Woman

The Buhl burial was found during road construction in January, near the town of Buhl, in South-central Idaho, in 1989. The remains were located in a highway gravel quarry at the west end of a prehistoric Lake Bonneville flood plain overlooking the Snake River Valley. Due to the dynamic context of the remains (the upper layers of soil and rock were collapsing as they thawed), and fear of the context and bones being destroyed the Idaho Historical Society reasoned that immediate excavation should follow. Most of the bones were excavated in an untraditional manner, picked from the profile and a majority had been accidentally removed by the front-end loader before archaeologists arrived. All in situ bones were located approximately 3 meters below the surface. The bones were displaced, but no evidence indicated that animal burrows had caused the displacement and the actual cause of the displacement was not apparent in the soil profile (Green et. al., 1993).

The local Shoshone-Bannock tribes permitted a piece of the skeleton to be radiocarbon dated, and yielded an age of approximately $10,675 \pm 95$ years before present from Beta Analytic. Local geomorphology of the area suggests that the radiocarbon dates are congruent with geology of the area and location of the bones (Green et al, 1993)

The skeleton was well preserved, although some damage occurred with the use of heavy machinery in normal quarry operation and the weight of the bone suggested little or no mineralization. This is most likely due to the sandy well-drained Lake Bonneville soils. The excavation yielded an incomplete skeleton but the cranium and mandible were complete and intact. The Buhl burial was a female based upon physical examination of the skull, because no pelvis was found. Based upon tooth eruption and epiphyseal unions she appeared to be between the ages of 17-21 at the time of death and stood about five feet two inches tall (Green et. al., 1993).

The Buhl skull exhibited craniofacial features within the range of American Indian or East Asian populations. The relationship with Native American and Asian populations was based upon morphological not metric analysis. Due to extreme occlusal wear it was not possible to gather any ancestry information from the teeth (Green et al., 1993)

Spirit Cave Man

Spirit Cave is located approximately seventy-five miles east of Reno, Nevada and was excavated in 1940 by S.M. Wheeler and Georgia Wheeler. The cave is a west facing, dry rock shelter, roughly twenty-five feet wide, fifteen feet deep and an average of five feet high. The cave was wave cut into a terrace on the beach of Lake Lahontan,

and its walls were tufa covered, which suggests the cave was submerged for long periods of time. The cave has a small chamber of the northeast corner of the main cavity and is filled with wind blown sand and rocks apparently brought in by people (Barker, et al. 2000).

There were several burials found inside the cave, but the human remains that this study is concerned with was named Burial #2. These remains are more commonly known as Spirit Cave Man. Spirit Cave Man was found 3 feet 9 inches under the surface in a pit lined with sagebrush and covered with rocks and sand. The body was wrapped in a fur blanket and a natural fiber mat (Barker, et al. 2000).

Spirit Cave Man was partially mummified and in fact hair still remained on the scalp. During initial observations and opinions the Wheelers surmised that Spirit Cave Man was a young adult male and between 1500 and 2000 years old (Barker, et al. 2000).

The Spirit Cave Mummy was later identified as a 45-55 year old male with hair and dental morphology that are biologically related to Northern Asians and Native Americans. Radiometric dating has also pushed back the Wheelers initial estimates of 1500-2000 years old, to $9,415 \pm 25$ years bp (Barker et al, 2000).

Jomon/Ainu Populations

According to Howells (1973, 1989) the most recent Ainu have been affected by Japanese admixture for quite sometime and those still living show no signs of wanting to preserve their current ethnic identity. The admixture has resulted from normal contact in the past but more recently from the adoption of unwanted Japanese children into Ainu

families. Because of this the Ainu skeletal examples that approach the present time must be considered less and less like aboriginal Ainu and more a product of admixture. To rectify this problem the skulls Howells chose to study were collected in 1888-89 by Koganei, and are presently housed at Tokyo University. Remains were collected almost entirely from abandoned graves and cemeteries from dates and affiliations that are known (Howells, 1989).

After study and consultation with Japanese experts on the Ainu culture it was decided that the samples for Howells study would be gathered from the southern territory, since this was believed to have been least impacted by Japanese contact. After excluding those villages of known long term Japanese contact Howells (1989) chose 48 males and 38 females (86 total) to represent the Ainu population in his study. I have used Howells original Ainu measurements for my study as well. This population as Howells (1995) notes is directly descended from the Jomon population. "In temporal terms, all Ainu are Jomon, but not all Jomon are Ainu (1995). Therefore, because of the short time, evolutionarily speaking, between the Jomon and Ainu, and Howells caution in choosing relatively "pure" Ainu specimens, we can use them as a reflection of the older Jomon population (Howells, 1995)

It is known today that the Ainu are by no means vanishing, but actually slowly growing in numbers over the past 100 years (Internet, 2001). The Ainu that Howells (1973, 1989) described were most likely the victims of western bias, and misunderstanding. The Ainu have been the victims of racial and political bigotry in Japanese for hundreds of years. Because they look so radically different from traditional Japanese the Ainu were easy targets for persecution and hatred. This led to numerous

members of the Ainu, much like Native Americans, to move to secluded areas and initially ignoring their culture (Internet, 2001). This is most likely what Howells (1973) was experiencing when he visited Japan to collect his specimens for his database.

The Ainu inhabit a small island to the north of Japan called Hokkaido, and the majority have lived there since their oppression began centuries ago. Ainu means “human” and are believed to be the native inhabitants of the Japanese Islands. The Ainu according to recent studies by Loring Brace (Corliss, 1989) seem to be the descendants of the Samurai, a powerful and noble fighting force in Japan. The results of this study caused significant controversy within Japanese culture, due to the somewhat noble history of the Samurai, but Brace based his results on numerous recent craniometric comparisons (Brace, 2000). Brace (2000) has performed statistical analysis on the victims of the battle at Kamakura City in 1333. These victims were Samurai warriors, and the results of statistical comparisons group the Samurai and the Ainu together. Historical accounts and paintings also show the Samurai different than modern Japanese peoples, with higher nasal bones and facial flatness, as well as many customs that are attributed to the Ainu cultures rather than Japanese (Brace, 2000).

The Ainu peoples are the direct descendent of the Jomon people who inhabited the same regions 10,000 years ago. The Ainu culture reached its height in the 13th and 14th centuries and passed on their culture through spoken word and tradition. In the 15th century Japanese invaders threatened the Ainu culture and imposed strict trade policies and began exploiting and discriminating against the Ainu (Cogen, 2000)

Today, the Ainu and Japanese governments have begun the task of improving the relationship between the two cultures. The Ainu are slowly beginning to once again embrace the rich culture and their past (Cogen, 2000)

PALEOINDIANS

Archaeologists, physical anthropologists and linguists have long assumed, as mentioned previously that there were several small migrations into North America. This theory seems to make the most sense. Perhaps though there were many more than three migrations, some which left no evidence whatsoever. These questions will most likely remain unanswered until technology or archaeology, linguistics and genetics find a breakthrough discovery. This research, however will attempt to add insight and confidence to the theory of multiple migratory trickles that lead to the peopling of North America and the rise of the Paleoindians involved in this study.

The peopling of the Americas has been the at the center of debate and study for over half a century, yet scientists are still no closer to reaching an agreement or finding definitive evidence of who these people were and when they arrived in the Americas. Initial research showed that the Clovis culture was the earliest group into North America. Years ago, following that discovery, scientists assumed that all cultures then spread out from Clovis and lead to modern Native American populations. Until recently this was accepted, but new discoveries and new evidence in craniometrics, linguistics, genetics, and archaeology have begun to change this paradigm. Scientists now believe that instead of a single large migration of Clovis people into North America around 11,500 years ago, that there was actually many small “trickles” of different populations into North America

long before and during the Clovis times. These trickles may have become integrated and mixed with other populations, some may be the direct ancestors of modern Native Americans, or some may have vanished leaving no trace today (Bonnichsen and Turnmire 1999).

This thesis does not attempt to unveil groundbreaking research in the dating of these arrivals. It does however try to find differences and comparisons between prehistoric populations (8,500-10,500), in an attempt to link them biologically based upon cranial measurements. This will allow the researcher (myself) to make inferences on whence these first pioneers of North America came and if the same populations or completely unrelated ones made these migratory “trickles” into the New World, between 8,500 and 10,000 years ago. The following section provides a basic summary of what is known about the earliest Americans. The general overview and facts and theories are based upon linguistic, genetic, physical and archaeological evidence and details the climate and surroundings these people encountered as they entered North America (Meltzer, 1993)

Initially after the discovery of Folsom and Clovis sites in the 1920s and 1930s, scientists assumed that not only were these cultures the earliest in North America, but that they were direct ancestors of modern Native Americans. In the 1930s Frank H. H. Roberts Jr. used the term Paleoindian. According to scientists (Bonnichsen and Turnmire 1999) this term implies direct biological and cultural continuity between modern Native Americans and founding populations (Bonnichsen and Turnmire, 1999). Bonnichsen and Turnmire propose that the use of term “paleoamerican” will better describe the first populations without implying biological and cultural continuance with modern Native

American populations. Paleoamerican describes all late Pleistocene and early Holocene populations and archaeological evidence (Bonnichsen and Turnmire, 1999). In the following pages I have chosen to use Paleoindian. The term Paleoindian has been used in the field of anthropology for over half a century, still widely today, and in the scope of my research I feel that strictly using the term “paleoamerican” may confuse the issues I am trying to address. By using paleoindian, although I am by no means assuming a direct link, neither cultural, nor biological, to modern Native American populations. I feel that many other scientists use this term freely without association to modern populations as well. The argument for or against the use of these terms is to not be discussed in this paper.

Who were the paleoindians then? For this thesis, as mentioned above, they are those people inhabiting regions of the New World, and those areas near it in late Pleistocene and early Holocene times, 8,500-10,500 ybp. When I speak of paleoindians I am also referring to the specimens involved in this study, Kennewick Man (Chatters, 2001, Powell and Rose, 1999) Skull 101(Xinzhi andZhenbiao, 1985) Spirit Cave Man (Barker et al, 2000), Buhl Woman (Green et al, 1998) and the individuals from the Windover Site (Freid, 2000). The Jomon (Howells, 1996) population is also included in this due to their antiquity. The Ainu, (Howells, 1995) however, while not necessarily paleoindians, are direct descendents of Jomon and because their database was more readily available are also used in this thesis. These populations are discussed later in this research.

Archaeological and Physical Evidence

Scientists agree that sometime around 12,000 years ago, a group of nomadic explorers made their way into North America, most likely across the land bridge exposed by glaciation (Fagan, 1987). This is known as Beringia. Once in northern Alaska, the surroundings looked much the same as Siberia, the land they had just left, and because of the massive ice-sheets, the explorers had no idea they had just crossed between two landmasses. The journey into North America has caused significant controversy between scientists, the facts of the journey and the date in which it took place quite often turns the field of anthropology against itself (Meltzer, 1993)

Scientists have been debating the initial timing of human entry into the Americas for nearly half a century. There are two schools of thought within this debate, the Early-Entry and Late-Entry models. These refer to the relative times when populations entered the North American continent. Perhaps the most popular variation of the Late-Entry model is the Clovis-First model, which proposes that around 11,500 years ago, a small group of hunters entered America from Siberia (Bonnichsen and Turnmire, 1999). The Clovis culture has been seen as a pioneering population of North America, they were armed with new technology (fluted projectile points) and were extremely successful in the surroundings of the new land. The fact that they carried only one tool kit made them very adaptive to changing scenarios. Clovis peoples were also highly mobile, distances of 200 plus miles from where stone was quarried to where it was abandoned are common (Meltzer, 1993).

Some of the facts, which nearly every anthropologist agrees on, are this: The North American continent was colonized during the Pleistocene or Ice Age. During this time the world was very different than it is now. Changes in solar radiation hitting the earth, due from tilts and wobbles in the earth's spin caused temperatures to drop and the ice sheets to grow immensely. The ice sheets then migrated south, forever changing the landscape, and environment of much of North America. Some scientists also still agree that these peoples came into North America through an ice-free corridor formed by the moraines of two separate glaciers, the Cordillean and the Laurentide ice sheets. This corridor was ice-free at least 12,000 years ago, which fits nicely into the most accepted model (Meltzer, 1993).

The question is, was the Clovis culture the only explorers to enter North America or were there multiple migrations into the continent? Neither question has been answered but, if the Clovis were the only people to migrate to North America then they colonized the western hemisphere, from Alaska to Chile, and from California to Pennsylvania, in a few short centuries (Meltzer, 1993).

This is a topic of debate within the scientific community. If indeed the Clovis were the first people in North America, then in a matter of 1,000 years their numbers would have increased rapidly and aside from them spreading across North and South America, they would have also been responsible for causing the extinction of over 80 genera of Pleistocene fauna in those areas (Bonnichsen and Turnmire, 1999). Some paleoecologists suggest that the large size of Pleistocene megafauna was irresistible to Clovis hunters. Paul Martin suggests that moving at a rate of ten miles per year and with a population doubling every 20 years it would have been easy to drive the megafauna to

extinction. Martin states that at this rate of population growth within 350 years of entering North America the Clovis would have reached the Gulf of Mexico and would have been 600,000 strong (Meltzer, 1993). There were many animals driven to extinction around Clovis times, yet only the mammoth and mastodon remains are found hunted. There are no sites linked with human hunting activities that have been found with any remains of the other extinct 40 plus North American genera found. If, as Martin states, the Clovis killed large numbers of fauna, their sites are not found. Moreover, there is a record of only a limited number of megafauna kill sites not anywhere close to the number you would expect a mass extinction (Meltzer,1993).

This seems highly unlikely for any group to accomplish, but especially a hunter-gatherer group in unfamiliar lands (Meltzer, 1993). First the fact a small group of hunter-gatherers could populate the entire land area of North and South America in 1,000 years is bit extreme. Modern day hunter-gatherers seem to move very slowly through their environments using every resource and practicing strict risk-management procedures. Secondly because the Clovis were hunter-gatherers they must have practiced risk-management, in order to insure their survival in lean years. This does not correspond with the notion that the extinction of most Pleistocene animals was caused by over hunting. The Clovis would surely have understood that a Mammoth or Mastodon would provide adequate food, and hide to supply a relatively large group of people for quite some time. As with most foragers, the Clovis most likely rarely killed large animals. The hazards with stabbing a 4 1/2 animal with a sharpened rock more than outweigh the food value. Furthermore, as a practice of risk-management, hunter-gatherers usually move on long before the resources in one area are used up, this allows the area most

recently hunted to restore itself while the band moves on, only to return several years later. The Clovis were most likely gatherers and opportunistic hunters that took advantage of easy kill opportunities presented to them with sick, and or trapped or dying megafauna (Meltzer, 1993).

The disagreements within the fields of archaeology and anthropology revolve around exactly when and how these peoples arrived. While there is no concrete evidence of habitation in North America previous to 12,000 years ago, there is evidence, however shallow that this first group of Americans arrived much earlier than previous thought, perhaps as early as 20,000 years before the present (ybp). Some archaeological sites possibly show a much earlier arrival in North America (pre-12, 000 years) these include Monte Verde, Chile and Meadowcroft Rockshelter, Pennsylvania (West, 1996).

Monte Verde, Chile has raised numerous questions on the antiquity of the peopling of North America. Initial studies showed charred plant remains and fractured gravels that date to approximately 33,000 ybp. Although these dates are problematic and not entirely agreed upon, another level yields dates of approximately 13, 000 ybp. Monte Verde II shows evidence of small floors with hearths and associated artifacts. Even if Monte Verde II dates to only 13,000 ybp, then this pushes the time of entry into North America, back several thousand years. Without entering North America several hundred to thousands of years before humans were in the southern tip of Chile, it seems unlikely that the earliest populations could survive, prosper and move so many miles in such a short time (West, 1996).

Meadowcroft Rockshelter, according to West (1996) does not have the validity problems associated with Monte Verde. There is no doubt that this is an archaeological

site, but the problem now lies within the dating. Several irregular blades and a few bifaces were taken from stratum that dates from 13,000-14,000 ybp. However, many archaeologists feel that there may be soil contamination that has pushed these dates much earlier than they truly are.

Before the peopling of the New World can be seriously looked at the climate of Beringia must be discussed, in order to see if it was in fact possible for the Paleoindians to even survive in the harsh surroundings it provided. Most of what scientists know of the climate of Beringia comes from studies of both the current shores. Fagan (1987) states however that some evidence, such as fossil mammoth bones have been recovered from the sea-bottom. During the height of glaciation, current sea levels were as much as 400 feet lower than today exposing miles of shoreline. Current findings now underwater, were once ancient shores. Siberia and Alaska, in most places, are extremely dry today, but paleoecological studies show that it was even drier and colder 18,000 years ago than today. On the surface this land seems inhospitable, but many scientists argue that this area may have been a refuge for animals and humans (Fagan, 1987)

We know from current study of the peoples of northern climates that the earliest inhabitants of the New World were most likely specialized in many ways to cope with this harsh new environment. These demanding surroundings require adaptations in their skin, clothing, social groups, living conditions, transportation and especially their economies. These economies were able to exploit the limited and restricted resources allowing these groups to not only survive, but also thrive. Archaeological evidence supports the theory that like today, these groups were small, mobile and made use of the vast hunting opportunities allotted to them (West, 1996).

Initial pollen studies show that Beringia was perhaps an arctic tundra much like the land today, however others argue, according to Fagan (1987), that Beringia may have been more steppe-like rather than tundra. If this is the case then Beringia would have been wetter and supported more grassland ecology than previously thought. Climate theories aside, we know that large megafauna inhabited the area of Beringia. With this in mind, how then did a dry, vegetation-less climate support large animals that, like the mammoth and mastodon need to eat continuously. Fagan argues that these large animals would have not only maintained the vegetation, but actually improved the growing conditions for Beringia. By grazing and trampling vegetation, the megafauna would have thinned the ground cover and improved soil quality through waste.

The mammoth and horse ingest large quantities of low-quality fodder, especially tall and medium-height grasses. Their feeding activities helped create patches of higher-quality short grass for more selective grazers like steppe bison. The result was a grazing succession in which each ungulate species created and maintained a level of environmental diversity to serve the needs of other animals in the same area (Fagan, 1987).

It has been demonstrated that Beringia could have supported not only animals but that humans could have easily found sufficient food supply by utilizing the flora and fauna within Beringia. Now, however, how did these populations reach the New World? The most accepted theory of course is that the first people into North America simply walked across the land bridge at the time of glacial maximum. This allows humans to enter the New World between 25,000 to 15,000 years ago or between 75,000 and 45,000 years ago when sea levels dropped. Archaeological evidence, which proves human occupation, from Diuktai Cave in Siberia dates to around 20,000 years ago. This allows the settlers to make it across the Bearing land bridge, but presents another problem. Once

in Alaska, the ice sheets would have caused an impassable barrier to the south. These ice sheets did not retreat until around 14,000 years ago, so if people were here earlier how did they pass the glaciers and into the temperate and fertile landscapes of North America (Meltzer, 1993)?

This leads to many theories and contradictions. Along with findings from Meadowcroft and Monte Verde, scientists know that the first Australians reached that land nearly 40,000 years ago and had to arrive there on crude rafts and boats. It may have been possible for the first Americans to journey south along the coast on rafts, but the water in the North Atlantic is very different from the tropical seas of the south Pacific. The Northern Atlantic was most likely clogged with ice flows, full of huge waves and extremely cold. These conditions would have made all but impossible to reach southern North America by sea. Therefore, if people were in North America, earlier than 14,000 years ago, then they must have used another route. Because of these and other contradictions, many scientists believe that early explorers actually took a route along the coastlines down into North America (Meltzer, 1993).

The Early-Entry model, examples listed above, while lacking a single scenario states that North and South America were both well populated before 14,000 years ago. In this model North America was populated by small groups with a generalized tool technology that consisted of simple flake tool technology from Northeast Asia well before the end of the last Ice Age. This contrasts greatly with the Late-Entry, Clovis First Model (Bonnichsen and Turnmire, 1999)

Physical anthropologists have also been studying physiological differences between ancient Americans. Many of these are based upon skull and skeletal

measurements as in this study, as well as inherited traits of Native Americans such as shovel-shaped incisors. Ales Hrdlicka, began studying these traits in the 1920s, and was convinced that since shovel shaped incisors were not only prevalent among Native Americans, but also inherited and that this population must have descended from one “historically related population” (Meltzer, 1993). This provided Hrdlicka with an important clue, if the current population of Native Americans still shared a number of inherited traits, then perhaps they had not been here long enough to diversify through evolutionary processes. The idea of using teeth as a method of testing biological affinity within Native and prehistoric populations has been expanded and analyzed more extensively by Christy Turner of Arizona State University (Meltzer, 1993).

Turner studies teeth because they preserve extremely well and all humans share the same general traits in regards to teeth, humans differ in what are known as secondary traits. Tooth anatomy is genetically inherited and modified little by use, health or environment; therefore if two groups share secondary traits, then as Turner argues they must be related. Turner looks at secondary traits such as shovel-shaped incisors, the number of roots on the first molars, Carabelli’s cusp (an extra cusp on the buccal side of the lower molars), and groove patterns in the molars (Meltzer, 1993).

The results of the above analysis, distinguishes European and African teeth from Asian. Turner then divides Asian teeth into two groups, Sundadont and Sinodont. The Sundadont pattern is older (17,000-30,000ybp) and is what lead to the Sinodont pattern, which is founding all American populations. The Sinodont group is then split further into three groups, Eskimo-Aleut, Greater Northwest Coast, and all other American Indians. These three groups, according to Turner were among the three migrations that led to the

peopling of the New World. Turner's three dental groups are linked to Greenberg's three linguistic groups (discussed below), but do differ in relative age and order. It is possible, however to date the age of the migrations based on dento-chronology. This technique looks at genetic rate of change of dental traits. Once figured out, Turner places the Amerind migration at approximately 13,500 ybp, the Eskimo-Aleut migration at 11,500 ybp and finally the Na-Dene postdates the other migrations (Meltzer, 1993).

Linguistic Evidence

Little is truly known of the first Americans, with the exception of a few stone artifacts most traces of their existence have been washed away with time and natural processes. Anthropologists have long assumed that there have several small waves of migrations into North America. These waves, scientist think would be closely related to one another, but very different from other waves that preceded or followed them. These theories are backed further by linguistic studies that show differences based on languages spoken among modern day Native Americans.

Linguistic evidence includes the languages themselves, i.e. vocabulary, sound systems, syntactic structures etc., and the current and previously inhabited geographical distribution of the languages and their speaker (Greenberg, 1996). Languages, like animals, have been divided into separate "genetic" groups of related and unrelated languages. This classification of language is an extremely important part of linguistics and sets the stage for all comparisons of language, genetic and cultural to be made. "Genetic classification is, then, the indispensable background, directly or indirectly, for

all historical inferences drawn from languages in the absence of direct, written historical records” (Greenberg, 526).

These inferences are important in studying the settlement of the Americas, and linguists are primarily concerned the number of settlements (languages), the relative chronology of these settlements, and the area of the first settlement and those of splits from the original group. Evidence shows that language spread is predominately a version of the original language and varies little. For instance, the French dialects spoken in different regions of France differ from each other far greater than the French spoken in France, Louisiana, Quebec and other French speaking parts of the world. This leads linguists to the conclusion that the French spoken around the world is due to recent migrations from France, and the drastic differences in dialects in France are part of a much older system (Greenberg, 1996).

Using these methods, linguists have been attempting to add insight into the questions of who were the first Americans, based upon studies of the evolution of languages. The predominant theory, within linguistics, now seems to be three major migrations into North America. The languages of Native Americans can be divided into three groups, Eskimo-Aleut, Na-Dene, and Amerind. These groups were found by comparing similar characteristics between many languages. Edward Sapir separated the languages of North America into six groups and then into the three groups by Joseph Greenberg who compared words not readily lost from languages such as pronouns and names for body parts (Greenberg, 1996)

The Eskimo-Aleut language is spoken on the Siberian and Atlantic Coast, and within the Aleutian Islands. This language groups is extremely homogeneous across

thousands of miles and many cultures, and for this reason linguists believe that these speakers were the most recent migrants to North America (Meltzer, 1993).

There are 38 Na-Dene languages spoken today and speakers range from sub-arctic Alaska and Canada to the Pacific Coast and United States southwest. While these languages are more diverse than the Eskimo-Aleut, they are still far more homogenous than the Amerind language group and for that are believed to have followed the Amerind speakers to North America (Greenberg, 1996)

The final group is the Amerind group, which makes up over 900 indigenous languages spoken in the New World. These languages are spoken from the tip of North America to the southern most point of South America. The large amount of diversity shows that this group has been in North America for the longest period of time, and was perhaps the first group of explorers to make the journey into the new continent (Meltzer, 1993). Linguists looking at the geographic spread of these languages assume that languages spread without regard to direction, but geographic and climatic barriers may have an affect on where language groups can migrate. For this reason, the most central area of the distribution of a languages' components is most likely the area of origin (Greenberg, 1996).

Greenberg (1996) breaks down the language groups spoken today in North America. There are only three places that people could have come from to populate North America, Europe or Africa, islands in the Pacific, and Asia. Evidence has shown that Indo-European languages, as well as African, are recent branches now spoken in the Americas.

The languages spoken in the Pacific Islands show the least depth and history, especially those islands closest to the American mainland. Also all these islands speak languages of the Polynesian subgroups of which are extremely young and not spoken on the mainland. These languages, most likely have spread from Australia, Thailand and then across the Pacific reaching the American outliers very recently (Greenberg, 1996).

This according to Greenberg leaves only Asia as a source for the peopling of the Americas. Greenberg agrees with Sapir's groupings of Native languages into three distinct groups.

It is clear that Eskaleut, Na-Dene, and Amerind are not branches of the same stock, much less the only branches of such a stock. If this is true, then there cannot have been just one migration followed by the subsequent differentiation of this family into three branches (Greenberg, 1996). He also traces each language group origins to Asia, and states that Eskimo-Aleut has the most recent ties with Amerind being the most diverse, and therefore as Sapir agrees the oldest stock.

Since as mentioned above the most central area of the language distribution is most likely the origin, Greenberg traces these language groups back to their likely geographic genesis. The Eskaleut origin is traced to southwestern Alaska. The Na-Dene complex Greenberg suggests has an "insular origin in the southeastern extension of Alaska adjacent to Canada" (1996:531).

The genesis of the Amerind language group, because of its diversity presents some problems. Amerind is spoken in many regions across North and South America, and while it's assumed that it came from Asia, the results do not necessarily show a strong Northern component. What they do show however is that the Language spread

extremely rapidly, since numerous separate branches were established. Greenberg concludes that the Amerind language group most likely started in the North then split and moved into the American Southwest. One group a, northern one remained there and diversified, while the southern group diversified and moved into South America (Greenberg, 1996).

The combinations of teeth studies, linguistics and now mitochondrial (mtDNA), have shown that there was most likely three separate migrations into North America. Recently mtDNA has been used in combination with blood groups and traditional genetic markers, to provide further insight into whom and when the first Americans entered North America. Dating of these migrations, using mtDNA, show that perhaps the earliest migration, the Amerind, left Siberia between 21,000 and 42,000 years ago. All of the studies mentioned above have led the way with groundbreaking research in the peopling of North America. My thesis will attempt to link these theories together with craniometrics. Later studies may be used to link, DNA, teeth and craniometrics together to help add insight to the peopling of North America (Meltzer, 1993).

The above examples are provided to give the reader and researcher a general background into the paleoindians and the journey to the New World. No matter what the time frame the accomplishments of the earliest settlers of North America are among the greatest of human conquests. The populations and individuals in my study were able to thrive in new and strange environments, and pass on their legacy for scientists today to decode.

METHODS AND MATERIALS

Why Statistical Analysis

The purpose of this study is to compare various prehistoric skulls from different geographic locations looking at their similarities and variations. These skulls were chosen because their ages are all relatively similar, between 8,500-10,000 years before present, with the exception of the Jomon (6,000-2,300 ybp) and the Ainu (700 ybp). Taking specimens of similar age lets the researcher look at these skulls and compare them to one another without worrying about how 8,000 years of microevolution may have affected their shape. Comparing an 8,000 year old skull with a modern skull would not be as accurate due to changes in morphology based upon normal variations. Comparisons are based upon 36 measurements of various positions of the skull and are explained below. The samples for this study consisted of 240 skulls (63 from Windover, 87 from Jomon and 86 from Ainu populations, Kennewick Man, Spirit Cave Man, Buhl Woman and Skull 101) each with numerous measurements were chosen, the data was then analyzed through multivariate analysis tests and results of how related these specimens are, were applied. Multivariate analysis was chosen as the most accurate and effective way to complete this study.

Scientists use discrete (non-metric) and discriminant analysis to study skulls, although there is some controversy on the effectiveness of discrete analysis, since it is completely objective. Multivariate analysis, part of discriminant analysis has become an accurate and popular way for scientists to study variations in the human skeleton, and more importantly, in this study, variations in the cranium. Multivariate analysis has can show subtle differences in the human skulls that are easily overlooked non-discriminant

analysis. Measurements taken can be compared against those from numerous populations to provide an overview and comparison to one another.

Multivariate analysis of the skull was chosen because use of it with the data and measurements available provides methods and an easy way to compare human variation. Usually measurements are easily acquired even from high quality casts, where as other methods, i.e. mtDNA in many cases cannot be collected from specimens. Multivariate analysis provides a relatively unbiased and objective method for comparison. Many anthropologists have, over the past few decades created a database of different populations, living and extinct to compare current measurements to. W.W. Howells database contains the measurements of over 2,500 skulls from numerous populations; Loring Brace has done the similar collections, as well from populations spanning the globe. These provide the scientific world with numerous populations from which to compare.

Multivariate analysis allows the researcher to compare several measurements on the skull with skull measurements from numerous populations at once. Multivariate analysis also makes it obvious where the variation lays within the skull shape, by making specific, the differences between populations.

Using multivariate analysis allows the entire skull to be compared and studied in an unbiased manner. Previously, specimens were compared based on a small number of measurements deemed important by the researcher(s). This calls upon personal judgment and bias in the interpretation of the study. According to Howells, though,

Present methods of multivariate analysis, however, allow a skull to be treated as a unit, i.e., as a configuration of the information contained in all its measurements. Next, they allow populations to be treated as configurations of such units, taking

account of their variation in shape because they in turn are handled as whole configurations of individual dimensions (Howells, 1973).

This allows the relationships and variations between all the populations being considered to be viewed in a complete and objective manner. Herein lies the strength of multivariate analysis; it considers the entirety of the population and the measurements and variations within while comparing them to another existing population and all its inclusive measurements. This information and its relationships and significance, although limited by the measurements chosen to represent the skull, are not biased by the researcher and provide an extremely detailed area of study (Howells, 1973).

Multivariate analysis also provides the researcher the opportunity to further catalogue the results. From visual discrimination based upon, hair form, skull shape, and skin color the researcher cannot truly compare or contrast specimens. Within the realm of multivariate analysis one can view more subtle traits and compare them with known populations thereby actually cataloging specimens into distinct populations and ancestries, i.e. not just "Mongoloid," as with visual analysis, but Ainu or Jomon. The long used Mongoloid, Caucasoid and Negroid differentiations are shrouded in racial undertones. Modern scientists believe that race does not exist and the descriptors used to separate peoples of the world into their respective "races" are merely surface adaptations based on human variations and environmental pressures. For this reason anthropologists today through studies and observations, abstain from using "race." In order to separate populations modern anthropologists now discuss specific ethnic groups instead of the broad racial categories of yesteryear.

Within this study, the results obtained were not used to place each specimen in its respective ancestral groups, but instead to, possibly find a link between the specimens

and make inferences about the peopling of the North American continent. Similarities in measurements would lead the researcher to believe that the specimens were from the same ancestral stock, and regardless of their geographic place in North America, most likely were from the same populations. Variations in measurements means the opposite, these peoples were not from the same populations and most likely are unrelated and came from different populations as they peopled North America.

Multivariate analysis defines a wide variety of tests and analyses. For this study I used a one-way Hotelling T^2 test and a Euclidean Distance Tree. The specifics of these tests are discussed later in this section as is a description of the methods of performing these analyses.

Choosing the Measurements

The populations for this thesis were chosen due to their antiquity and completeness of the skull. The sample consists of remains that date between 8,000 and 10,000 years before present. These dates once again do not refer to the Jomon and Ainu populations. These two populations were chosen because previous studies link the Ainu to some modern paleoindian groups (Powell and Rose, 1999) and Howells (1973) links the Ainu and Jomon populations together. These dates were chosen in an attempt to isolate the paleoindian groups within these remains. However, by choosing remains that date back around 8,000 ybp I, the researcher, understand that I have limited myself and my research based purely upon the number of measurable skulls this old.

As mentioned above, my research was limited by the absence of the physical specimens. All of the specimens I studied were previously measured by someone else.

This method, unfortunately because of the nature of this study, was the only way to achieve the results. Because many of these specimens no longer exist or cannot be studied I had to rely on previous research. Although this does increase the chance for inconsistencies within the measurements, this was the only plausible route. Furthermore, the measurements contained many times were not congruent with one another. The chance for continuing research based upon future finds is great, and ideally the opportunity for measurement and study will arise.

Finally the sheer lack of specimens makes this project difficult. It is hard to formulate a statistical study based upon so few individuals with so few measurements. Ergo, this is all we have, and these few specimens and the knowledge they can lend must be examined carefully. Research of this nature not only provides scientists with possible answers to ancestral ties, but it can also add to information about the peopling of the New World.

Variation in skeletal morphology is the result of not only genetic, but also environmental differences between groups. It is assumed, as stated previously, that groups with similar cranial form are more closely related than groups that vary greatly in craniofacial morphology. Previous studies indicate that heredity greatly influences cranial shape, as well as adaptations to environmental stimuli (Buikstra and Ubelaker, 1994).

Craniometric data is useful to address questions of ancestry, morphology, and geographical and cultural relationships. Not only are answering these questions important in modern forensics, but in the case of this study, they are important in exposing prehistoric possible links in geographically separated populations. Skull

analysis are typically used in studies, where ancestral links are attempting to be established, because it provides the researcher with numerous measurements and usually shows the level or relatedness better than postcranial measurements.

Previously physical anthropologists and osteologists have used measurements that typically define sex, age and genetic differences in groups. With the advent of computers and more detailed methods for studying and approximating, the list of measuring points continues to grow. W.W. Howells and Loring Brace have established large databases of measurements and points from numerous populations across the world both living and extinct.

The most applicable cranial measurements for this study would be those variables that are least affected by environmental conditions and perturbations. The ideal measurements are those that are most heritable, since I am attempting to compare populations across a wide range of environments, but more importantly identify them as genetically linked populations. Environments while they do play a very important part in craniofacial morphology are not as important in this study as are genetics. It is understood that changes in morphology will occur across different environments as populations spread out and adapt. These changes however, because I am using specimens relatively close in age (8,000-10,000 ybp) or in the case of the Jomon and Ainu much more recent but known to be related, should not be as prevalent due to the short time period, evolutionarily speaking, as those caused by genetics. Consequently, if populations differ dramatically from each other, then it can be assumed that they come from different ancestries.

Of the possible measurements, facial, vault and mandibular, facial measurements reveal the subtle differences in populations and are considered more effective in discriminating among groups. Craniofacial measurements have been known to show ancestry and the ability to separate human populations better than dental measurements. Previous studies have also shown that physical and morphological differences in the facial features will be present in genetic lineages. Therefore the majority of these measurements include the orbital, nasal, and zygomatic bones of the cranium (Freid, 2000).

The measurements chosen have been those that are most commonly used in such studies. Unfortunately, since other researchers took these measurements, I have had to use what information they have provided. Standards have been in place for over half a century and previous researchers did measure from many of the same facial landmarks. These landmarks were put into practice by earlier researchers such as W.W. Howells, C. Loring Brace, Martin and Buikstra and Ubelaker.

Buikstra and Ubelaker, use a primary data set of 24 cranial and 10 mandibular measurements. The mandibles of the specimens in this study, with the exception of a few, were not measured, due to lack of actual mandibles, and the fact that jaw shape and size can be significantly altered by environmental and adaptive strategies, i.e. eating behavior. Most specimens were complete craniums and therefore the measurements herein are typically those of the cranial nature.

Buikstra and Ubelaker (1994) also applied intra and interobserver tests to check the validity of their measurements. Most researchers recommend a replication study in order to check ones' measurements. Intraobserver error studies focus on the single

researcher that previously took the measurements being able to replicate them; conversely interobserver error studies are designed to check for replication of results between multiple researchers. These tests usually occur after a period of time has elapsed between the initial measurements and the replication of those same measurements. Buikstra and Ubelaker (1994) suggest that enough individuals be measured during the replication to compose a sample of 10-20% of the total population.

All the researchers in these previous studies followed a simple rule in order to reduce error overall. This decree is to attempt to make replication of measurements easy by determining an efficient landmark from which to measure on a repeatable basis (Howells, 1973). Within the Windover data group Freid separated the measurements into small groups of 6-10 variables and limited her measurement sessions to no more than three hours.

W.W. Howells noted that the way two researchers hold the skull and even their measuring tools could have noticeable effects on the final results. A small mismeasurement, of even a couple millimeters will permeate all the data and can skew the final results.

Because Howells data set contained over 2,500 skulls reducing error and checking it was inconceivable due to the large size of the sample. Howells carefully checked the accuracy of his instruments and made adjustments accordingly. Throughout the course of the study he was also inspecting all the measurements and checking unusually high or low readings. These readings were marked and rechecked by the original researcher and another one at a later date. Along with high and low measurements all the measurement

sheets were checked daily and any suspicious measurement was marked and checked at a later time.

The Kennewick Skull has an added advantage in accuracy. This is due to the fact that the specimen was measured several times over the course of many months. Dr. James Chatters performed the initial investigation, and then Dr. Joseph Powell and Dr. Jerome Rose conducted later research on Kennewick Man. The results vary somewhat, but the complete published results are those of Powell and Rose. They were hired by the United States government to study the Kennewick bones and present their findings to a committee in accordance with the Native American Graves Protection and Repatriation Act.

Powell and Rose applied the above mentioned error tests when measuring the Kennewick Skull, in addition they were also able to reference some of Chatter's previous measurements. The Kennewick needed to be reconstructed, because many of the cranial elements were fragmentary. The team chose to use a wax instead of permanent glue, and several times pieces were removed and refitted until the researchers agreed on their placement. A small gap was present between the maxillary and zygomatic bones because the zygomatic had been previously permanently affixed in an incorrect position. Powell and Rose (1999) however concluded this small (1 mm) gap did not affect the metric data collected from the cranium.

Prior to the arrival of the Kennewick skull, Powell collected skull measurements from other crania from the Maxwell Museum's Documented Collection. These measurements were rechecked after a period of four days in preparation for the

Kennewick measurements. Along with Chatters' data a reconstruction of the Kennewick skull was also measured and checked against the original for differences.

The measurements were performed and checked by both Powell and Rose over the course of the investigation. The rates of intra and interobserver error were low and will within the acceptable limits. Only small differences between the cast and the original were noted, these were due to the inability to locate certain sutures on the cast (Powell and Rose, 1999).

In the data sets used as measurements in my current research, the scientists previously have evaluated and checked their work for errors. This was obtained in many ways but all data was certified valid by the previous researcher. The measurements that I have chosen to use have checked for accuracy by me, as they were copied to my database, and also evaluated with the help of SPSS 11.

I have chosen variables based upon those that through past studies have been found to show the most heritability and those that are least affected by external forces. These were decided upon, not only because these measurements are common and easily obtainable, but because within the scope of my study they will provide the best results.

Definition of Measurements

The measurements used in this study are defined and described in Buikstra and Ubelaker (1994), Howells (1973), and Freid (2000). The measurements chosen for this study were taken from Freid (2000) from her Windover population measurements. This population was chosen because it contained the most measurements and therefore assumed that a large number of measurements could be transferred to the other study populations. However, it must be noted that not all of the measurements were found to

be in common with the other groups and many did not transfer, and were not used in the course of this study. The measurements and their reference points are listed and described below and are taken directly from Buikstra and Ubelaker (1994).

Measurements, descriptions and illustrations taken from Buikstra and Ubelaker (1994)

DEFINITIONS OF CRANIAL MEASUREMENTS (Figures 1-9 illustrate measurements)

1. **Maximum Cranial Length (g-op):** distance between glabella (g) and opisthocranium (op) in the midsagittal plane, measured in a straight line. *Instrument:* spreading caliper. *Comment:* Place skull on side, holding one end of caliper at glabella and extending caliper until maximum diameter at posterior aspect of skull is obtained.
2. **Maximum Cranial Breadth (eu-eu):** maximum width of skull perpendicular to midsagittal plane wherever it is located, with the exception of the inferior temporal lines and the area immediately surrounding them. *Instrument:* spreading caliper.
3. **Bizygomatic Diameter (zy-zy):** direct distance between most lateral points on the zygomatic arches (zy-zy). *Instrument:* spreading or sliding caliper.
4. **Basion Bregma Height (ba-b):** direct distance from the lowest point on the anterior margin of foramen magnum (ba), to bregma (b). *Instrument:* spreading caliper.
5. **Cranial Base Length (ba-n):** direct distance from nasion (n) to basion (ba). *Instrument:* spreading caliper.
6. **Basion Prosthion Length (ba-pr):** direct distance from basion (ba) to prosthion (pr). *Instrument:* spreading or sliding caliper.
7. **Maxillo-Alveolar Breadth (ecm-ecm):** maximum breadth across the alveolar borders of the maxilla measured on the lateral surfaces at the location of the second maxillary molars (ecm). *Instrument:* spreading caliper. *Comment:* The points of measurement (ecm) are customarily *not* found on the alveolar processes, but are located on the bony segment above the second maxillary molars.
8. **Maxillo-Alveolar Length (pr-alv):** direct distance from prosthion (pr) to alveolon (alv). *Instrument:* spreading or sliding caliper. *Comment:* Sliding caliper applicable only if incisor teeth have been lost. Position skull with basilar portion facing up. Apply a thin wire, wooden rod, rubber band, or other similar device to the posterior borders of the alveolar arch and measure the distance from prosthion to the middle of the wire/band (on midsagittal plane).

- 9. Biauricular Breadth (au-au):** least exterior breadth across the roots of the zygomatic processes (au), wherever found. *Instrument:* sliding caliper. *Comment:* With the skull resting on the occiput and with the base toward the observer, measure to the outside of the roots of the zygomatic processes at their deepest incurvature, generally slightly anterior to the external auditory meatus, with the sharp points of the caliper. This measurement makes no reference to standard landmarks of the ear region.
- 10. Upper Facial Height (n pr):** direct distance from nasion (n) to prosthion (pr). *Instrument:* sliding caliper. *Comment:* This measurement may be estimated under conditions of minor alveolar resorption. It should not be taken if resorption is great.
- 11. Minimum Frontal Breadth (ft-ft):** direct distance between the two frontotemporale (ft). *Instrument:* sliding caliper.
- 12. Upper Facial Breadth (fimt-fmt):** direct distance between the two external points on the frontomalar suture (fmt) *Instrument:* sliding caliper.
- 13. Nasal Height (n-ns):** direct distance from nasion (n) to the midpoint of a line connecting the lowest points of the inferior margin of the nasal notches (ns). *Instrument:* sliding caliper.
- 14. Nasal Breadth (al-al):** maximum breadth of the nasal aperture (al-al). *Instrument:* sliding caliper. *Comment:* Be certain measurement is perpendicular to the midsagittal plane.
- 15. Orbital Breadth (d-ec):** laterally sloping distance from dacryon (d) to ectoconchion (ec). *Instrument:* sliding caliper. *Comment:* for standardization and practical reasons, measure the left orbit. Measure the right orbit if the left is damaged, and record the side measured on the recording form.
- 16. Orbital Height:** direct distance between the superior and inferior orbital margins. *Instrument:* sliding caliper. *Comment:* measurement is taken perpendicular to orbital breadth and similarly bisects the orbit. Avoid notches on either orbital border.
- 17. Biorbital Breadth (ec-ec):** direct distance between right and left ectoconchion (ec). *Instrument:* sliding caliper. *Comment:* This measurement may be difficult if the anterior lateral orbital margins are sharp.
- 18. Interorbital Breadth (dal):** direct distance between right and left dacryon (d). *Instrument:* sliding caliper.
- 19. Frontal Chord (n-b):** direct distance from nasion (n) to bregma (b) taken in the midsagittal plane. *Instrument:* sliding caliper.

20. Foramen Magnum Length (ba-o): direct distance from basion (ba) to opisthion (o). *Instrument:* sliding caliper. *Comment:* tips of caliper should rest precisely on opposing edges of the border of foramen magnum.

21. Foramen Magnum Breadth: distance between the lateral margins of foramen magnum at the points of greatest lateral curvature. *Instrument:* sliding caliper.

22. Chin Height (id gn): direct distance from infradentale (id) to gnathion (gn). *Instrument:* sliding caliper. *Comment:* id may be estimated in slightly eroded specimens by reference to alveolus adjacent to lateral incisors. If alveolus is markedly eroded, specimen should not be measured.

23. Height of the Mandibular Body: direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen. *Instrument:* sliding caliper.

24. Bigonial Width (go-go): direct distance between right and left gonion (go). *Instrument:* sliding caliper. *Comment:* Place the blunt points of the caliper to the most prominent external points at the mandibular angles.

25. Bicondylar Breadth (cdl-cdl): direct distance between the most lateral points on the two condyles (cdl). *Instrument:* sliding caliper.

26. Maximum Ramus Breadth: distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of the jaw. *Instrument:* sliding caliper.

27. Maximum Ramus Height: direct distance from the highest point on the mandibular condyle to gonion (go). *Instrument:* sliding caliper or mandibulometer.

38. Mandibular Length: distance of the anterior margin of the chin from a center point on the projected straight line placed along the posterior border of the two mandibular angles. *Instrument:* mandibulometer. *Comment:* Apply movable board of the mandibulometer to the posterior borders of the mandibular rami and the fixed board against the most anterior point of the chin. Mandible may be stabilized by gently applying pressure (one or two fingers) to the left second molar.

For further definition of measurement points see Appendix A.

Methodology

The remains chosen and measured in this study were previously recorded by other researchers. The inability to measure the remains myself also puts certain

limitations on my research. However because many of the skeletons have since been repatriated or no longer exist, this is an acceptable limitation of my research. By choosing the above measurements, it was hoped that they would allow the best reflection of genetic and morphological traits and a gauge of similarity between the skulls.

Once the skeletal data sets were selected {Kennewick Man (Powell and Rose 1999), Skull 101(Xinzhi and Zhenbiao, 1985) Buhl Woman,(Green et al, 1998) Spirit Cave Man (Barker et al, 2000) The Windover population (Freid, 2000) and Howell's Jomon and Ainu (1966,1973) populations} the measurements were entered into Microsoft Excel in spreadsheet form. The entered measurements were then visually checked and compared with the original data sets to ensure no mistakes were made in the transposing of data. The final Excel measurements were then copied to SPSS 11.0 and the range, minimum statistics, maximum statistic, mean and standard statistic were calculated to once again check for mistakes. A large mean, range or standard deviation shows that a measurement was incorrectly entered. For instance, if most glabella-occipital lengths (gol) were between 160 and 200, if the maximum is 2000 or the minimum is 19 then it is apparent that numbers were entered incorrectly.

The measurements were then compared between each of the samples to be studied, to determine which measurements were similar and could be evaluated. If the variables were not present in all the individuals for each test, then that measurement was dropped. For example, when compared, the measurements for Skull 101 and the Windover population include 18 different measurements. But when Skull 101 is compared with the Jomon population only 8 measurements were used because that is all the two samples have in common. Because of the small sample numbers, no missing data

treatments were used. It was thought that by performing these treatments the results may be skewed. Even if one individual skull within the Windover population did not include, for instance, the biaucular breadth (aub) and that measurement was one determined earlier to be common between both subjects for that analysis, then that entire measurement was dropped for all the skulls and not included in that particular analysis.

Furthermore, because the Jomon, Ainu and Windover populations all consisted of both male and female skulls, the measurements were not standardized, in order to make up for the size difference between males and females. Buhl Woman was then compared directly against the raw measurements of the above listed populations. Since a the statistical test used compares the means of each measurement, the size differences between males and females would in effect be nullified and a comparison with Buhl Woman could be made with confidence.

The remaining variables were entered into Excel spreadsheets containing only the measurements the two samples had in common. Once entered into appropriate spreadsheets and, after all missing measurements were excluded, the Excel spreadsheets were saved in text form (tab-delimited) and then moved into S-plus. S-plus is a statistical program that uses UNIX and PC and a Java-based interface. S-plus gives the user control to edit and maintain data in word pad and to essentially fully change the computations for the data. Once the data-sets were transformed from Excel tab-delimited format and saved in S-plus, files were created with each data-set in order to compare the groups. The Hotelling T^2 test program used in Splus was written by Hiroaki Oe from University of Michigan. These files consisted of the appropriate measurements in common with each sample. Next the outfile was created in order to read the results.

These files were created in word-pad so they could be read and edited and then the one-way Hotelling T^2 test in S-plus was run using the edited information. S-plus is one of the few programs available to run a one-way T^2 test. The results were shown in the appropriately named outfile and then printed to be easily studied. The one-way or one-sample T^2 test is used to compare a group (i.e. Windover) to an individual (i.e. Skull 101) in an attempt to see if that individual is statistically part of the group it's tested against. Being a multivariate test, the one-sample T^2 tests samples that contain many variables. The one-sample test is used when both components of the comparison have multiple variables, but when comparing a group to one individual, a two-way or two-sample test is used when comparing a group to another group, both as well with multiple variables (Hiroaki Oe, 2002). For instance, the Windover sample group consisted of 63 skulls all with numerous measurements. The Skull 101 sample was comprised of only one skull, but also with numerous measurements. Even though both samples originally contained over 30 measurements when compared together 18 measurements were found to be common between the samples. That is to say that both Windover and 101 had maximum cranial length, maximum cranial breadth and 16 other measurements in common. A one-way T^2 test takes the mean for each measurement in all 63 individuals in the Windover site and compares it to Skull 101's measurements giving the researcher a measure of statistical similarity. As mentioned previously, similarities in skull shape can be indicative of similar ancestry, so according to the results of the T^2 if the "p" value for the T^2 statistic is zero then there is absolutely no similarity, statistically speaking, between the two samples. The closer the "p" value is to one, the more statistically similar the two specimens are. A "p" value of one would indicate two statistically identical specimens.

Furthermore, if the results show a “critical value” with a 95 % confidence rate of say 45, then for the samples to be related statistically the Hotelling T^2 statistic or “T” value would be close to 45 as well. In reality my “p” value was zero and my critical value for this particular sample (Windover vs. Skull 101) was 45 and my “T” value was 27,799. This shows that according to this test, the Windover population is statistically very different from Skull 101, and therefore these samples do not share common ancestry. These results will be examined in detail in the results and discussion sections of this paper.

Neighbor-Joining Trees.

The next calculation that was performed was the Neighbor-joining tree based on Euclidean Distance; this program was also written by Hiroaki Oe, with assistance from Noriko Seguchi of the University of Montana. A Euclidean distance tree shows the degree of relatedness between all of the populations when compared to each other. All individuals and populations are compared at mass to determine, based on the available data, which samples are more likely to be related. A Euclidean distance test will compare populations to other populations, but because I did not have the specimen count to allow this, I had to compare populations to individuals. The individual skulls (Spirit Cave Man, Buhl Woman, Skull 101 and Kennewick Man) were viewed by the program as populations. This could lead to some discrepancies in the comparison, because the comparison was made between the mean of the populations to the actual data of the individuals. Unfortunately, due to the small sample size available this was the only way to complete the Euclidean distance tests. This program also used C-scores as a method of evaluation. A C-score is used to control the variations in size. Using C-score is one

method of standardizing the data. Howells (1989) states “C-scores do make a size correction, they do reveal shape, and they do make the two sexes comparable.” Looking for relationships in the raw measurements is usually ineffective. C-scores do not change relationships; they bring differences in the raw measurements to light by showing the relations between the specimens in a measurable way. The Neighbor-joining tests, while looking at C-score and taking the mean of the population, do not however, look at variance, therefore because of the small sample size used some comparison errors could occur. The equations (see Appendix D) for C-score used in this program are based upon Howell (1989) and Brace (1990).

These results however compelling, can be somewhat misleading because they take into account only the samples being compared. For instance, when comparing the Jomon, Ainu populations with Kennewick Man and modern Native American populations, the results may show Kennewick Man linked to the Ainu and Jomon populations before those of the modern Native Americans. But as the tested groups grow in number, now add Spirit Cave Man, Buhl Woman, the Windover Population, Skull 101 and Chinese Neolithic and Bronze Age populations, the results may show Kennewick Man far from being linked to the Jomon and Ainu populations. When compared to certain populations it would be possible to draw links between any number of statistically unrelated populations.

The method of comparison that was chosen for this research is called the neighbor-joining method. This system is based upon finding operational taxonomic units, or neighbors. These neighbors minimize the total branch length at each stage of the clustering. Within this method it is also possible to obtain the branch length between the

specimens as well. This type of phylogenetic tree was developed by Saitou and Nei, in order to increase the efficiency of these trees and produce a tree under the principle of minimum evolution (Saitou and Nei, 1987).

This test shows a measure of statistical relatedness based on the populations entered into the program. The results are shown by connecting lines, the most related are closest on the “tree” and are connected by a series of attached lines. The populations or individuals that are least related are farthest away on the tree and the lines between them are the longest. For this study all the individuals and populations were run together to see how closely related they were.

The neighbor -joining Euclidean distance tree was produced much the same as the as the T² test results were. A group file was produced and all the in common measurements were combined into a file. These measurements were then run through S-plus and plugged into the Euclidean distance program (Oe and Seguchi, 2002). This program allows the user to change the root and if desired to measure the distance of the branches between populations. This test differed from the T² test however, it measured more populations which included Chinese bronze-age, Kurgan and Chinese neo-lithic populations as a reference points. These added populations were thought to be unrelated to the current study group and would thereby add depth to the distance tree.

DISCUSSION AND SUMMARY

I specifically chose skulls of similar age for this study to in an attempt to find links of common ancestry. These results can not dispute however, that the Windover population and Skull 101, or any of those studied for that matter, did not come from a

similar population at some point in time. The results are only looking at the similarities between the populations that I chose which existed 8,000 to 10,000 years ago. The ancestors of these skulls may be from the same populations 100,000 years ago and by 8,000 years ago, the populations had been so long diverged that no statistical similarities were detected.

Unfortunately, my results are very similar for all my comparisons. The results all have “P” values of zero and critical and t-values differing very significantly. These raw results can be viewed in the Tables in Appendix B, and are discussed below.

Summarized results are found in this section in Results Tables 1 and 2.

Buhl Woman

As mentioned previously, a “P” value of zero indicates no statistical significance, furthermore, the closer the critical value and the T^2 statistic are, the more significance as well. The Windover test compared six variables: Maximum cranial length (gol), Basionasion length (bnl), Maximum cranial breadth (xcb), Bizygomatic breadth (zyb) Basion prosthion length (bpl) and Nasal breadth (nlh). These were the only measurements that every individual within this comparison comprised. The results show a T^2 statistic of 252.87777, and a critical value of 14.766. Once again the closer these numbers the more statistically similar these two are. A P value of zero already shows no statistical similarities, but when the critical value and T^2 statistic are compared, it is realized just how far apart these two samples. A T value of 20 would show a statistical relationship, but if this was achieved the P value would not have been zero. See Table 1 for results.

Next Buhl Woman was compared to the Ainu population (Table 2.) The same six variables were used. The limited numbers of variables used are in part due to the

antiquity of Buhl Woman and the damage she sustained while buried. Again a P value of zero is found and a critical value of 14.11548 compared to a T² statistic of 227.25925. Once again these two specimens are significantly different.

Finally Buhl Woman was compared with the Jomon population, and the same six variables were found to be in common (Table 3). In this test a T² stat of 334.98397 is compared with a critical value of 14.09591 and a P value of once again, zero. However, it is shown that out of the three populations compared with Buhl woman, she is furthest away from the Jomon population and closest to the Ainu; however they are still far from being members of the same group or ancestry.

Skull 101

Skull 101 was compared to the Windover population, the outfile shows a P value of zero, a critical value of 45.5847 and an unfortunate T² statistic of 27799.54617. The results for the Buhl Woman/ Windover comparison above showed a large difference, but I feel it is safe to say that Skull 101 and the Windover population are extremely different populations. Eighteen variables were tested: The six variables mentioned above were used, along with Minimum frontal breadth (frb), Nasal breadth (nlb), External Avelor length (mal), Orbital height, left (obh)Frontal chord (frc), Mid facial breadth (mfb), Upper facial height (nph), interorbital breadth (iob) and Anterior interorbital breadth (aib). (See Table 4).

Next, Skull 101 was compared with the Jomon population (Table 5). Eight variables were compared; Max. Cranial length, Basion-nasion length, Max. cranial breadth, Bizygomatic breadth, Basion-prosthion length, Nasal height, External alveolar breadth and Upper facial height. The Hotelling T² statistic is 2482.63015 and the critical

value is 17.92198, while the P value remains zero. This test is closer than Skull 101 versus the Windover population but, nevertheless extremely far away.

Finally the Ainu and Skull 101 were compared using 11 variables: Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Bizygomatic breadth (zyb) Basion prosthion length (bpl) and Nasal breadth (nlh), Orbital height, left (obh) Frontal Chrod (frc), External Aveolar breadth (mab), Orbital breadth, left (obb), and interorbital breadth (dkb). This test resulted in similar results as the above tests, no relationship of any significance. A T^2 statistic of 21687.13417 and a critical value of 23.92053 were found, with a P value of zero (See Table 6).

Kennewick Man

The Kennewick tests are much the same, with the exception that the most variables were found and be in common and used in the tests. The large number of common variables is a reflection of the nature of the find. Kennewick man was extremely well preserved and is a very recent find. The scientists involved also knew that Kennewick Man was to be repatriated, and therefore were extremely thorough in their measurements.

Kennewick Man when compared to the Windover population (Table 7) yields the same results as seen previously. Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Minimum frontal breadth (frb), Biaucular breadth (aub) Basion prosthion length (bpl) and Nasal height (nlh), External alveolar breadth (mab), External alveolar length (mal), Orbital height, left (obh) Frontal Chrod (frc), External Aveolar breadth (mab), Orbital breadth, left (obb), and interorbital breadth (dkb), Biorbital breadth (ekb), Malar length (xml) and Cheek height (wmh), were all

compared and tested. The T^2 statistic is 11011.73338 and the critical value is 42.38809, leaving the P value as zero.

When compared with the Ainu population, 14 variables were tested (See Table 8). These included: Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb) Biaucular breadth (aub) Basion prosthion length (bpl) and Nasal height (nlh), Orbital height, left (obh) Frontal Chrod (frc), External Aveolar breadth (mab), Orbital breadth, left (obb), and interorbital breadth (dkb), Biorbital breadth (ekb), Malar length (xml) and Cheek height (wmh). This yields a critical value of 30.27239 and a T^2 stat of 3583.81172, and a P value of zero.

Finally Kennewick was run against the Jomon population where six variables were used. These variables were Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Basion prosthion length (bpl) and Nasal height (nlh), and Nasal breadth (nlb). Once again the P value is zero and the critical value is 14.09591 versus a T^2 statistic of 640.19705. See Table 9 for results.

These results show that if rank the similarity of the populations then Kennewick Man is most similar to the Jomon population, and furthest from the Windover population. These results were corroborated with previous studies by Powell and Rose within a Euclidean distance tree. Within the distance tree Kennewick Man is closest to the Jomon population; however with the T^2 test we can see that Kennewick is still not statistically a part of the Jomon population. The Euclidean distance test performed by Powell and Rose only shows that when compared to other populations, such as modern Native Americans, that Kennewick Man is more closely related to the Jomon than to the Native American populations of today.

Spirit Cave Man

The final group of tests looks at Spirit Cave Man and his relationship to Windover, Ainu and Jomon populations. The Windover test (Table 10) compares seven variables: Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Basion prosthion length (bpl), Bizygomatic breadth (zyb), Nasal height (nlh), and Nasal breadth (nlb). The results are as follows, a critical value of 16.88071 and a T^2 statistic of 1158.31378, with a P value of zero.

When compared with the Ainu population compares six variables: Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Basion prosthion length (bpl), Bizygomatic breadth (zyb) and Nasal height (nlh). These results (Table 11.) show a T^2 statistic of 2197.1921 and a critical value of 14.11548, with a P value of zero.

Finally the Jomon comparison shows a P value of zero, a T^2 statistic of 1110.97137 and a critical value of 16.00059 when comparing seven variables: Maximum cranial length (gol), Basion-nasion length (bnl), Maximum cranial breadth (xcb), Basion prosthion length (bpl), Bizygomatic breadth (zyb), Nasal height (nlh), and Nasal breadth (nlb). (See Table 12. for results).

These results show that Spirit Cave Man is closest to the Jomon and furthest from the Ainu populations, but once again no statistical significance is shown.

Results Table 1.

	Kennewick Man vs. Windover	Kennewick Man vs Ainu	Kennewick Man vs. Jomon	Spirit Cave Man vs Windover	Spirit Cave Man vs. Ainu	Spirit Cave Man vs Jomon
Hotelling T2 Stat:	11011.73338	3853.81172	640.19705	1158.31378	2197.1921	1110.97137
P-value for T2 Stat:	0	0	0	0	0	0
Critical Value for .95-alpha:	42.38809	30.27239	14.09591	16.88071	14.11548	16.00059

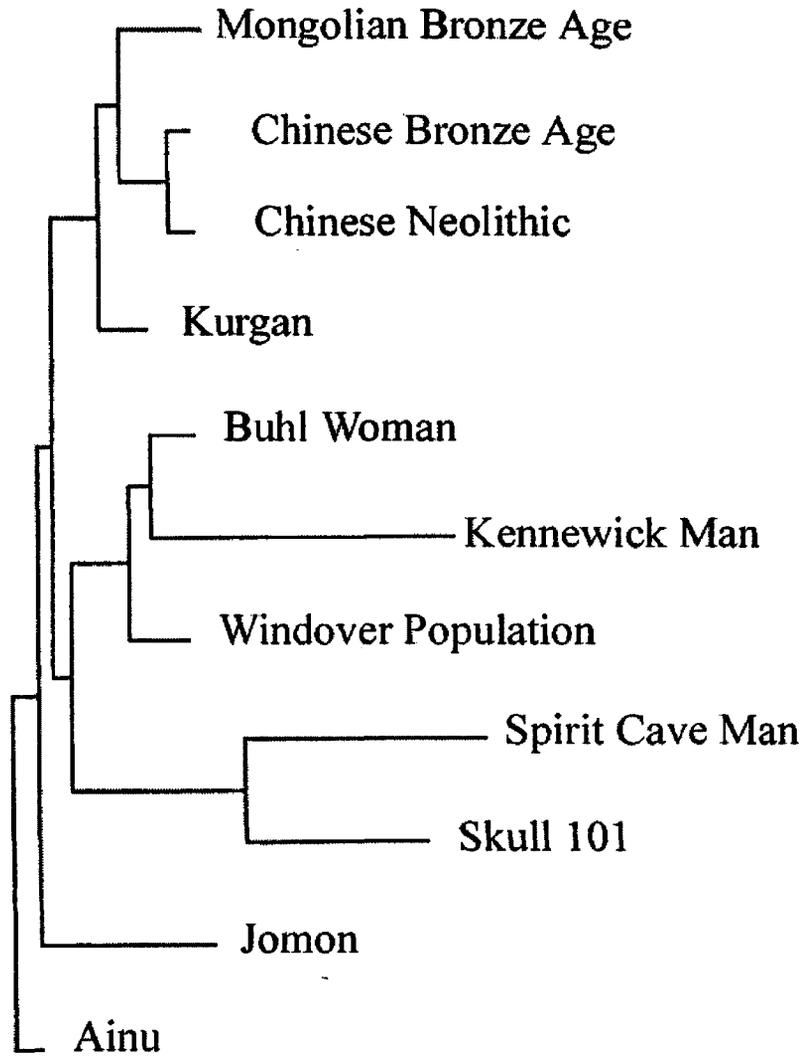
Results Table 2.

	Buhl Woman vs. Windover	Buhl Woman vs Ainu	Buhl Woman vs Jomon	Skull 101 vs Windover	Skull101 vs. Jomon	Skull 101 vs Ainu
Hotelling T2 Stat:	252.87777	227.25925	334.98397	27799.54617	2482.63015	21687.13417
P-value for T2 Stat:	0	0	0	0	0	0
Critical Value for .95-alpha:	14.766	14.11548	14.09591	45.5847	17.92198	23.92053

Neighbor-Joining Tree Results

The results of the Euclidean distance tree tests (Oe, 2002) show interestingly that Spirit Cave Man and Skull 101 are the closest to each other on the tree than the other groups tested (Figure A.) This means according to this experiment that Spirit Cave Man is more closely related to Skull 101 than he is to Kennewick Man, Buhl Woman, the Windover, Jomon or Ainu populations. Many of the newest radiocarbon dates on Skull 101, may even place it over 29,000 years old. It would seem that a skull found in North America (Spirit Cave Man) that dates to around 9,500 years old would be more closely grouped to other remains found in that region that date to about the same time, i.e. Kennewick Man, the Windover population. Instead, however Spirit Cave Man is closely related to Skull 101, although these remains are located thousands of miles away Skull 101 lived thousands of years previous to Spirit Cave Man. For actual branch lengths and distances, see Table 13 in the Appendix.

Figure A.
Neighbor-Joining Euclidean Distance Tree Results



What does it all mean?

This project was undertaken in an attempt to link early inhabitants in North America, together with each other or their parent populations. The paleoindians, as discussed previously, are still mysterious and their origins clouded in the unknown. The hopes of this project were to define a traceable lineage or ancestry between the groups studied, in order to discuss and apply the knowledge the peopling of North America. While this did not happen and no links were established, these answers can still tell us much about the settlement of the New World.

The lack of statistical evidence to show ancestry does not however tell us that these populations were at one time not related. The results though do show that they were far diverged from each other at the time discovery and study. This can be interpreted in one of two ways: The populations and individuals studied are not of the same ancestry and are all descendents of varying populations around the globe. These populations then migrated into North America possibly between 12,500 and 8,500 years ago and spread out to settle in their respectable climates where their remains were found today. This scenario works well with Greenberg's theory discussed earlier in this research. Greenberg (1996) believes that three distinct migrations were made into North America from Asia. These migrations then split up to form the linguistic groups that we see today. If the specimens represented in this study are all from varying populations, then it is possible that they were part of these three distinct migrations, and show no statistical relatedness whatsoever, this also means that the New World was populated by people from the Asian continent.

Christy Turner's theories on the changing physical attributes of teeth, do lend some support to the above hypothesis of three distinct migrations to the new world. Turner shows that paleoamericans share the same set of dental traits with Northern Asians (Fagan, 1987). The changes in morphology of dentition can also lead to a time line of approximately how long it has taken for the changes to take place. After calculation Turner shows that the first crossing of the Bearing land bridge and movement into Alaska would have taken place 14,000 years ago. This initial migration was then followed by immigrants from Siberia and the ancestors of modern coastal Indian. These are congruent with Greenberg's three migrations: first Amerind, then Na-Dene and finally Aleut-Eskimo (Fagan, 1987). These theories are by no means accepted by all anthropologists and linguists today, they are merely a small part of the numerous studies attempting to find strong evidence of early occupation in North America.

The second interpretation places the specimens as part of the same populations perhaps over 40,000 years ago. This large group then moved into North America during the Mid-Wisconsin phase and began to settle and spread out. This was a time between 60,000 and 25,000 years ago of glacial retreat. Most of North America was glacial free at this time and climates would have been similar to tundra climates of today. Although today we still have no concrete evidence of humans in the New World at this time, this does not mean that people were not here. Fagan reiterates "there is so far absolutely no evidence for human settlement in North America in the Mid-Wisconsin" (1987:137). Archaeology is unfortunately based largely on luck and chance, and if the remnants of the earliest settlers were not deposited in the correct environments, or are now miles out at

seas, chances are scientists may never find the evidence needed, to support such a paradigm change.

Perhaps the reason scientists find no evidence of earlier habitation is because they are looking in the wrong places. Recent discoveries may now show some evidence that the peopling of the New World happened very differently than once believed. It is entirely possible that the earliest settlers into the New World did not cross the Bering land bridge and move south into the unglaciated parts of North America as is now believed. Loring Brace has shown links between paleoindians and the Jomon and Ainu peoples of Asia. These people are unlike modern Asians but are the ancestral inhabitants of the Japanese Island of Hokkaido and are described by Brace as Eurasian (Brace et. al., 2001).

The relationships between paleoamericans and Eurasians gave Dr. Dennis Stanford the idea to look to Europe instead of Asia for answers to the question “Where did the first Americans come from?” Sites such as Meadowcroft Rock Shelter and Monte Verde, Chile, have always raised eyebrows in the field of Anthropology because they do not fit well within the current models. Because of sites like these, Stanford began to look elsewhere for clues to early migrations. He began looking at the Clovis tool-kit and trying to find its predecessor or similar technology in Asia reasoning if the migrations came from Asia across the Pacific then he would find the tool-kits there. Instead he found what he regards as a similar technology in France, with prehistoric people known as the Solutrean. The parallels between the Clovis and Solutrean points were extremely similar if not identical. According to Stanford no other tool technology in world does what the Solutrean and Clovis flintknapping techniques achieve (Chandler, 2002).

Admittedly this is a very different direction from previous theories of the peopling of North America. If this theory is true then paleoindians would have crossed the Atlantic Ocean, a journey of nearly 3,000 miles, in small crude boats (Chandler, 2002).

If the journey was made by boats however, this could also explain the rapid expansion and population of the New World. A small journey of 20 miles could take a few days on foot while carrying food and supplies, but on an ocean going craft that same journey could be accomplished in no time.

Over time (at least 30,000 years) these groups, once in North America, would have evolved independently of each other based on climatic and genetic variables and today are seemingly unrelated. This validity of this interpretation depends on the date of entry into North America. People would need to be in the New World much earlier than once thought in order for a divergence of this magnitude to take place. This possible explanation has implications to rewrite the history and peopling of North America.

While the notion of peoples populating North America some 40,000 years ago is still considered far fetched by many anthropologists, evidence may eventually show this to be true. Monte Verde as discussed earlier, while controversial is showing radiocarbon dates of nearly 30,000 years before present. Since Monte Verde is located in the southern tip of South America, most people believe that if these dates are in-fact verified, then populations had to be in North America nearly 10,000 years before they reached southern Chile, South America. Furthermore whether or not the Monte Verde dates are accurate, early travelers to the New World could have skirted the shorelines in watercraft and made to the furthest outreaches of land in much less time than previously thought.

If populations are migrating to North America and separating, it is very possible, after a number of years to have such great diversity among paleoindians. As the populations spread out and became isolated from each other and the parent population, normal mutations based on human variations would have begun to show themselves. There is also a possibility of mixing of gene pools leading to further variations. Perhaps, there were two initial populations of immigrants into the New World and they split apart from their respective parent populations. These two groups could then have intermarried and caused much variation among the modern populations studied today. The evidence of one of the populations could have been effectively wiped out leaving virtually no trace today.

This study was not able to find or trace lineages of the paleoindians. However with the neighbor-joining method of phylogenetic trees, the research does show some interesting similarities. As mentioned above Spirit Cave Man and Skull 101 are “closely related” on the tree. It must be reiterated though, that this method only takes into account the populations that are compared within this method. With this in mind, it is however equally compelling that these two skulls would be closer in similarity, than the Jomon and Ainu, which according to Howells (1973) are related, or other North American paleoindians, for that matter. These two specimens are separated by 20,000 years and thousands of miles. If members of the same populations thousands of years ago, we most likely would see no similarities today due to genetic variation and divergence. One possible scenario may be that Skull 101 and Spirit Cave Man are actually related, Spirit Cave Man is, a member of the population which includes Skull 101. If this is the case, then for the similarity to show up as it did, Spirit Cave Man’s population may be more

recent immigrants to the New World, having migrated from the region of Skull 101's population very recently. This would then show the similarity between the two, while not showing the divergence we see with the other paleoindian groups. Meaning if Skull 101 and the population it was part of were living in the same climate and relatively isolated from genetic drift for generations the descendent of this population would morphologically and statistically be very similar. Since Skull 101 and Spirit Cave Man according to the results of the tree appear to be similar, then it is possible that Spirit Cave Man and his parent population is a direct descendent of the population including Skull 101. The reason for their similarity, in part could be due to the late arrival and migration of the Spirit Cave Man's population into North America. This would allow little time for divergence from the original population located in China. Unfortunately, methods for accurately statistically comparing two individual specimens (i.e. Spirit Cave and Skull 101) do not currently exist. Perhaps, the questions of their similarities will be addressed as the technology comes to light. Furthermore, one of the emerging theories discussed previously may also shed new light on these similarities.

Modern advances now make it possible to answer some of these questions. With mtDNA, scientists can now actually find genetic links between populations, making ancestry undisputable. The problem with mtDNA, is that the remains must be uncontaminated and not fossilized. Small portions of the specimens must be available and must be destroyed in the process. Many of the subjects I have chosen to study are no longer available or the remains are in poor shape making mtDNA analysis impossible. Perhaps further advances in technology and new finds will hope to provide answers to the question of "Who were the first Americans?"

Appendix A

ALARE (al): Instrumentally determined as the most lateral points on the nasal aperture in a transverse plane. (Paired)

BREGMA (b): The ectocranial midline point where the coronal and sagittal sutures intersect.

DACRYON (d): The point on the medial border of the orbit at which the frontal, lacrimal, and maxilla intersect: dacryon lies at the intersection of the lacrimo-maxillary suture and the frontal bone. There is often a small foramen at this point. (Paired)

ECTOCONCHION (ec): The intersection of the most anterior surface of the lateral border of the orbit and a line bisecting the orbit along its long axis. To mark ectoconchion, move a toothpick or other thin straight instrument up and down, keeping it parallel to the superior orbital border, until you divide the eye orbit into two equal halves. Mark the point on the anterior margin with a pencil. (Paired)

GONION (go): A point along the rounded posteroinferior corner of the mandible between the ramus and the body. To determine the point, imagine extending the posterior ramus border and the inferior corpus border to form an obtuse angle. The line bisecting this angle meets the curved gonial edge at gonion. (Paired)

EURYON (eu): Instrumentally determined ectocranial points on opposite sides of the skull that form the termini of the line of greatest cranial breadth. (Paired)

FRONTOMALARE TEMPORALE (fmt): The most laterally positioned point on the fronto-malar (fronto-zygomatic) suture. (Paired)

FRONTOTEMPORALE (ft): The point where the temporal line reaches its most anteromedial position on the frontal. (Paired)

GNATHION (gn): The most inferior midline point on the mandible.

INFRADENTAGE (id): The midline point at the superior tip of the septum between the mandibular central incisors.

NASION (n): The point of intersection between the frontonasal suture and the midsagittal plane.

NASOSPINALE (ns): The point where a line drawn between the inferiormost points of the nasal (piriform) aperture crosses the midsagittal plane. Note that this point is not necessarily located at the tip of the nasal spine.

PROSTHION (pr): The most anterior point in the midline on the alveolar processes of the maxillae.

ZYGION (ry): Instrumentally determined as the most lateral point on the zygomatic arch. (Paired)

AURICULARE (au): Not a standard landmark as defined here. Instead it is defined as a point on the lateral aspect of the root of the zygomatic process at the deepest incurvature, wherever it may be. (Paired)

BREGMA (b): The ectocranial midline point where the coronal and sagittal sutures intersect.

FRONTOMALARE TEMPORAIE (fmt): The most laterally positioned point on the fronto-malar (fronto-zygomatic) suture. (Paired)

FRONTOTEMPORALE (ft): The point where the temporal line reaches its most anteromedial position on the frontal. (Paired)

CONDYLION LATERALE (cdl): The most lateral point on the mandibular condyle. (Paired)

GLABELLA (g): The most anterior midline point on the frontal bone, usually above the frontonasalsuture.

GNATHION (gn): The most inferior midline point on the mandible.

GONION (go): A point along the rounded posteroinferior corner of the mandible between the ramus and the body. To determine the point, imagine extending the posterior ramus border and the inferior corpus border to form an obtuse angle. The line bisecting this angle meets the cowed gonial edge at gonion. (Paired)

INFRADENTALE (id): The midline point at the superior tip of the septum between the mandibular central incisors.

LAMBDA (l): The ectocranial midline point where the sagittal and lambdoidal sutures intersect. If location of this point is rendered difficult by the presence of wormian bones, locate the point where projections of the sagittal and lambdoid sutures would meet.

NASION (n): The point of intersection between the frontonasal suture and the midsagittal plane.

NASOSPINALE (ns): The point where a line drawn between the inferior most points of the nasal (piriform) aperture crosses the midsagittal plane. Note that this point is not necessarily located at the tip of the nasal spine.

OPISTHOCCRANION (op): Instrumentally determined most posterior point of the skull not on the external occipital protuberance.

PROSTHION (pr): The most anterior point in the midline on the alveolar processes of the maxillae.

ALVEOION (aiv): The point on the hard palate where a line drawn through the most posterior points of the alveolar ridges crosses the midline.

BASION (ba): The midline point on the anterior margin of the foramen magnum. For cranial height measurements, the point is placed on the anteroinferior portion of the foramen's rim. For basinasal and basiprosthion measurements, the point is located on the most posterior point on the foramen's anterior rim and is sometimes distinguished as endobasion.

ECTOMOLARE (ecm): The most lateral point on the outer surface of the alveolar borders of the maxilla, often opposite the middle of the second molar tooth. (Paired)

EURYON (eu): Instrumentally determined ectocranial points on opposite sides of the skull that form the termini of the line of greatest cranial breadth. (Paired)

OPISTHION (o): The midline point at the posterior margin of the foramen magnum

ZYGION (ry): Instrumentally determined as the most lateral point on the zygomatic arch. (Paired)

Appendix B.

Table 1.

Buhl Woman vs. Windover Population

GroupNo.Obs : 63.

Sample Mean (difference)

[1] 179.383 99.625 131.815 121.883 97.744 49.21

Null Hypothesis

[1] 181 101 139 131 103 50

Sample Covariance Matrix

	v.1	v.2	v.3	v.4	v.5	v.6
v.1	82.532	57.074	35.214	82.663	54.545	31.170
v.2	57.074	63.868	26.986	85.254	62.052	37.743
v.3	35.214	26.986	38.578	43.544	23.528	14.889
v.4	82.663	85.254	43.544	152.058	86.213	54.683
v.5	54.545	62.052	23.528	86.213	72.707	35.150
v.6	31.170	37.743	14.889	54.683	35.150	29.515

Hotelling T2 statistic : T = 252.87777

P-value for T2-statistic: P = 0

Critical value for 0.95-alpha :14.766

Table 2.

Buhl Woman vs. Ainu Population

GroupNo.Obs : 86.

Sample Mean (difference)

[1] 185.012 103.651 140.372 134.209 101.407 49.733

Null Hypothesis

[1] 181 101 139 131 103 50

Sample Covariance Matrix

	v.1	v.2	v.3	v.4	v.5	v.6
v.1	57.337	31.8994	25.5887	41.230	33.1232	12.5961
v.2	31.899	28.1574	13.5484	28.922	24.1652	9.0928
v.3	25.589	13.5484	23.9778	20.864	11.9997	6.0646
v.4	41.230	28.9218	20.8640	48.886	28.8916	13.4513
v.5	33.123	24.1652	11.9997	28.892	33.7065	7.0507
v.6	12.596	9.0928	6.0646	13.451	7.0507	9.8238

Hotelling T2 statistic : T = 227.25925

P-value for T2-statistic: P = 0

Critical value for 0.95-alpha :14.11548

Table 3.
 Buhl Woman vs. Jomon Population

GroupNo.Obs : 87.

Sample Mean (difference)
 [1] 181.894 102.647 141.273 138.452 100.278 47.892

Null Hypothesis
 [1] 181 101 139 131 103 50

Smple Covariance Matrix

	v.1	v.2	v.3	v.4	v.5	v.6
v.1	50.3683	25.8058	7.0089	22.5596	29.2218	10.4013
v.2	25.8058	33.4890	6.7275	21.4738	28.3019	10.9998
v.3	7.0089	6.7275	25.3116	17.4078	4.6678	5.6599
v.4	22.5596	21.4738	17.4078	45.8204	18.4328	9.9359
v.5	29.2218	28.3019	4.6678	18.4328	39.4423	9.6252
v.6	10.4013	10.9998	5.6599	9.9359	9.6252	11.0275

Hotelling T2 statistic : T = 334.98397
 P-value for T2-statistic: P = 0
 Critical value for 0.95-alpha :14.09591

Table 4.
Skull 101 vs. Windover Population

GroupNo.Obs : 63.

Sample Mean (difference)
[1] 178.816 99.289 131.480 92.044 121.266 97.413 49.009 24.600
[9] 61.115 47.328 32.377 37.526 21.994 107.507 95.924 62.310
[17] 90.534 17.254

Null Hypothesis
[1] 204.0 111.0 143.0 107.0 143.0 106.2 58.0 32.0 69.2 57.0 48.5
[12] 31.5 19.1 115.5 106.2 77.0 110.0 19.1

Smple Covariance Matrix

	v.1	v.2	v.3	v.4	v.5	v.6	v.7	v.8
v.1	80.2086	58.1091	34.0677	30.6752	81.396	55.5737	33.9556	12.7598
v.2	58.1091	65.9122	27.7306	27.5294	87.127	64.0728	40.4303	14.1893
v.3	34.0677	27.7306	38.0344	15.1703	43.041	24.2670	16.6303	6.6150
v.4	30.6752	27.5294	15.1703	22.6013	40.382	26.4011	18.4171	6.1940
v.5	81.3963	87.1272	43.0409	40.3824	152.051	88.0690	58.2542	22.1128
v.6	55.5737	64.0728	24.2670	26.4011	88.069	74.7039	37.8035	15.0564
v.7	33.9556	40.4303	16.6303	18.4171	58.254	37.8035	32.3355	9.2402
v.8	12.7598	14.1893	6.6150	6.1940	22.113	15.0564	9.2402	5.4148
v.9	28.8851	29.7428	15.8791	14.0323	42.894	31.3049	16.3395	7.0301
v.10	36.9407	40.6287	13.4831	18.3147	59.250	44.2251	26.1445	10.0045
v.11	6.9552	7.5348	2.8250	4.5368	10.857	4.9391	6.4087	1.8199
v.12	19.4818	19.0232	8.9868	10.3272	28.981	18.2753	12.2118	4.7035
v.13	12.9216	14.8347	5.6894	6.2937	21.003	15.0940	9.7927	3.8120
v.14	22.7497	23.4088	23.0376	15.0002	42.335	20.5281	17.9576	7.9830
v.15	67.5963	75.0736	32.2073	35.4531	114.967	77.9575	48.4495	19.3474
v.16	39.6405	48.4027	19.8596	19.1166	69.551	51.4875	36.9515	11.3601
v.17	33.5527	28.5972	3.4737	15.9045	50.686	30.1252	24.7313	9.5719
v.18	9.6733	10.8443	5.3513	4.3560	14.922	11.0062	7.0552	2.5612

	v.9	v.10	v.11	v.12	v.13	v.14	v.15	v.16
v.1	28.8851	36.9407	6.9552	19.4818	12.9216	22.7497	67.5963	39.6405
v.2	29.7428	40.6287	7.5348	19.0232	14.8347	23.4088	75.0736	48.4027
v.3	15.8791	13.4831	2.8250	8.9868	5.6894	23.0376	32.2073	19.8596
v.4	14.0323	18.3147	4.5368	10.3272	6.2937	15.0002	35.4531	19.1166
v.5	42.8940	59.2500	10.8574	28.9808	21.0034	42.3353	114.9666	69.5505
v.6	31.3049	44.2251	4.9391	18.2753	15.0940	20.5281	77.9575	51.4875
v.7	16.3395	26.1445	6.4087	12.2118	9.7927	17.9576	48.4495	36.9515
v.8	7.0301	10.0045	1.8199	4.7035	3.8120	7.9830	19.3474	11.3601
v.9	20.2896	20.5177	2.4178	9.1592	5.9730	12.9368	37.7950	21.6504
v.10	20.5177	36.4599	3.8731	12.7231	9.0966	18.9859	52.5335	33.1216
v.11	2.4178	3.8731	3.6603	2.8486	1.7406	4.5217	9.0352	6.7739
v.12	9.1592	12.7231	2.8486	7.4912	4.0813	6.8469	24.2942	14.4895
v.13	5.9730	9.0966	1.7406	4.0813	5.7228	4.8668	17.7497	11.1568
v.14	12.9368	18.9859	4.5217	6.8469	4.8668	177.6262	39.0076	13.6671
v.15	37.7950	52.5335	9.0352	24.2942	17.7497	39.0076	104.3040	58.5704
v.16	21.6504	33.1216	6.7739	14.4895	11.1568	13.6671	58.5704	52.8605
v.17	6.3889	27.6404	11.1423	11.8001	4.7609	10.3890	38.2087	34.3929
v.18	4.1579	5.8542	1.0720	2.5773	3.9707	3.0094	12.2073	8.2490

	v.17	v.18	v.7	v.8
v.1	33.5527	9.6733	24.7313	7.0552
v.2	28.5972	10.8443	9.5719	2.5612
v.3	3.4737	5.3513	6.3889	4.1579
v.4	15.9045	4.3560	27.6404	5.8542
v.5	50.6857	14.9219	11.1423	1.0720
v.6	30.1252	11.0062	11.8001	2.5773
			v.13	4.7609
			v.14	10.3890
			v.15	38.2087
			v.16	34.3929
			v.17	147.0135
			v.18	3.3975

Hottelling T2 statistic : T = 27799.54617
P-value for T2-statistic: P = 0
Critical value for 0.95-alpha : 45.5847

Table 5.
Skull 101 vs. Jomon Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 87.
Sample Mean (difference)
[1] 181.894 102.647 141.273 138.452 100.278 47.892 24.920 67.209
Null Hypothesis
[1] 204.0 111.0 143.0 143.0 106.2 58.0 32.0 77.0
Smple Covariance Matrix
      v.1      v.2      v.3      v.4      v.5      v.6      v.7      v.8
v.1 50.3683 25.8058 7.0089 22.5596 29.2218 10.4013 5.30815 14.32582
v.2 25.8058 33.4890 6.7275 21.4738 28.3019 10.9998 2.61513 15.11429
v.3 7.0089 6.7275 25.3116 17.4078 4.6678 5.6599 3.24131 3.79717
v.4 22.5596 21.4738 17.4078 45.8204 18.4328 9.9359 3.98641 12.87041
v.5 29.2218 28.3019 4.6678 18.4328 39.4423 9.6252 2.87843 16.18937
v.6 10.4013 10.9998 5.6599 9.9359 9.6252 11.0275 0.68050 11.32493
v.7 5.3081 2.6151 3.2413 3.9864 2.8784 0.6805 4.14872 0.37808
v.8 14.3258 15.1143 3.7972 12.8704 16.1894 11.3249 0.37808 22.30941
Hotelling T2 statistic :      T = 2482.63015
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :17.92198
*** End of Output Summary ***

*** OUTPUT for T2test completed ***

```

Table 6.
Skull 101 vs. Ainu Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 86.
Sample Mean (difference)
[1] 185.012 103.651 140.372 134.209 101.407 49.733 64.779 34.186
[9] 40.953 21.233 110.802
Null Hypothesis
[1] 204.0 111.0 143.0 143.0 106.2 58.0 69.2 48.5 31.5 19.1 115.5
Sample Covariance Matrix
      v.1      v.2      v.3      v.4      v.5      v.6      v.7
v.1 57.3371 31.8994 25.58870 41.2301 33.123175 12.5961 16.96769
v.2 31.8994 28.1574 13.54840 28.9218 24.165224 9.0928 10.60898
v.3 25.5887 13.5484 23.97783 20.8640 11.999730 6.0646 9.16360
v.4 41.2301 28.9218 20.86398 48.8864 28.891563 13.4513 17.95322
v.5 33.1232 24.1652 11.99973 28.8916 33.706463 7.0507 12.03177
v.6 12.5961 9.0928 6.06463 13.4513 7.050703 9.8238 5.82463
v.7 16.9677 10.6090 9.16360 17.9532 12.031774 5.8246 13.82328
v.8 1.3118 1.1812 0.72147 1.5308 0.075446 2.4451 0.19227
v.9 9.6750 6.8326 3.56382 9.6725 6.391022 3.3131 3.37345
v.10 6.3694 5.5579 2.50649 6.4630 5.312331 1.3761 1.31882
v.11 21.5721 8.3264 11.63169 11.5414 8.568821 5.1332 6.89819

      v.8      v.9      v.10      v.11
v.1 1.311790 9.67496 6.36939 21.57207
v.2 1.181179 6.83261 5.55787 8.32639
v.3 0.721471 3.56382 2.50649 11.63169
v.4 1.530827 9.67253 6.46295 11.54137
v.5 0.075446 6.39102 5.31233 8.56882
v.6 2.445105 3.31314 1.37615 5.13318
v.7 0.192266 3.37345 1.31882 6.89819
v.8 3.221201 0.88075 0.79394 0.47864
v.9 0.880746 4.04435 0.72012 3.30476
v.10 0.793943 0.72012 4.96917 0.70876
v.11 0.478637 3.30476 0.70876 20.60046

Hotelling T2 statistic :      T = 21687.13417
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :23.92053

*** End of Output Summary ***

*** OUTPUT for T2test completed ***

```

Table 7.
 Kennewick Man vs. Windover Population
 GroupNo.Obs : 63.

Sample Mean (difference)
 [1] 178.816 99.289 131.480 92.044 118.878 97.413 49.009 24.600
 [9] 61.115 47.328 32.377 37.526 21.994 95.442 50.864 38.175
 [17] 107.507

Null Hypothesis
 [1] 189.0 113.0 140.0 110.0 128.0 113.0 55.0 25.0 66.0 56.0 36.9
 [12] 45.0 17.0 105.0 46.5 24.0 111.5

Sample Covariance Matrix

	v1	v2	v3	v4	v5	v6	v7	v8
v1	80.2086	58.1091	34.0677	30.6752	56.3452	55.5737	33.9556	12.7598
v2	58.1091	65.9122	27.7306	27.5294	59.2662	64.0728	40.4303	14.1893
v3	34.0677	27.7306	38.0344	15.1703	34.7482	24.2670	16.6303	6.6150
v4	30.6752	27.5294	15.1703	22.6013	29.1839	26.4011	18.4171	6.1940
v5	56.3452	59.2662	34.7482	29.1839	87.2089	58.6275	41.6381	13.1974
v6	55.5737	64.0728	24.2670	26.4011	58.6275	74.7039	37.8035	15.0564
v7	33.9556	40.4303	16.6303	18.4171	41.6381	37.8035	32.3355	9.2402
v8	12.7598	14.1893	6.6150	6.1940	13.1974	15.0564	9.2402	5.4148
v9	28.8851	29.7428	15.8791	14.0323	30.5481	31.3049	16.3395	7.0301
v10	36.9407	40.6287	13.4831	18.3147	40.1672	44.2251	26.1445	10.0045
v11	6.9552	7.5348	2.8250	4.5368	7.4931	4.9391	6.4087	1.8199
v12	19.4818	19.0232	8.9868	10.3272	19.2719	18.2753	12.2118	4.7035
v13	12.9216	14.8347	5.6894	6.2937	14.6359	15.0940	9.7927	3.8120
v14	49.0518	52.2570	23.1274	26.5796	53.8085	51.7821	33.5142	12.7949
v15	30.0885	39.3103	19.2797	15.4211	37.1376	41.1348	26.9931	9.2357
v16	34.6582	39.4449	17.5943	16.1153	38.7861	41.1090	26.5024	9.9370
v17	22.7497	23.4088	23.0376	15.0002	30.7824	20.5281	17.9576	7.9830

	v9	v10	v11	v12	v13	v14	v15	v16
v1	28.8851	36.9407	6.9552	19.4818	12.9216	49.0518	30.0885	34.6582
v2	29.7428	40.6287	7.5348	19.0232	14.8347	52.2570	39.3103	39.4449
v3	15.8791	13.4831	2.8250	8.9868	5.6894	23.1274	19.2797	17.5943
v4	14.0323	18.3147	4.5368	10.3272	6.2937	26.5796	15.4211	16.1153
v5	30.5481	40.1672	7.4931	19.2719	14.6359	53.8085	37.1376	38.7861
v6	31.3049	44.2251	4.9391	18.2753	15.0940	51.7821	41.1348	41.1090
v7	16.3395	26.1445	6.4087	12.2118	9.7927	33.5142	26.9931	26.5024
v8	7.0301	10.0045	1.8199	4.7035	3.8120	12.7949	9.2357	9.9370
v9	20.2896	20.5177	2.4178	9.1592	5.9730	24.1341	19.3284	19.6571
v10	20.5177	36.4599	3.8731	12.7231	9.0966	34.1734	27.6097	29.0778
v11	2.4178	3.8731	3.6603	2.8486	1.7406	7.3783	4.0328	4.1123
v12	9.1592	12.7231	2.8486	7.4912	4.0813	17.8575	11.2709	11.5706
v13	5.9730	9.0966	1.7406	4.0813	5.7228	13.0949	8.4001	8.9970
v14	24.1341	34.1734	7.3783	17.8575	13.0949	49.3241	30.5358	31.7833
v15	19.3284	27.6097	4.0328	11.2709	8.4001	30.5358	34.0669	27.6813
v16	19.6571	29.0778	4.1123	11.5706	8.9970	31.7833	27.6813	31.2470
v17	12.9368	18.9859	4.5217	6.8469	4.8668	20.5872	26.8013	13.3498

	v17	v9	v10	v11	v12	v13	v14	v15	v16
v1	22.7497	12.9368	18.9859	4.5217	6.8469	4.8668	20.5872	26.8013	13.3498
v2	23.4088	18.9859	4.5217	6.8469	4.8668	20.5872	26.8013	13.3498	17.9576
v3	23.0376	4.5217	6.8469	4.8668	20.5872	26.8013	13.3498	17.9576	7.9830
v4	15.0002	6.8469	4.8668	20.5872	26.8013	13.3498	17.9576	7.9830	7.9830
v5	30.7824	4.8668	20.5872	26.8013	13.3498	17.9576	7.9830	7.9830	7.9830
v6	20.5281	20.5872	26.8013	13.3498	17.9576	7.9830	7.9830	7.9830	7.9830
v7	17.9576	13.3498	17.9576	7.9830	7.9830	7.9830	7.9830	7.9830	7.9830
v8	7.9830	17.9576	7.9830	7.9830	7.9830	7.9830	7.9830	7.9830	7.9830

Hotelling T2 statistic : T = 11011.73338
 P-value for T2-statistic: P = 0
 Critical value for 0.95-alpha : 42.38809

Table 8.
Kennewick Man vs. Ainu Population

*** OUTPUT for T2test ***

*** Output for One-sample Test ***

GroupNo.Obs : 86.

Sample Mean (difference)

[1]	185.012	103.651	140.372	122.523	101.407	49.733	64.779	34.186
[9]	40.953	21.233	100.360	51.453	23.140	110.802		

Null Hypothesis

[1]	189.0	113.0	140.0	128.0	113.0	55.0	66.0	36.9	45.0	17.0	105.0
[12]	46.5	24.0	111.5								

Smple Covariance Matrix

	v.1	v.2	v.3	v.4	v.5	v.6	v.7
v.1	57.3371	31.8994	25.58870	28.1335	33.123175	12.5961	16.96769
v.2	31.8994	28.1574	13.54840	19.5546	24.165224	9.0928	10.60898
v.3	25.5887	13.5484	23.97783	17.6193	11.999730	6.0646	9.16360
v.4	28.1335	19.5546	17.61925	29.9704	18.019605	9.5702	12.54584
v.5	33.1232	24.1652	11.99973	18.0196	33.706463	7.0507	12.03177
v.6	12.5961	9.0928	6.06463	9.5702	7.050703	9.8238	5.82463
v.7	16.9677	10.6090	9.16360	12.5458	12.031774	5.8246	13.82328
v.8	1.3118	1.1812	0.72147	1.2747	0.075446	2.4451	0.19227
v.9	9.6750	6.8326	3.56382	6.2802	6.391022	3.3131	3.37345
v.10	6.3694	5.5579	2.50649	4.6458	5.312331	1.3761	1.31882
v.11	23.4958	16.6723	8.55192	16.2998	18.283532	6.2824	8.40522
v.12	21.4715	17.2047	10.35452	15.8208	18.175906	6.5631	11.00717
v.13	8.9054	6.2580	2.98296	5.0084	7.536236	2.9559	3.83315
v.14	21.5721	8.3264	11.63169	8.5918	8.568821	5.1332	6.89819

	v.8	v.9	v.10	v.11	v.12	v.13	v.14
v.1	1.311790	9.67496	6.36939	23.4958	21.471471	8.90535	21.57207
v.2	1.181179	6.83261	5.55787	16.6723	17.204705	6.25798	8.32639
v.3	0.721471	3.56382	2.50649	8.5519	10.354516	2.98296	11.63169
v.4	1.274743	6.28015	4.64575	16.2998	15.820849	5.00838	8.59181
v.5	0.075446	6.39102	5.31233	18.2835	18.175906	7.53624	8.56882
v.6	2.445105	3.31314	1.37615	6.2824	6.563142	2.95592	5.13318
v.7	0.192266	3.37345	1.31882	8.4052	11.007166	3.83315	6.89819
v.8	3.221201	0.88075	0.79394	2.0143	-0.072742	-0.24689	0.47864
v.9	0.880746	4.04435	0.72012	6.9586	4.439697	1.23905	3.30476
v.10	0.793943	0.72012	4.96917	5.7650	2.859654	1.07220	0.70876
v.11	2.014332	6.95863	5.76501	19.0910	11.115603	3.96133	5.64102
v.12	-0.072742	4.43970	2.85965	11.1156	21.503651	5.56463	7.32220
v.13	-0.246890	1.23905	1.07220	3.9613	5.564630	5.60844	3.05084
v.14	0.478637	3.30476	0.70876	5.6410	7.322201	3.05084	20.60046

Hotelling T2 statistic : T = 3583.81172
P-value for T2-statistic: P = 0
Critical value for 0.95-alpha : 30.27239

*** End of Output Summary ***

*** OUTPUT for T2test completed ***

Table 9.
Kennewick Man vs. Jomon Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 87.
Sample Mean (difference)
[1] 181.894 102.647 141.273 100.278 47.892 24.920
Null Hypothesis
[1] 189 113 140 113 55 25
Smple Covariance Matrix
      v.1    v.2    v.3    v.4    v.5    v.6
v.1 50.3683 25.8058 7.0089 29.2218 10.4013 5.3081
v.2 25.8058 33.4890 6.7275 28.3019 10.9998 2.6151
v.3 7.0089 6.7275 25.3116 4.6678 5.6599 3.2413
v.4 29.2218 28.3019 4.6678 39.4423 9.6252 2.8784
v.5 10.4013 10.9998 5.6599 9.6252 11.0275 0.6805
v.6 5.3081 2.6151 3.2413 2.8784 0.6805 4.1487
Hotelling T2 statistic :      T = 640.19705
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :14.09591
*** End of Output Summary ***
*** OUTPUT for T2test completed ***

```

Table 10.
Spirit Cave Man vs. Windover Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 63.
Sample Mean (difference)
[1] 178.816 99.289 131.480 121.266 97.413 49.009 24.600
Null Hypothesis
[1] 195.0 106.0 135.0 141.0 97.0 49.3 26.2
Smple Covariance Matrix
      v.1   v.2   v.3   v.4   v.5   v.6   v.7
v.1 80.209 58.109 34.068 81.396 55.574 33.9556 12.7598
v.2 58.109 65.912 27.731 87.127 64.073 40.4303 14.1893
v.3 34.068 27.731 38.034 43.041 24.267 16.6303 6.6150
v.4 81.396 87.127 43.041 152.051 88.069 58.2542 22.1128
v.5 55.574 64.073 24.267 88.069 74.704 37.8035 15.0564
v.6 33.956 40.430 16.630 58.254 37.803 32.3355 9.2402
v.7 12.760 14.189 6.615 22.113 15.056 9.2402 5.4148
Hotelling T2 statistic :      T = 1158.31378
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :16.88071
*** End of Output Summary ***

*** OUTPUT for T2test completed ***

```

Table 11.
Spirit Cave Man vs. Ainu Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 86.
Sample Mean (difference)
[1] 185.012 103.651 140.372 134.209 101.407 49.733
Null Hypothesis
[1] 195.0 106.0 135.0 141.0 97.0 49.3
Smple Covariance Matrix
      v.1   v.2   v.3   v.4   v.5   v.6
v.1 57.337 31.8994 25.5887 41.230 33.1232 12.5961
v.2 31.899 28.1574 13.5484 28.922 24.1652 9.0928
v.3 25.589 13.5484 23.9778 20.864 11.9997 6.0646
v.4 41.230 28.9218 20.8640 48.886 28.8916 13.4513
v.5 33.123 24.1652 11.9997 28.892 33.7065 7.0507
v.6 12.596 9.0928 6.0646 13.451 7.0507 9.8238
Hotelling T2 statistic :      T = 2197.1921
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :14.11548
*** End of Output Summary ***

*** OUTPUT for T2test completed ***

```

Table 12.
Spirit Cave Man vs. Jomon Population

```

*** OUTPUT for T2test ***
*** Output for One-sample Test ***
GroupNo.Obs : 87.
Sample Mean (difference)
[1] 181.894 102.647 141.273 138.452 100.278 47.892 24.920
Null Hypothesis
[1] 195.0 106.0 135.0 141.0 97.0 49.3 26.2
Smple Covariance Matrix
      v.1    v.2    v.3    v.4    v.5    v.6    v.7
v.1 50.3683 25.8058 7.0089 22.5596 29.2218 10.4013 5.3081
v.2 25.8058 33.4890 6.7275 21.4738 28.3019 10.9998 2.6151
v.3 7.0089 6.7275 25.3116 17.4078 4.6678 5.6599 3.2413
v.4 22.5596 21.4738 17.4078 45.8204 18.4328 9.9359 3.9864
v.5 29.2218 28.3019 4.6678 18.4328 39.4423 9.6252 2.8784
v.6 10.4013 10.9998 5.6599 9.9359 9.6252 11.0275 0.6805
v.7 5.3081 2.6151 3.2413 3.9864 2.8784 0.6805 4.1487
Hotelling T2 statistic :      T = 1110.97137
P-value for T2-statistic:      P = 0
Critical value for 0.95-alpha :16.00059
*** End of Output Summary ***
*** OUTPUT for T2test completed ***

```

Table 13. Neighbore-Joining Branch lengths and distances

- 1 Mba Mongolian Bronze Age
- 2 Kur Kurgan
- 3 Cba Chinese Bronze Age
- 4 Cne Chinese Neolithic
- 5 Buh Buhl Woman
- 6 Scm Spirit Carve Man
- 7 Sku Skull 101
- 8 Jom Jomon
- 9 Win Windover
- 10 Ken Kennewick
- 11 Ain Ainu

	Mba	Kur	Cba	Cne	Buh	Scm	Sku	Jom	Win	Ken
Kur	0.624									
Cba	0.540	0.553								
Cne	0.684	0.566	0.196							
Buh	1.302	0.863	0.981	0.971						
Scm	2.226	2.249	2.403	2.452	2.358					
Sku	2.090	1.881	2.186	2.185	1.977	1.612				
Jom	1.102	1.214	1.123	1.224	1.377	2.009	2.507			
Win	1.240	0.682	1.070	1.047	0.540	2.263	1.647	1.561		
Ken	2.477	1.917	2.073	1.952	1.349	3.079	2.547	2.415	1.463	
Ain	0.996	0.675	0.922	0.957	0.735	1.818	1.798	0.885	0.737	1.785

Neighbor-Joining Method

Node 12	OTU 6 (0.9193)	OTU 7 (0.6927)
Node 13	OTU 3 (0.0878)	OTU 4 (0.1082)
Node 14	OTU 5 (0.1801)	OTU 10 (1.1689)
Node 15	Node 14 (0.0918)	OTU 9 (0.2352)
Node 16	OTU 1 (0.3249)	Node 13 (0.1891)
Node 17	Node 16 (0.0859)	OTU 2 (0.1998)
Node 18	Node 15 (0.2340)	Node 12 (0.6819)
Node 19	Node 17 (0.1985)	Node 18 (0.0827)

Appendix C.

The Following drawings are taken from Buikstra and Ubelaker (1994).

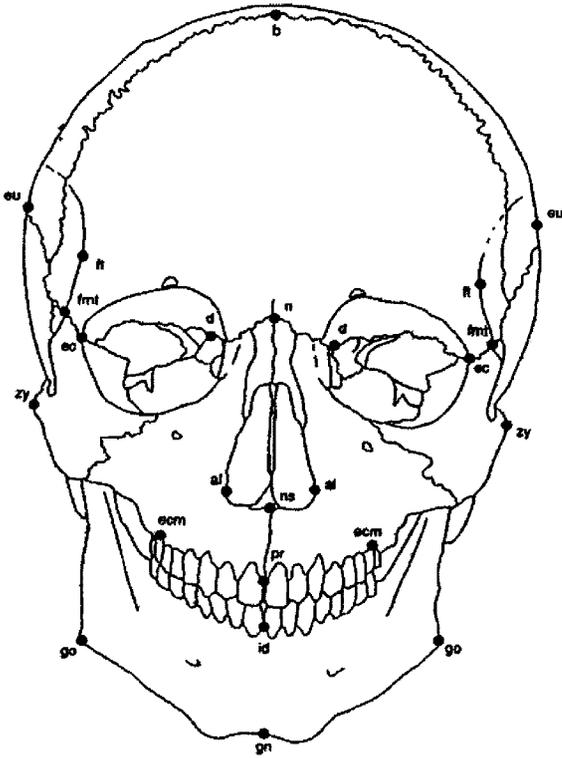
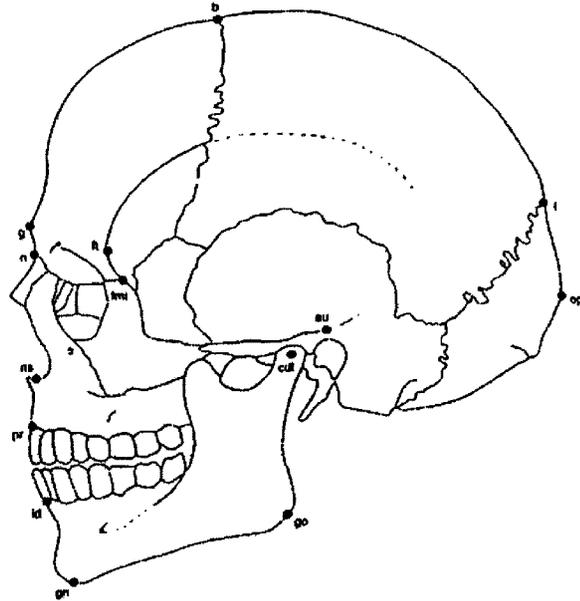


Figure 1.
Measurement Landmarks of the Skull (anterior view)

Figure 2.
Measurement Landmarks (lateral view)



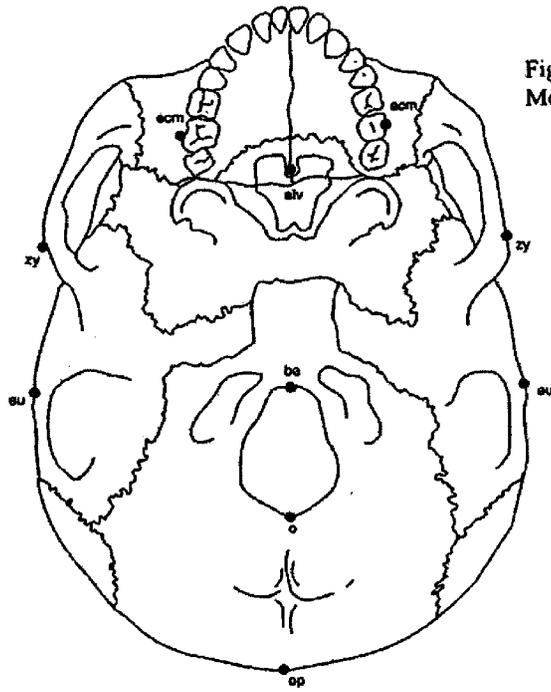


Figure 3.
Measurement Landmarks (basilar view)

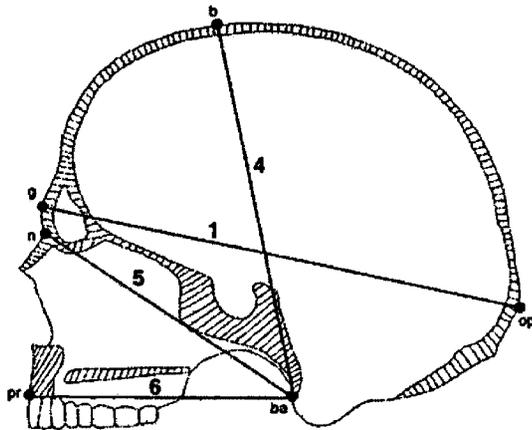


Figure 4.
Measurements in the sagittal plane.

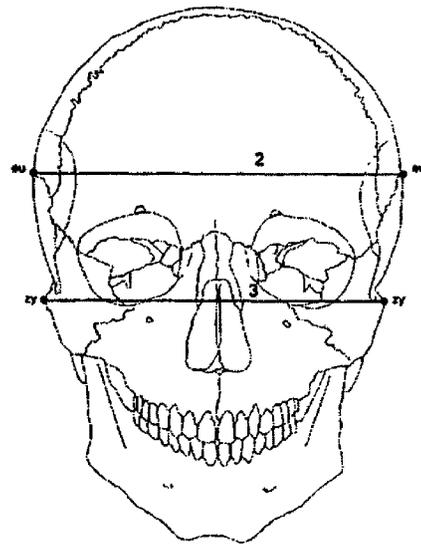


Figure 5.
Maximum cranial breadth and
bizygomatic diameter.

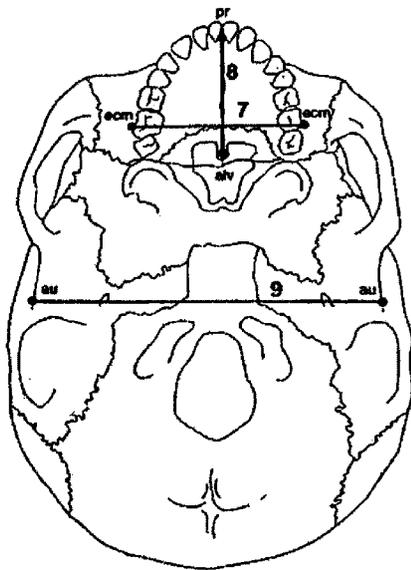


Figure 6.
Measurements basilar view

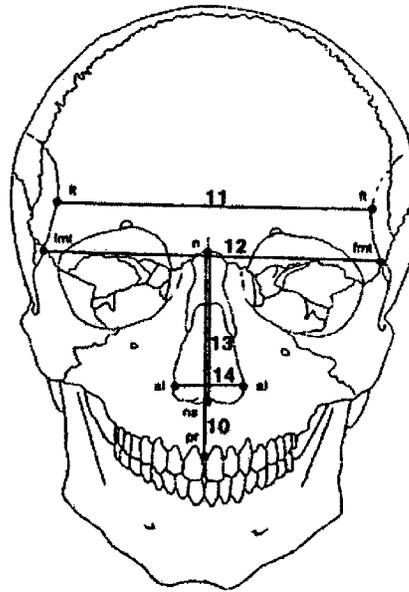


Figure 7.
Measurements anterior view

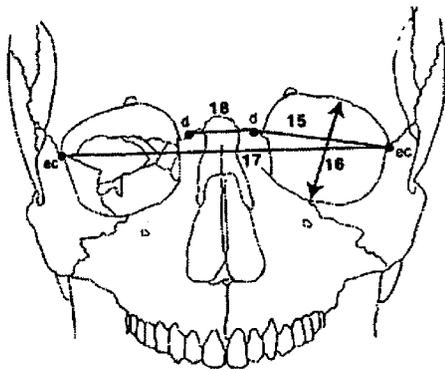


Figure 8.
Measurements of the orbital region

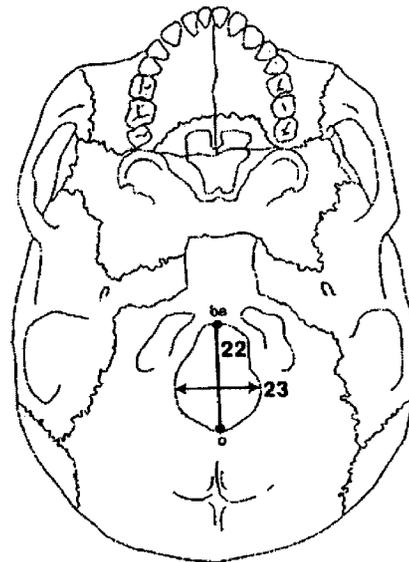


Figure 9.
Foramen magnum length and breadth

Appendix D. C-Score Equation For Neighbor-Joining Tree

$$Z_{ijk} = \frac{x_{ijk} - \bar{x}_{ijk}}{\sigma_{i.k}} \quad (1) \quad \begin{array}{l} i=1, \dots, I \text{ (variables)} \\ j=1, \dots, n_k \text{ (observations)} \end{array}$$

$$\bar{z}_{.jk} = \frac{\sum_{i=1}^I Z_{ijk}}{I} \quad (2) \quad k=1, \dots, K \text{ (groups)}$$

$$C_{ijk} = Z_{ijk} - \bar{z}_{.jk} \quad (3)$$

$$C_{ik} = \frac{\bar{C}_{i.k}^{(f)} + \bar{C}_{i.k}^{(m)}}{2} \quad (4) \quad \left\{ \begin{array}{l} \bar{C}_{i.k}^{(f)} \text{ --Mean over } j \text{ when } j \text{ is female} \\ \bar{C}_{i.k}^{(m)} \text{ --Mean over } j \text{ when } j \text{ is male} \end{array} \right.$$

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