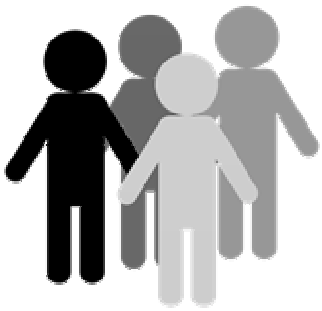
Maryland Essays in Human Biodiversity



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Maryland Essays in Human Biodiversity

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Appreciating Forensic Dentistry: A Look into Forensic Odontology

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Key Words: forensics, fingerprints, DNA analysis

When a plane crashes, it is the grim but important task for investigators to identify human remains and match them to the list of people who were on the tragic flight. A relatively fast, accurate and comparatively inexpensive technique is to use dental records. Teeth are unique, like fingerprints, and no two are identical (Hench 2000). While forensic dentistry is beginning to get the recognition it has deserved for years, it is unfortunate that it has taken events like the terrorism of September 11th to bring attention to this important and underserved field.

Teeth, like bone, survive long after the soft tissue of the skull has been destroyed in tragic events, such as fire. Bones can also be used in anthropology, however these techniques require a history of injuries (broken bones or screws) and a corresponding medical record for the individuals or else bones would not be helpful in identifying remains. Teeth are normally damaged by tooth decay, which originates by the addition of sugars to one's diet. After death, these factors no longer apply and allow the dental structures to last indefinitely (Mastey 2002). Furthermore, teeth have a tendency to survive high temperatures and trauma due to their enamel, which is "98 percent inorganic and less susceptible to decay than soft tissue or bone" (Hench 2000). Enamel is the hardest substance in the human body, and helps preserve the teeth from disintegrating over time. Additionally, even if the teeth are destroyed, which requires temperatures at about 1100°F, certain restorations, such as crowns or bridgework, can survive the extreme heat (Mastey 2002).

Recently the war in Iraq has led to the deaths of Saddam Hussein's two sons, Uday and Qusay. The world saw horrific pictures of the two bodies, yet were not convinced of either's identity until later, when positive identification using "dental and medical records [used to distinguish] the two men killed in a gun battle at a villa in northern Iraq" (Guardian 2003).

Dentists take x-rays to use them as a diagnostic tool, keeping detailed records for each patient of not only problem teeth but also of healthy ones. People who have had braces or their wisdom teeth removed have had panoramic x-rays, which show the entire mouth. These in-depth records allow for fast and very accurate identification of remains even in cases when nothing but teeth can be used for identification purposes. A typical person is more likely to have visited a dentist than to have been fingerprinted (Hench 2000).

Teeth have distinguishing grooves and pits that a forensic dentist can match with the victim's past X-rays. Furthermore, a twisted root or root canal treatment could be another major delineating clue to a victim's identity. Sometimes people have teeth extracted to make room in their mouth or to obtain a proper occlusion. These missing teeth can provide even more clues for unidentified remains to be matched with x-rays or dental records.

The American Board of Forensic Odontology has set forth the four conclusions that a forensic dentist can definitely reach using its techniques (Pretty and Sweet 2001): (I) Positive Identification- the antemortem and postmortem data match in sufficient detail, with no unexplainable discrepancies, to establish that they are from the same individual. (II) Possible identification- the antemortem and postmortem data have consistent features, but because of the quality of either the postmortem remains or the antemortem evidence, it is not possible to establish identity positively. (III) Insufficient evidence- the available information is insufficient to form the basis for a conclusion. (IV) Exclusion- the antemortem and postmortem data are clearly inconsistent.

If a clue to the identity of the deceased is discovered, and all that is needed is positive identification, the forensic dentist can take postmortem radiographs that "replicate the type and angle" of the antemortem records (Pretty and Sweet 2001). Sometimes, these teeth cannot be X-rayed properly due to complications such as body conformation as a result of rigor mortis. In these cases, the teeth and jaw may need to be removed with consent from the coroner or medical examiner (McGivney 2003). Soft tissue is removed, along with muscle and lingual attachments, usually followed by using a surgical mallet and chisel under the zygomatic arch (McGivney 2003). This technique can also be applied if a murder victim is to be cremated, allowing the teeth to be examined further, even after the remains are put to rest (McGivney 2003).

When the identity of the deceased is completely unknown, the doctor creates a postmortem record by

charting and describing all key factors about the dental structures (Pretty and Sweet 2001). These factors can be as simple as whether or not the tooth is permanent or deciduous. If teeth are missing, the dentist can determine if it is from before death or a result of the event leading to death. Further investigation may show an unerupted tooth or endodontic treatment. If the entire cranium is intact an examination of the size, shape and placement of the sinus cavity can prove helpful.

Forensic dentistry can create a possible profile of a deceased individual when absolutely no indication of the identity remains. The unique aspect of teeth is that they are blind to race. An X-ray of a tooth is just that. If it matches perfectly, it is a definite identification with unarguable methodology supporting the claim. Although sometimes skull shape can give hints of ethnicity, racial profiling does not need to be called into question (Pretty and Sweet 2001). Furthermore, clues to gender can come from the shape and size of the cranium (Pretty and Sweet 2001). Approximate age can be determined by looking for the presence of primary or permanent teeth, identifing wear on the teeth, and the presence or absence of dentures. In fact, sometimes the dentures can help identify the body an another distinguishing factor. Dentures can be compared with old models originally used to mold the dentures (Pretty and Sweet 2001). Since it is common practice to use the Universal Numbering System using the numbers 1-32, in addition to the actual name of the tooth, a forensic dentist can type all of these details into a computer and obtain a list of possible matches (Mastey 2002, McGivney 2003).

Forensic dentistry has also been developing techniques to accurately identify bite marks and match them with their instigator. If proven as accurate as many believe, these techniques could identify rapists, if the attacker has marks matching the victim's bite pattern. This would require the dentist to keep some alginate, or something similar, and both maxillary and mandibular trays (McGivney 2003). Furthermore, remains of teeth and jawbones can help investigators move beyond just identification to determining the nature of the events behind the victim's death. Damage to the mouth region can confirm the point of impact or perhaps a broken jaw will show that a violent crime took place.

The future of forensic dentistry seems to moving in the same direction as many other fields, especially towards the understanding and use of DNA in this era of genomics. In February of 2002, Dr. Joseph DiZinno D.D.S spoke on behalf of the FBI on the importance of DNA in forensic dentistry. He elaborated on matching DN A from dental tissue to other tissue in the body or family members, using several different techniques (DiZinno 2001). 004Fne of these techniques is the polymerase chain reaction (PCR), which is a “technique that allows amplification of DNA at pre-selected, specific sites (Pretty and Sweet 2001). This allows postmortem DNA from dental tissues to be matched up with samples from hairbrushes or even family members (Pretty and Sweet 2001).

Leading forensic dentists have determined that the best source for DNA within dental tissues is from Genomic DNA, which they obtain by using the cryogenic grinding method (Pretty and Sweet 2001). Cryogenic grinding means the teeth are ground at sub-zero temperatures, somewhere between zero and -70°C, and are frozen using liquid nitrogen, keeping the chemical composition constant and not damaged by the heat caused by normal grinding techniques (Wang 1997). Following the cryogenic grinding, PCR techniques are used, a large quantity of DNA is obtained, and a genotypic comparison can be made with antemortem samples.

Forensic Dentistry is a very exciting and under-appreciated field. It is a great complement to the life of a practicing dentist, and it is rarely a full-time job. Forensics is a great way for dentists to use the techniques and skills they have obtained through dental practice in a different and interesting way. Dentists can spend their days in a traditional practice, seeing patients, addressing every-day problems, then be called in for tragic events, and use their talents in a totally different light. Besides honing their talents of dentistry the forensic perspective offers mystery and a chance for dentists to keep interested in their profession.

The forensic aspect opens up an entirely different world within dentistry, allowing the dentists that venture into it to be pioneers in the field developing novel techniques and refining current ones. Most dentists enjoy puzzles and challenges similar to diagnosing a patient’s problem and then discerning a feasible solution. Forensics is similar. The dentist is presented with a mystery and using the pieces they are given, they can solve the puzzle of the victim’s identity and find clues as to how and when death occurred. Ideally, the entire mouth would be intact and possible identities are known. However, missing teeth or unknown persons just add another challenging facet to the field that most dentists would find an interesting test. They come up with new tactics, using the pieces they have to solve the problem.

Regrettably, at this time it is not as easy as one might think to volunteer their time as a forensic dentist. Most dentists called into tragedies are either full-time government workers or associated with a major University. In the future, it would benefit all parties concerned if more agencies are willing to work with outside dentists. However, the private-practice dentists themselves need to take more initiative in setting up forensic teams, and not always depend on organizations to facilitate the process. In this way dentists would not remain in one setting but could enjoy both the practicing and forensic aspects of their profession. One organization trying to do this is the American Board of Forensic Odontology (ABFO) which may help lead dentists toward these efforts.

Indeterminate Biological Sex: An issue of gender determination

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Key Words: trangsgender, hemaphroditism and pseudohemaphroditism, adrenal hyperplasia, androgen insensitivity

In a world where so much of ones personal identification and social classification depends on the presence or lack of certain genitalia, what is to be done when a child of ambiguous sexual anatomy is born? Intersexuality is defined as a "set of medical conditions that features congenital anomaly of the reproductive and sexual system, producing embryos and children with sex chromosomes, external genitalia, or internal reproductive system that is not considered standard for either male or female (Intersex Society of North America [ISNA] 2003). These children, identified as 'intersex' or 'transgender', represent any deviation from the chromosomal, anatomical, and hormonal dimorphic ideal. They constitute approximately 1.7 percent of American births, leaving physicians to explain otherwise natural biological variation as deformity and holding them responsible for imperative gender determination and assignment (Fausto-Sterling 2002).

Background

The empirical study of sexology began in the scientific realm of essentialism and evolutionary thought. According to the earliest records, the act of intercourse evolved and existed purely for reproductive purposes. Socio-biologists applied the theory of Natural Selection to explain male hyper sexuality and promiscuity as a natural desire to procreate and prolong the species, while perceived female disinterest in sex and desire for monogamy resulted from the need for familial support in the rearing of offspring (McCammon *et al*. 1998).

Modern western culture is thoroughly dedicated to the idea that there are only two genders: Male and Female. The question, then, is: "What makes us 'women' or 'men'? Our chromosomes, our genitalia, our personal and social sexual constructs, or all of the above?" (Dreger 1998)

Historically, as a society we have a firmly established and widespread, semiotic system of identification and classification of these genders, including behavioral cues and gender roles, with extreme emphasis placed on the recognition and prominence of sexual organs. The sexual foundations of the western world were polarized and conservative from the start, leaving little room for ambiguity. However, as with the majority of genetic prescriptions, there are many gradations between biological male and female involving natural processes, which can occur at any stage in gestation or hormonal development. Psychologist John Mooney explains:

> "All humans start on the same road, but the path rapidly begins to fork. Potential males make a series of turns in one direction and potential females in another. In real time, the road begins at fertilization and ends during late adolescence. If all goes as it should, there are two, and only two, possible destinations: Male and Female." [Mooney and Tucker 1975]

Biological Determinants

Primary embryonic development begins with an undistinguished fetal gonad capable of producing either testes or ovaries. Therefore, while the male and female external organs evolve from one set of structures, the internal organs (such as uteri and sperm transport ducts) evolve during embryonic development from separate structures. Genetically, sex is determined in the uterus beginning with X chromosome genes, or a female embryo. In order for a male embryo to form there must be a Y chromosome present, carrying the Master-Sex-Determinant gene (SDY). Therefore, male sex is determined by a necessary addition, and female sex is a 'default'. In order for successful male development to occur the embryo must first hormonally suppress the development of internal female genitalia, and secondly genetically and hormonally construct both internal and external male features. (Fausto-Sterling 1995)

If at any point during the fecundating process there is a malfunction of the SDY and the uterine defenses against female hormonal influence are abandoned, the "default" X chromosome genes will take over fetal influence and the resulting child will be born of mixed or indeterminate sex. These ambiguously sexed babies are traditionally classified as either hermaphrodites containing both male and female genitalia, 'male pseudohermaphrodite' lacking ovaries, or 'female pseudohermaphrodite' lacking testes. However, not all variations are apparent externally at birth.

Sources of non-evident deviation are syndromes such as Androgen-Insensitivity Syndrome (AIS), otherwise known as testicular feminization syndrome. These individuals have male XY chromosomes and testes, but their hormonal androgen receptors cannot read their male testicular hormones and therefore mature along the default of female maturity. AIS has a frequency of approximately one in every 60,000 births, but it is usually not noticed until puberty when these seemingly 'normal' looking girls do not menstruate due to a lack of ovarian system (Dreger 1998).

Klinefelter syndrome is more common, appearing in approximately 1 out of every 800 births. This is the result of a male zygote inheriting an extra X chromosome from either their father or mother. Resulting in the abnormal karyotype of 47 XXY. Hypospadias is a syndrome referring to the irregular placement of the male urethral meatus, which is usually found at the tip of the penis. This normally tiny hole may be located anywhere along the underside of the penis, as well as behind the penis completely, or taking up a certain

length of the penis and resembling a type of vagina along the shaft.

The most common determinant of intersexuality among XX individuals is Adrenal Hyperlapsia, or CAH. "An anomaly of adrenal function causes the synthesis and excretion of an androgen precursor, initiating virilization *in-utero*. Because this originates metabolically, masculinizing effects continue after birth and sexual phenotype varies along the full continuum" (ISNA 2003). In addition to abnormal physical appearance, metabolic difficulties can easily arise, upsetting the serum sodium balance. Another XX metabolic interference is Progestin Induced Virilization. Throughout the 1950s the drug Progestin, which can be metabolically converted to an androgen by an XX fetus, was given to pregnant women.

> "The results of this virilization never damaged uteri or uterine tract, but range from simple enlarged clitorises to entire phallic development and fusion of the labia. Some extreme cases can eliminate vaginal or cervical presence, as the uterine tract is connected to the upper portion of the urethra internally." [ISNA 2003]

Since this process occurs before birth, feminization at puberty is possible because ovaries are functional and therefore releasing the proper female hormones.

Treatment

In the middle half of the 20th century the study of endocrinology, or the hormonal system and its constituents, was developed at Johns Hopkins University, leading doctors to believe that internal sexuality of infants could be altered to match external sexual appearance by hormonal therapy and influence. When faced with the 'psycho-social emergency' of sexual abnormalities at birth, physicians have the following rule of thumb:

> "Genetic females should always be raised as females, preserving reproductive potential, regardless of how severely the patients are virilized. In the genetic male, however, the assignment of gender is based on the infants anatomy, primarily the size of the phallus." [Donahue, Powell and Lee 1991]

The average length of a male penis at birth is between 1 and 1.5 inches. However, if a baby is born with a penis of 0.6 inches or less, the penis is generally removed along with the testes and a vaginal opening is created. "In cases of intersexed children assigned the female gender, surgeons may carve a large phallus down into a clitoris attempting to make it appear invisible when standing, create a vagina using a piece of colon, and mold a labia out of the remnants of the penis" (Dreger 1998). These 'boys' are then raised as 'girls' along with a thorough regiment of hormone therapy. Explanations sympathetic to masculine identity include the necessity to be able to urinate standing up and interact with other boys in youth, as well as the necessity to penetrate during intercourse, provide sexual pleasure to females, and be capable of properly impregnating females.

In addition, girl infants born with overly enlarged clitorises (exceeding one centimeter in length) are often subject to immediate clitordetamies for ascetic purposes of social acceptance, as to not have their protrusion mistaken for a phallus. Female infants will also undergo surgery to lengthen or expand the vaginal cavity to enable it to fit average sized penises. Both male and female reconstructive surgeries limit to disable personal capability for sexual pleasure and orgasm in exchange for asthetic normality.

It is extremely rare for either an XX or XY sexually abnormal infant to be created a penis as penises are thought to require much more precision and accuracy to be believable while vaginas are less scrutinized. Generally, physicians will use the standard of reproductive potential for sex determination. The only occasions when emergency gender alteration will favor a male sexual identity is in the case of true hermaphroditism, when both a physically 'perfect' penis and vagina are present. In this instance, physicians will save the penis and attempt the elimination of the vagina through fusion of the labia (Fausto-Sterling 1995).

Conclusion

The biological determinants of human mental and physical sexuality are as varied and diverse as the possibilities of phenotypic expression. Parental influence, as well as developmental malfunctions in embryonic hormonal development and early maturation through puberty can cause endless permutations of external sexual organs, internal reproductive tracts, assigned gender, and intra-psychological sexual character. One in every hundred people have bodies that differ from the 'standard' male or female form, and one or two in every thousand people undergo surgery to 'normalize' genital appearance (ISNA 2003). Yet, our 'liberal' western culture continues to be extremely conservative when it comes to acceptance of sexual variation, concerning both the physical body and personal expression through selection of sexual partners and identity. Science has had a tradition of dragging the traditionalists into modernity and acceptance through biological and methodical explanation. Hopefully, the coming century will bring with it a deeper understanding and acceptance of human sexual variation, and accordingly, a deeper appreciation and awareness of our own personal sexual nature.

Japanese Identity through Anime

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Key Words: Japan, anime, Ganguro, Chapatsu

Walking down the street in Japan, you might be surprised to see a variety of faces that appear in what was supposedly a homogeneous population. Where history is marked by periods of isolationism and nationalism, Japan now caters to cultures worldwide—could it be one of the lesser known cultural centers of the world? A closer look at some the faces reveals a striking resemblance to characters from *Tenchi Muyo*, *Sailor Moon*, and *Ranma ½*, popular movies in Japan. Wildly colored hair, tanned brown skin, miniskirts and platform shoes. The most unusual thing is that description is of *animes*—similar to American cartoons or a Japanese interpretation of animation.

Who are the people behind the faces, and what are they representing in the society of Japan? The answer may be in understanding the historical background of Japan since the Tokugawa period. Anime and *manga*, which is the print form of anime, and the interpretations of seemingly diverse nature of Japanese society could also give answers to this variation.

Tokugawa Japan underwent close to three centuries of isolation. During this period the Shogun banned all foreign books and forbade any travel outside of Japan (Japanese 2001). Japan flourished in the face of this oppression, especially in its arts and culture. It wasn't until a series of famine and natural disasters and finally the arrival of Commodore Perry in the mid 19th century did the Japanese government allow its ports open for trade (Japanese 2001).

The ensuing periods, Meiji and Imperial periods, were marked with series of adjustments including a revamp of school systems to model that of the Europeans, and the introduction of the bi-cameral government—also an European influence (Japanese 2001). In the midst of all these changes, however, Japan still emphasized its traditional Japanese religions and philosophies. (They) began forming a military, whose operations spurted the rise of nationalism in Japan. (They) began to focus on the conquest of China in order to gain more power and respect (Japanese 2001).

The more significant period came afterwards in the transition between the Imperial period, to what is now Contemporary Japan. Military had fueled the Nationalist campaigns for Japan and used comic strips as vehicles for information. Artists used these to express their misgivings about the war and the government subsequently forced them to change topics or be punished (Beginnings 2001). The Japanese government knew that not only were these comic strips popular, they could use the strips to depict a biased perspective of the war. However, as Japan lost its war and resigned itself to a new constitution, the country may have lost a bit of confidence.

The comic industry was able to reform itself after the war and many new artists surfaced as a result. Many of them were influenced by Western ideologies such as the animation styling of Disney movies (Beginnings 2001). Newer forms of comic art appeared and two of these, manga and anime, would later become a significant part of Japanese society.

Although early manga and anime were influenced by Western culture, it is still uniquely Japanese in that it is an expression of common themes particular to the Japanese. With the historical background, it is probably not inconceivable to say that manga and anime both have a profound force in today's Japan. As a reflection or as trend setter, the question is what makes Japanese identity in today's youth very confusing.

One of the interesting facets of manga and anime is the wide variety of hair color. In addition to black and blonde hair, there are even colors a normal human being would not normally have—purple, blue and gold. During the 90s, the color of hair among the Japanese youth took on many levels. The trend was called *Chapatsu. This* literally means brown hair, but it can be applied to other colors such as red, blue, or gold (Masaichi 2000). The trend was started by a group of high school boys known as Furyo (or bad boys), who were retaliating against the school's strict dress codes (Masaichi 2000). Another way of altering hair without the chemicals comes from the popularity of wigs. A fashioned wig comes in a variety of styles that reminisce of manga or anime, and American icons such as Madonna or Naomi Campbell. In fact, Naomi did more than inspire hair color change, but even skin color.

In a country as homogeneous as Japan, it would be surprising to see so much variety in physical appearances, especially in terms of skin color. The *ganguro* look describes girls who not only have dark skin, but also have the complete outfit, which consists of a miniskirt, platform shoes, dyed blonde or brown hair, and plucked eyebrows. The physical aspects of the ganguro look is not popular in manga or anime, but sometimes the clothes worn are very similar to what manga and anime characters wear.

Other forms of altering identities include wearing different color contact lenses (i.e. blue colored lenses as a complement to blonde hair), sporting afro hair styles, and basically manga-like fashion.

It must be hard to expect a country with centuries of tradition to cater to a youth population that embraces the physical attributes of other cultures. The question is whether there is an underlying sentiment of supporting Western ideologies as a result of a nation that was once very powerful. Do the *ganguro* girls secretly want to be who they are made up to be? Do some of the styles these youth trendsetters pick up from anime reflect an identity crisis? Is

anime or manga a vehicle of expression for today's Japanese youth?

In fact, many of these trends (i.e. *chapatsu*) are embraced on a wider level, but *ganguro* is found in smaller population and *gongoru* (i.e. even darker skin) has an even smaller following. However, even if *ganguro* girls, for example, are normal sightings in the streets, they are still scorned by the general public. In one roundtable of discussion of *ganguro* girls, one of them notes her transition to the *ganguro*, saying, "It started with my hair and then everything else followed from there, and before I knew it I looked like this" (Masaichi 2000). To her, the *ganguro* look was not a method used to stand out from the rest, but something that started out as a fashion trend that just continued on its path. Nevertheless, parents would call them *bakemono* or "monsters," after a Japanese anime (Masaichi 2000). *Ganguro* girls found acceptance among other *ganguro* girls and it's not uncommon to see them in groups of three or four. Could it be that youths are participating in a form of social resistance? *Chapatsu* started out as a rebellious act against strict dress codes and the *ganguro* look has a similar take.

The *chapatsu* technically started in the 1950s and 60s but faded shortly after, then resurfaced in the 90s. However, like most of the trends described previously, the *chapatsu* are slowly fading away. *Chapatsu* is still found among the general public, but in very subtle forms. *Ganguro* girls of the 90s are now resorting back to their old image. Many had based their decision on the ability to get jobs if they changed their image from the *ganguro* look. Perhaps then, these expressions are merely trends and not characteristics of a social resistance movement. How does that explain different hair colors in anime?

As odd as it seems to compare manga and anime to understand Japanese identity, they have been (and still are) popular commodities in Japanese society. Unlike the cartoons in America, anime caters to people of all ages in Japan. However, like cartoons in America, they have been around for a little under a century. As vehicles for propaganda in World War II, manga and anime have powerful themes such as ideologies about spirituality, nationalism, and relationships. Evidence in the past has shown that they can give insight to a Japanese way of life. So, does the current fascination of hair color (i.e. blonde) have an indication of a country whose history is deep rooted in tradition to take a more Western approach to identity. The answer may be no.

Hair color could merely be a preference of the artist who designed the manga or anime. Originally the mangas were drawn in black, white, and grey (Sharer 2001). The hair was often left "blank," so readers could differentiate between characters easily. Once color was available to the artists, as a result of technological advances, the artists filled in whatever color they felt suited the character's persona. However, in choosing these colors, artists used black for traditional characters and blonde for characters exhibiting haughtiness, airheadedness or cruel intentions (Sharer 2001). Then there are characters with hair beyond what a normal human being would have—purple, blue or other colors were for characters that have supernatural ability (Sharer 2001). Anime fashion, although more recurrent than a Halloween night, might just be limited to those that have expressed interest in the manga or anime themselves and not really a resort to a political stance.

As diverse are these faces in the crowd, it is not surprising that it is hard to pinpoint one explanation for this sudden surge of interest in non-Japanese cultural traits. And although manga and anime served as opportunities to express or define Japanese identity, it may have blurred or even have no direct part in this superficial form of human biodiversity. It is clear that the "trend" is either weakening or diminished in most places and rather than a cultural revolution, a fashion fad that only lingers in the diary of teenagers now grown up.

Harmonizing with Human Variation: The Role of Music in Biodiversity

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Key Words: biomusicology, music origins

My primary research, as an undergraduate, is focused on biological anthropology, and the dynamic role that human biodiversity plays in sculpting the populations of our world. As an anthropologist, I am trained to look for continuities and patterns of cohesion across disciplines as they pertain to theories of evolution and ecology – the dominant theoretical paradigms of biological anthropology. One universal pattern that I have been recently turned on to – at least in the case of origin studies – is that of music. Music is connected to all cultures of the globe; every known culture has some form of music (Brown *et al.* 2000). The idea is nothing new; it has confounded musicologists and other scholars who have, for centuries, strived to understand the origins of music. In recent years, there has been a resurgence of interest in connecting the origin of music to human evolution (Brown *et al.* 2000, Cross 2001, Huron 2001). However, not simply as a product of human evolution, but rather as an adaptive force that helped shape human evolution. Although my research on the subject of music origin is nowhere near complete, I am writing this essay now to help facilitate a

forum for conjecture on the subject of music and biology – since so little has been done. I will introduce the relatively new discipline of biomusicology and review some of the literature, and the major shortcomings and criticisms that have befallen the field. Although I am not an expert in the field, I will demonstrate – from a bioanthropological view – ways in which biomusicology presents a unique tool to understand human biodiversity. In particular, music and musical ability are indeed a force of, and a force within, human biological diversity. These ideas, as conjectured by many scholars, have direct implications on human evolution.

A Brief Introduction to Biomusicology

In 1997, the Institute of Biomusicology held a workshop about music origins in Florence, Italy. The ensuing book entitled simply, *Origins of Music* offers an intriguing collection of papers on the subject that sheds light on the struggle of music origination and evolution studies within the later half of the 20th century. The chapter, "An Introduction to Evolutionary Musicology" by Brown, Merker, and Wallin, identifies the struggles that had pushed the study into "obscurity" and "disrepute" (Brown *et al.* 2000). Brown *et al.* cites misconceptions about evolution, racial implications, and dismissal of biological concepts during the post-war 1940's as factors for the failure of musicology to contribute to the study of human origins. Brown *et al.* conjectures that music offers three major areas in human origin studies arguing musical universality in human cultures – this area preludes to the evolution of the vocal chords and inner ear in all human populations – parallel dynamics with language studies, and the study of migration patterns. These areas have been well researched within the many disciplines dealing with human origins, but the need for a "long-overdue renaissance on the topic of music origins" (Brown *et al.* 2000) has given rise to the new discipline of biomusicology.

The research field "biomusicology" was coined by N.L. Wallin as an attempt to put musicology studies into the path of human origin studies. It comprises an interesting approach to human biological studies that has, despite its unique qualities, yet to produce any major theories on human origin studies. The field consists three branches: *Evolutionary musicology* – concerning the origins of music, *Neuromusicology* – concerning cognitive mechanism of music processing, and *Comparative musicology* – concerning the function and uses of music in human cultures (from Brown, Merker, and Wallin 2000). It is the assumption that music has a relationship to human origins, and therefore biology, that underpin the approach of biomusicology. The very concept that it has any relationship to evolution has been recently explored and offers staunch criticisms of evolutionary approach.

Music As Evolutionary

As a biological anthropologist, biomusicology begs many questions, the foremost screaming; How then are humans diverse, biologically, in terms of music? Is there some gene that allows us to make music? Is the ability to sing a universal or are some people more physiologically capable? Although humans are diverse in terms of musical ability – though one must be careful in definition of musical ability as a cultural construct, especially to avoid misconceptions of racial and evolutionary hierarchies – such diversity offers only speculation about a specific gene controlling the penchant most humans have for music (Huron 2001). In fact, no gene for behavior has yet been identified in the human genome.

If we were to consider a greater aptitude for music production as a factor of biological diversity, is it logical to say such ability is inheritable and thus a possible product of evolutionary adaptation? David Huron recently tackled that question in an article entitled; "Is Music an Evolutionary Adaptation?" Although Huron is a proponent of biomusicology, his criticism of music evolution has – at least in my mind – constructed many barriers for the advancement of the field. According to Huron, recognizing that evolutionary theories of music – and inheritance of musical ability – is "wholly speculative," and has yet to produce testable hypotheses and empirical data, weakens the evidence that music has adaptive and evolutionary functions (Huron 2001). Huron culminates the major approaches to music evolution into several scenarios that comprise a must read for anyone interested in the survival value of music. However, it is maintained that, at best, the evolution of music is a "complex genesis … built on several adaptations…involving complex co-evolutionary patterns with culture" (Huron 2001).

Simple put, evolutionary principles alone cannot entirely explain the origins of music – although several points make good arguments. In fact, such thinking has led to major criticism of the pursuit.

Music as Biodiversity

My goal in this essay is to illustrate ways in which music relates to biodiversity. So I ask again, how is it that humans are biologically diverse musically? Better yet, how is it that biodiversity can help facilitate the understanding of biomusicology? First we must recognize that the suggestion pg some human groups being 'naturally' better at music than other human groups is an idea that, as many scholars have pointed out (Brown *et al.*, Cross, Huron), presents racial paradigms and hierarchies of class, society and evolutionary success based on the ridicules notion of musical superiority. It is the stereotypical statement I've heard so many times in the past stipulating, "blacks have more rhythm than whites" that attracted my interest toward biomusicology in the first place. It is entirely possible for people to believe that someone is better at music based solely on a phenotypic expression such as skin color. These issue are outside of my scope, but they form constraints to understanding the origin of human music making which must act as guidelines for future suggestions that humans may differ biologically in terms of music and music ability.

With ideas of inner ear, vocal chord, and genetic evolution fighting with fundamental music evolution problems, exemplified above, biomusicologists have been able to investigate other physiological aspects that may make us unique musically. The real meat and potatoes of

such studies originate in neurological studies. One example demonstrates the differences in brainwave patterns between professional musicians and non-musicians stipulating the notion of plasticity – that an "organism is responsive to its environment, especially during formative years of growth and development" (Johnston and Little 1999) – as a major factor in the ability to achieve absolute pitch (Schalug 2001). While others, such as Sandra Trehub, conjecture that, there may be a "human predisposition for processing music" (Trehub 2001). Other studies suggest that there is, a little understood, but identifiable effect of music on the endocrine system (Fukui 2001). Most predominantly studied is the effect of music on testosterone levels. Hajime Fukui argues that music listening actually lowers levels of testosterone in both men and women (Fukui 2001). Although the numerous contemplations of brain function and endocrine relations to music suggest that there may be a biological reason for music ability, many critics still consider such ideas misguided and to be simply part an eclectic cultural construction of what defines music (Brown *et al.* 2001, Huron 2000).

There are no testable hypotheses about genetic origins of music. However, the human genome and cultural genome projects are striving toward understanding all human genes and the complex relationship between gene and environment interactions. As different environmental triggers are understood to turn genes 'on and off', the diversity of our own genetic make-up and how it interacts with our environment forms the key components motivating the biological sciences to understand human biological diversity. It is by moving away from formulating speculative theories of music evolution and moving toward understanding the complex relationship between music and social environment that will help validate biomusicology as a viable discipline (Cross 2001).

For me, bioanthropology represents an approach to viewing problems. Applying concepts of human biodiversity can help approach the problems of understanding biomusicology. The notion that music ability and music creation and music listening have a biological basis is what makes us musically biologically diverse. It is too simple of an answer to seek when asking; is there a gene that makes us musical? I highly doubt it. There is no musical bone. However, nothing is quite that simple in the biological world. All humans are diverse biologically simply considering the dynamics of our genetic make-up. Accepting that we are diverse in our ability to resist disease is not much further from viewing musicality as a biological diversity. If it is possible to trigger a genetic response, such as cancer, from electromagnetic waves, what effect might sound waves have on our genes?

In our ability to express ourselves musically, we find our biological diversity. That is, the expression of music by the multitudes of human populations varies greatly from culture to geographical location. Do these directly affect our music and musical ability? That is a question I do not intend to answer within this essay However, I am aware that our biological diversity is both a product of and a product in our culture and our environment. The inescapable connection between biology, environment, and culture are the theories behind plasticity and adaptability as they could, and should, apply to music origin studies.

Conclusion

Music seems to relate to our biological diversity in many ways. We cannot yet say if there is an actual physiological diversity for music. However, music is expressed diversely across all human cultures. Music affects our endocrine system differently (Fukui 2001); music affects our brain functions differently (Faulk 2001); and we are predisposition to process music (Trehub 2001). In its universality among humans, music begs evolutionary origins. I am not attempting to convince any reader that music has evolutionary and adaptive origins. My goal is to facilitate discussion on the subject, to introduce readers to the intriguing field of biomusicology, and to investigate the field with a biological anthropological approach. I highly suggest that any interested reader not rely solely on my interpretation of biomusicology, as my research on the subject has not yet been completed.

The Global War Against Biodiversity

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Key Words: environment, endangered species, genetic diversity, agriculture

In the past few decades a sort of ecological awakening has occurred. Environmental protection and conservation have become issues of serious political concern, though not serious enough. Today's younger generations will certainly face the consequences of climate change, deforestation, and population growth in their lifetime. The repercussions of anthropogenic processes occurring presently will extend far into the future, and of such processes, the rapid loss of biodiversity in the ecosphere arguably poses the greatest threat. The diversity of species on Earth and intraspecific genetic diversity among humans are crucial elements that maintain our existence. The process of natural selection acts

upon a given number of variations, eliminating varieties that are incompatible with changes in the environment as they occur. Greater biological diversity in a species increases that species' odds of surviving environmental change. To a species, environment means all living things surrounding it, as well as the inorganic environment of the planet. The process also applies to the global ecosystem: greater biodiversity means a lower risk of an ecosystem collapse. (Cardinale *et al.*, 2002) Earth has experienced numerous climatic changes in its four billion year history, along with many small-scale ecosystem collapses, and there is no reason to suspect this will not continue. Because we are a global species, the continued global existence of human civilization is inexorably linked to the survival of our global ecosystem. Given the desire to continue our existence, it follows that our behaviors should aim to preserve biodiversity around the planet and within our own species.

Just over 500 generations ago, the agricultural revolution represented a dramatic shift in competitive behavior among *H. sapiens sapiens.* Incipient agriculture bloomed between the Tigris and Euphrates rivers in modern day Iraq, creating a surplus of food. As animal populations typically react to a food surplus by increasing in size, the early agricultural civilizations swelled. Unchecked growth then led to a food shortage, at which point the Neolithic farmers faced a choice: either starve and allow the population to decrease to a level sustainable by the land they cultivated, or put more of the surrounding lands under cultivation to increase their food supply. Choosing the latter, they initiated a yo-yo effect that resulted in more and more land falling under human cultivation. Agricultural human populations became sedentary as their food source required constant stewardship. As the demand for agricultural land grew, these humans were brought into conflict with their surrounding environment. In order for agriculture to be efficient, they had to eliminate competition for space and resources. There was conflict with nomadic, non-agricultural, and other agricultural peoples. Warfare evolved as a means to expand these agricultural empires; humans battled humans on an unprecedented scale. But one important war that began in this age has been fought ever since, and its implications for the future of life on Earth is alarming. This war is the war on biodiversity.

The primary problem of agriculture is efficiency. It is a simple thing to prune fruit or cereal-bearing plants, quite another to ensure that enough of them grow in a given area to support a particular population. The agricultural revolution occurred when early farmers implemented a solution to the efficiency problem: declaring war on two categories of life. The first category included species that competed with the food species for land and nutrient resources—any 'weed,' tree, vine, or shrub that occupied space or collected sunlight that might otherwise be used by food crops. This brought about swiddens, plows, and eventually herbicides. The second category included any species that directly competed with the agriculturalists by consuming the food crops, such as rodents, birds, and insects. With the demand for increased efficiency (as territorial expansion was not always an option), species in both categories were labeled mortal enemies by the agriculturalists. In the same manner, pastoral humans declared war on carnivorous species that fed on their herds and flocks.

As agriculture spread around the world, this war was fought on new fronts. Concurrently, the world's human population grew quickly. Having learned how to manipulate their own food supply, they seemed no longer at the mercy of the environment. Whenever food grew scarce, more land could be cultivated. Agriculture and the war on biodiversity seemed to be a tremendously beneficial behavioral adaptation. By approximately the year 1850 AD, humans numbered 1 billion for the first time in history. At that time, something else was changing, and changing fast. This new change resulted in the human population doubling to 2 billion by about 1927, doubling again to 4 billion by about 1974, and increasing to 6 billion by 1999 (Cohen, 2003). This change was the industrial revolution.

Having relied on human and draft animal labor to plow fields for crops previously, food production growth had been inhibited by the biological capacity for work of living animals. Vastly improved metallurgy skills had been helpful but were nothing compared to the impact of modern machinery—the internal combustion engine in particular. Devices such as mechanical reapers, plows, tractors, and threshers tore at the soil and crops with almost unthinkable efficiency. Around the same time, advances in chemistry spawned the use of artificial nitrogen fertilizers and more lethal pesticides and herbicides. More complex irrigation technologies made use of land formerly too arid for farming. Together these developments skyrocketed crop yield per area; human food production continues increasing to this day. The war against biodiversity has, like all human warfare, grown more efficient and lethal. Modern humans are exceptionally good at fighting biodiversity, as the growing list of endangered species implies (US Fish & Wildlife Service, 2003).

The reduction in biodiversity that humans have inflicted on the global ecosystem may be endangering our survival in several ways. The diet of modern humans is radically more limited in scope than the diet of our foraging ancestors; even pre-industrial revolution humans enjoyed a far greater variety of crop foods. In the post-industrial age, however, modern plant-breeding techniques and the demand for increased efficiency are greatly reducing food diversity. Of roughly five thousand species of plants that humans have used for food, only about 150 are involved in world commerce. Wheat, rice, and maize alone account for approximately 60% of the calories and 56% of the protein that humans obtain from plants (World Resources Institute, 2003). As a result, we suffer increased susceptibility to disease and malnutrition. The potato blight and ensuing famine that afflicted Ireland in the 1840s was a dramatic example of how reliance on a small variety of food products decreases our odds of surviving environmental change. Most humans today are unaccustomed to periodic dietary changes, having eaten more or less the same few staple foods their entire lives. Should rapid environmental change

wipe out these staples, human civilization will face famines of unprecedented scale.

The processes that make biodiversity advantageous for ecosystem survival also make it advantageous for species survival. Human biological and behavioral variations increase our odds of survival, as a species in general, during periods of environmental change. The war against biodiversity, though, has been brought to bear on human variation as well. The 20th century gave rise to philosophies in which the central tenet was the absolute superiority of *one narrowly defined group* of biological traits. The concept of "ethnic cleansing" and the genocides it provokes are wholly counterproductive—their aim is, indeed, to *eliminate* human variation to whatever extent possible, leaving one "race" as the ultimate result of "natural" selection. This theory, most famously embodied by Hitler's "final solution," views evolution as a finite process intelligently designed to create a finished product. While much progress has been made in discrediting the theory, it continues to hold sway with millions of underinformed humans. Biodiversity needs to be understood as the fuel for an ongoing process that sustains life, both in humans and the greater ecosystem without a final product.

A lack of diversity in human behavior may inhibit human variation. Sedentary agriculturalists were likely the first to concentrate their numbers in urban areas. The industrial revolution's demand for increased efficiency in production multiplied urban concentration. The growing interconnectedness of global commerce generates millions of vectors every day along which pathogens may spread. With efficiency as the prime directive, humans have unintentionally created mechanisms that allow pathogens to spread quickly around the world. However, these mechanisms allow host resistance alleles to spread at the same time. If human reproductive behavior could be as diverse as that of the pathogens, humans could win the battle (Altizer *et al.*, 2003). Ethnocentrism, religion, and nationalism, however, are major inhibitors of this behavior. The human tendency to divide into exclusive groups and the idealization of nobility through bloodlines threaten human variation.

Variation on the genetic level can provide protective benefits too. Balanced polymorphisms result when natural selection favors a heterozygous genotype. The parasite *Plasmodium falciparum*, which causes malaria, for example, will more successfully attack the red blood cells of a host with the heterozygous normal hemoglobin genotype. Research shows that the heterozygous abnormal genotype which produces Hemoglobin E may provide protection against severe malaria (Chotivanich *et al.*, 2002). This is an exemplary aid for understanding the genome as a complex system in which variation allows the organism the best chance of survival. In this example the balance is between a fatal phenotype and a potentially fatal parasitic invasion.

It is quite possible that intraspecific diversity impacts ecosystem biodiversity as well. Recent research with plants indicates that in ecosystems where there is little genotypic variation within each species, an overall decrease in speciation will result (Booth *et al.*, 2003). How deep is the interactive complexity? The exact relationships are still too ambiguous to describe, but the question itself is of primary significance and the reason to strive for a better understanding of the function of biodiversity. In an age of cultural and economic globalization and rapid human population growth, continued ignorance is perilous.

These problems, viewed from a biocultural perspective, suggest that courses of action contrary to conventional wisdom (which tells us we must increase production to meet the needs of a growing population) may be required to improve the odds for our continued survival. It is a dilemma, undoubtedly. The growth and expansion of our species is resulting in lost ecosystem biodiversity as we wipe out uncounted thousands of other species. Humans must find and implement methods to check population growth. Newly aware of the importance of biodiversity to our own survival, we must change agricultural practices to balance the need for food with the need to maintain a wide array of genetic potential in the ecosystem. Because the elitist attitudes on variation within our own species create a significant disincentive to reproduce across culturally defined groups, the spread of human alleles is inhibited. This gives pathogens a competitive advantage. Faced with this reality, a desire to survive requires that we dismantle the global network that now unites our population, or rapidly outgrow the divisiveness so prevalent throughout the history of human civilization. Somehow we must end the global war against biodiversity.

The Health Consequences of Modernization in Traditional Societies

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Key Words: socio-economic status, nutrition, globalization, industrialization

Modernization, as used in the context of this paper, is defined as the "interaction of less complex energetic, technological, and socio-economic systems characterized by regional production and consumption with contemporary economic systems of industrial technology influenced by the national and international market, as well as social and political factors." (Ulijaszek, Johnston, & Preece 1998) Author and anthropologist John Relethford further explains that "compared to rates of change in historic and prehistoric times, modernization in many parts of the world today is occurring almost instantaneously." (Relethford 2003) Furthermore, "modernization in non-Western nations takes place within a framework of colonial and neocolonial dominance in which growth- and health-related problems cannot be predicted from what is known of the modernization of Western nations." (Ulijaszek, Johnston, & Preece 1998). Previously traditional societies in developing countries have taken on new biological stresses due to rapid population growth, economic and political change, increased use of natural resources, and higher levels of pollution. (Relethford 94)

These new biological stresses have manifested in many ways and effect the health of children, the levels of physical fitness and the nutritional content of their diet. The most important factors in the growth and development of children in rapidly modernizing societies are food intake and infectious and invasive diseases (Ulijaszek, Johnston, Preece 1998). While in most cases, scientists have found that height and weight of children increase from that of children growing up in their traditional societies, this does not mean that these bigger children are healthier. Studies on circumpolar populations have found that obesity, diabetes, and heart disease are on the rise because of poor nutritional habits (Shephard and Rode 1996). These societies are traditionally semi-nomadic, and they get their food from hunting, gathering, and fishing. Their traditional food is high in protein and polyunsaturated fats, and low in carbohydrates. Having access to only certain foods also makes these groups intolerant of glucose, lactose, and sucrose. These societies, due to their historical tradition of hunting, also tend to have high levels of physical fitness. Few diseases affected these populations until white settlers were introduced into their environment. The population was largely maintained by infanticide, accidents, starvation, and suicide of the elderly (Shepard and Rode 1996).

Today, some societies are in the midst of changing from a traditional hunting and gathering society into a modern technological society. The relatively rapid introduction of modern houses, electricity, nursing stations, and schools have led to many growing pains for these burgeoning societies. Nutritionally, these populations tend to have vitamin deficiencies, and they lack adequate intake of fruits and vegetables (Shephard and Rode 1996). One explanation for poor diet is that the cost of shipping food to arctic regions is very high, causing prices to rise. Another reason is simply that the populations who have never experienced eating certain fruits and vegetables lack the nutritional education to make healthy food choices. These societies typically decrease their use of traditional foods, due to the rapidly expanding population – making it harder to acquire enough food for every one with simply hunting and gathering. The decrease may also have resulted from a new, more expensive method of harvesting using snowmobiles. Some farmers may not have been able to keep up with the demand due to their lack of money to buy a snowmobile (Shephard and Rode 1996). Furthermore, many developing societies find "western" processed foods to be more sophisticated than their traditional diets, and enjoy soft drinks and fast food much more than traditional, cultural foods. Besides obesity, these new nutritional habits also lead to high blood pressure. Scientists have found that blood pressure is higher in modernized societies and is increasing among the elderly of these populations, while in traditional societies, blood pressure is low and does not rise as one grows older. This change is due to the population changes in diet, physical activity, and level of stress (Relethford 2003).

These diseases have also impacted children in these societies. Shephard and Rode found that the children in the circumpolar regions have shown increases in body fat, decreases in muscle strength, and decreases in aerobic power. They suggest that these changes are due to the introduction of Western television into their homes, and the fact that schooling does not allow them to hunt outside. Hunting is the traditional activity from which most members of their society got their exercise historically (Shephard and Rode 1996). In general, the reliance on the snowmobile of the arctic populations to get around the expansive tundra, rather than the time-consuming snow-shoe, allow children and adults alike to get less exercise than their ancestors (Shephard and Rode 1996).

In rapidly modernizing societies, obesity, diabetes, hyperglycemia, hypercholesterolemia, and lung disease (from cigarettes) are all on the rise. These are caused by the population's changes in eating and activity levels, due to Western neo-colonizing influences. However, Shephard and Rode state that they have found no evidence that these diseases have changed genotypic and phenotypic characteristics on the circumpolar populations that they were studying (Shephard and Rode 1996).

Though the aforementioned diseases are serious, they are not immediately life-threatening. In their study on

circumpolar populations, Shephard and Rode found that the population surged in certain societies during the 1950s (Shephard and Rode 1996). This surge in population was due to the influences of Western society that were incorporated into their traditional lives, by means of missionaries, government programs, and colonists. Life-threatening diseases are now cured by medicine from local hospitals and doctors. Starvation is no longer a major problem due to the shipment of Western food into local grocery stores and markets. More importantly, Westernized culture also influences fertility. As the traditional prolonged lactation of infants decreased from three years to about one year, the length of time between pregnancies also decreased, resulting in more births per woman (Shephard and Rode 1996). Western medicine and hospitals have increased chances for survival for babies and their mothers, whereas the harsh realities of the natural arctic elements would have diminished the population. Although government programs, starting in the 1970s, encouraged native women to use contraceptives such as the birth control pill, few women did. Thus, the birth rate continued to rise as the death rate decreased. This caused the population pyramids of these societies to resemble the population demographics developing countries, with a large youth population and small elderly population. However, from 1990 to the present day, the population has started to stabilize, now that contraceptives are more common in these areas (Shephard and Rode 1996).

As a student of sociology, I am interested in the impact of globalization, and the resulting rapid modernization, on human populations and their cultures. Although the field of sociology has given me the tools to study cultural and societal effects of modernization, there is little emphasis on the biological impact of it. However, I have come to realize that individuals impact their societies, and thus, what happens to an individual can have resounding effects on society and culture as a whole. Thus, one cannot truly dig deep into a culture or society without studying the human beings, through both psychological and biological studies. For instance, during the colonization of the Americas, American Indians died by the thousands just by the diseases the colonists carried to their land. Since they had never come in contact with these diseases before, the deaths were explained with cultural reasons. Furthermore, the decreasing populations of each tribe led to a consolidation of survivors from different tribes into new ones, with new cultural practices. Thus, what happened biologically to individuals created new societies and new cultures – with new norms and behaviors. With this understanding, the study of biological anthropology will help me become a better sociologist, with new tools and new ways of thinking to find solutions to sociological problems.

What is interesting to me is the fact that the problems of modernization are most severe when populations make very rapid transitions from traditional societies to modernized, technological societies. Although there were initial difficulties in the beginning of Western industrialization, the relatively long period of time it took to fully transition from agricultural to industrialized society allowed the societies to modify their developments to avoid or lessen those problems. And though Western industrialized societies still do have many problems due to the industrialization process, these problems are not as severe as those in societies rapidly transitioning into industry in twenty or thirty years' time.

Suggestions on how to help these societies transition more comfortably and deal with their rapidly changing environment are few and far between. Both sociologists and anthropologists alike tend to find themselves in conflict with economists and powerful transnational companies. Because this new modernization comes from the largely Western multi-corporations in a neo-colonization ideology, the health risks of the native populations are of little value to the capitalists moving into these developing societies solely to win a profit.

My suggestions are ones of compromise between these conflicting ideologies. I would suggest educating native populations about nutrition and the health risks associated with fast food or processed foods although I think McDonald's can still operate in American Samoa. Education could occur through government-funded schools and ads on TV, billboards, or nutritional information could help educate those in the population who have only recently had to choose between fruits or fried chicken. The government could also use the same techniques to encourage more physical activity. Requiring school-aged children to be enrolled in a sport or a gym class would be a good start to incorporate exercise into daily life. Free or low-fee gym classes could encourage members of the older populations to get the physical activity they lost when their societies began to modernize. Also ad campaigns can be useful to encourage people to walk or bike to short distances, rather than using vehicles to get to those places.

Although the studies I have found about modernization in traditional societies in the context of human biology have expanded my horizons on studying this topic, many times the studies left me with more questions than when I started. For instance, many studies do not mention, or only skim the surface of, the impact of pollution due to rising technologies. With the increase in factories and cars, as well as other sources, the rise in air and water pollution is substantial. Many studies fail to mention the impact of contaminated air or water on a population who is not used to such things, and consequently, whose bodies may be more susceptible to problems arising from those pollutants. Furthermore, due to an increased importance in work and capitalism, I would be interested in the health impacts of working conditions in these societies. Due to multinational conglomerate corporations, many of the people employed in developing countries are working in poor conditions, with little pay. I also did not find many reports of modernization's impact on the environment, or natural resources. The depletion of natural resources, as well as natural habitats for animals and people, most likely create a variety of problems, as they do for Western societies today. Mental health is also an important topic to raise in the context of this subject, but this is another issue that is seldom addressed. Sociological

studies during the time of the Western Industrial Revolution concentrated on alienation and depression due to the stress of the new period, and the social accommodations required because of this new type of society. I imagine today's developing societies are going through a similar adjustment problem, and I would be interested in learning more about the mental health of their native populations.

Sudden technological advances have historically created many problems for human societies. However, today's advances in developing societies are incredibly rapid, with Western technology becoming fully integrated into these societies within twenty and thirty years. The stresses caused by these changes can be overwhelming, and this is evident in studies of biological fitness in native societies becoming modernized by the West. The main conclusions determine that obesity, diabetes, and heart disease are on the rise, and physical activity, and consequently, physical fitness, have decreased in what was once a healthy population. In order to minimize further damage to these societies, mass nutritional and health education needs to be integrated into their media and in school curriculums. Because these changes have occurred in a relatively rapid progression, there is little comprehensive material studying the effects of modernization on these societies. Further research should be done on environmental problems and on mental health. Only then can we begin to understand what can be done to create a smoother transition into the fast-paced, technological world of the modern era.

Sight and Other Effects on the Study of Race

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Key Words: sight-bias, judgement, categorizing, stereotypes

Of the five human senses, sight may be the most relied upon sense. In a foreword to Laura Sewall's *Sight and Sensibility,* David Abram tells us that:

> "Vision, more than any other sense, has lent its particular character to Western civilization, and indeed that the cool detachment and objectification associated with the modern, technological enterprise can be understood as the result of an overemphasis on visual ways of interacting with the world". [Sewall 1999]

This means that humans, place a high value on vision, and suggests that people are exposed to so much visual stimuli each day that we have become cold and disconnected with the world and each other.

Humans use sight to detect danger, locate food, find an acceptable mate, and see where they are traveling. Sight also helps people identify their kin, distinguish between healthy and harmful foods, and find their homes. But, even though sight is an extremely reliable source for these identifications, it also means humans come with a sight-bias: when people see something, they assume it is true. Sight gives us an automatic proof for whatever it is we are arguing. Before the digital age, and the greater ease with which photographs and videos could be manipulated, the reality of events depicted in photographs were not disputed.

Humans also place their own type of bias upon their sight. Personal biases and influences affect what people see as much as their biology does. Reasons for seeing things certain ways differ greatly from person to person and context to context. For example, for a person who has only owned fish their entire life, a guinea pig may appear to be a large and difficult pet to own. On the other hand, a person who has only owned Cocker Spaniels will see a guinea pig as a small and easy-to-care for pet. This relatively simple and innocent form of contextual bias shows how two people view the same object in contrasting ways.

To complicate the example a little, say that both people were to move into an apartment complex where only "small" animals are allowed. The person who owns fish would automatically assume their pet is small, but so might the dog person. The dog owner does not want to lose the dog, so his small-animal views change. In reality, the apartment complex would see the Cocker Spaniel as being a medium to large sized pet. The owner has clouded his judgment of the size of the pet because of the fear of the apartment terminating his lease. In this case, motive and context play a large part in sight, and both will inevitably affect one's judgment of it.

It is clear that humans place a large importance on sight, and that our preferences, motives, and culture play a key role in our interpretation of what we might see or observe. Sight-bias goes beyond seeing, interpreting, and believing; it gives us means to categorize. Humans exist in a universe that is larger than they can imagine. In order to live our lives every day, we search to make our realities small, tolerable, and understandable. Reducing things to fit into our lives help us focus on surviving. Since the evolution of modern man, we have been categorizing our realities. In an essay titled *Humans as Symbolic Creatures*, Herbert Blumer states that "we use categories to perceive, interpret, and store information because it is not possible for us to attend to all the stimuli that bombard us constantly…These categories give order to an otherwise chaotic existence" (Kollock 1994). He stresses that nature itself does not categorize, humans do. In this context, humans need to categorize to live their daily lives simply.

Humans categorized animals and plants early on to know what was safe to eat. Ancient humans were organized into groups and tribes with multiple subcategories which defined the divisions of labor within the group. Today, we have categories for everything from stars, landmasses, sounds, to academic units. Categorizing may make our lives easier to handle, but it also allows us to classify ourselves. Social classes, economic classes, caste systems, political structures, and location of residence are among the many ways we have chosen to categorize ourselves.

Combining our sight-bias with our need to categorize has placed a tremendous emphasis on how humans view each other: "In contrast to touching, tasting, or even hearing, and over-engagement in seeing…is at least partly to blame for our contemporary recklessness toward the earth and toward one another" (Sewall 1999). In Linnaeus' time of taxonomy and animal classification, sight had never failed us. Judgments and interpretations of what was seen were not seen as problems or issues of debate. When it came time to answer the question of human biodiversity, what "better" law to turn to than appearance. Indeed, Spencer Wells, in his book *The Journey of Man*, states, "The study of human diversity was, until the twentieth century, limited to variation that could be observed with the naked eye" (Wells 14).

Skin color is the most obvious of phenotypic diversity among humans, but hair color and type, eye color and shape, height, and facial features also provide means for categorizing, or, in other words, stereotyping. Our sight-bias and classification tendencies are the reasons why ethnic variation has been the primary concern in most studies of human biodiversity.

If sight-bias were such a huge issue in how we perceive each other, wouldn't it make sense that we would also categorize based on gender? Not necessarily. Unlike all other animal species, humans not only have concealed ovulation, but also cover our reproductive organs with clothing. Sight does not provide a huge bias in this case. Nevertheless, early biologists recognized some kind of sexual dimorphism to be apparent in almost all species in the animal kingdom. This means that gender was viewed as law, and race as categorizing. Thus, those studying human biological variation would not have felt as strong a need to prove/justify a law as they would have a category.

On the other end of the spectrum, there are differences between men and women that have been proven and accepted to give men advantages over women since the emergence of anatomically modern humans. These would include strength, size, and the ability to be mobile (as opposed to dealing with pregnancy). Men were, and still are in most cases, stronger and larger than women. Men are not restricted by pregnancy and childbirth, as are women. Obvious factors such as these become overall defining characteristics for genders. If those differences were obvious enough and were not up for debate, other issues were thought to follow suit, such as intelligence and potential. Though these examples, by today's standards, did not prove any superiority of one sex over the other, they were enough for early anthropologists to dismiss the gender issue.

Men and women have also always co-existed. There was never a time when either sex was not aware of the other. Such was not the case with ethnicities. For centuries, peoples of different geographical areas were confined by natural barriers, such as water, ice, or the desert, and were not aware that variance in humans even existed. Today, humans can observe different cultures, and see how different people around the world look. This was not the case in the beginning of anatomically modern human beings (and after the extinction of other Homo species).

However, with the emergence of the feminist and homosexual movements, gender is becoming a more discussed and debated topic, much like ethnicity. In the past, gender was not as large a concern in human biodiversity studies because of deep-rooted male vs. female classifications. But currently, issues in gender are as widely debated as those in race.

With all these topics influencing human biodiversity research, why do some get priority over others? In the past, the main contributing factor was the struggle for power. Power meant, and still means, control over resources, more children, luxuries, better health care, and overall safety. Those who studied human biodiversity were mostly interested in finding justifications to their "superiority" over others. In other words, putting our sight-bias in the context of a struggle for power resulted in judgments rationalizing it. According to Joseph L. Graves Jr. in his book *The Emperor's New Clothes*, "Racist ideologies provid[ed] a moral justification for maintaining a society that routinely deprive[d] certain groups of their rights and privileges" (Graves 2001).

Pseudo-sciences, biased data collection, measuring body parts, and typology dominated early anthropological and biological studies of biodiversity:

> "Before there were scientific examinations of human diversity, unscientific definitions must by necessity have prevailed. Such definitions were by nature arbitrary, therefore inconsistent; and hypotheses concerning them would have been untestable." [Graves 2001]

Finding bias justifications of power was not difficult if one knew where to look. Justifications were not taken lightly either. Enslavement, wars, and even genocide have resulted from "proof" of superiority of one people over another.

Though humans place a high level of trust in what they see, they also see what they believe. The earlier example of the pet owners demonstrates this concept. The dog owner saw his Cocker Spaniel as small because of the apartment complex rules. The owner needed to think that the dog was small and so he saw it as such; judgment was clouded based on context. A broader example is that mankind has always thought itself to be the most superior form of animal. Thus, most of early research interpreted various results and data in an effort to show this was true. If we already believe in something, chances are we will find a way to justify it.

Unfortunately, "because seeing determines action, the recognition of both our projections and our internal powers to co-create the world has significant implications for the quality of our lives and for the quality of life on the planet" (Sewall 1999). This means that our sight and perceptions are capable of steering science in a way that will benefit our existing beliefs. Religion, worldview, and culture embed these beliefs into societies: "Vision is socially produced and tends to confirm and reproduce the culture that brought it into being" (Levin 1997). If Europeans believed themselves to be a superior "race" prior to any application of scientific method, they would, regardless of data, prove it.

Humans, in the pre-Darwinian early 19th century, were also going through a sort of identity crisis. Enlightenment ideas were challenging those brainstormed two hundred years earlier in European Renaissance times. New methods and theories were being used to collect data. Increases in trade and exposure to new cultures brought insecurities and questions of human identity. After Darwin's controversial *Origin of Species* was released, variation and diversity became hot topics in science. Even through current times, people have struggled with identity questions such as: Who are we? Why are we the way we are? and Where do we fit into the environment, animal kingdom, and universe?

Landmark research discoveries such as Darwinian natural selection, adaptation, and variance, Mendelian genetics, micro and macro evolution, molecular genetics, archeological fossil finds, and living primate studies have all provided us with partial answers to those questions above. Fortunately, curiosity is part of human nature but partial answers or half-truths tend to emphasize the incorrect answers.

In conclusion, ethnic and "racial" variations have been the primary focus of most past and contemporary human biodiversity studies because of the need to categorize. Our historical reliance on sight has led to stereotyping by appearance. Though a natural assumption would be that gender would also be an equally dominant area of study, gender roles have, in the past, been accepted as canonical and are thus less debatable. Also, both sexes have always lived together co-existing, unlike two groups who look very different and come from different areas. The selection of research priorities in the area of human biodiversity has mostly been influenced by the struggle for power, the need to define human identity, and pre-existing cultural belief and worldview.

The Fallout of a Post-Biological Race Concept Era

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Key Words: biological race, self-identification, education models

> "It may be doubted whether any [human] character can be named which is distinctive of a race and is constant…. The diversity of [allotment of characters into race categories]…shows that they [races] graduate into each other, and that it is hardly possible to discover clear distinctive characters between them."

Outside of the slightly anachronistic language, the sentiments iterated above can be found easily in an endless plethora of recent publications concerning human biological diversity and the concept of race. Indeed, the issue of race and biology has been the focus of a series of semi-popular titles emerging over the last few decades. A list of just a few of these reflects the multiple approaches taken: J.L. Graves, Jr.'s reformatory *The Emperor's New Clothes*; S. Molnar's holistic *Human Variation*; J. Marks' historical *Human Biodiversity*; S. Olson's narrative *Mapping Human History*; J.P. Rushton's controversial *Race, Evolution, and Behavior*; and S.J. Gould's ever-popular *The Mismeasure of Man*. These and many other titles indicate a resurgence of interest in describing modern human origins, especially in light of genomic and proteomic research, and the ensuing variation found in modern groups. The irony is that the statement above was composed in 1871, by an aging and politically beleaguered Darwin, in his *The Descent of Man, and Selection in Relation to Sex*. Even 132 years ago, however, as evidenced by Darwin's writings, the debate was hardly novel.

There is a difference now, though, from the time Darwin, Huxley, and others argued the applicability of natural selection to humans, beyond the obvious augmentations and deletions to evolutionary hypotheses. For the first time, biologists—ranging from anthropologists to geneticists—are coming to a basic understanding of what, fundamentally, makes human populations unique from one another. It does not seem to be much that separates these populations. Rosenberg *et al.* recently cited the amount of genetic variation between populations at 1-12% (2002), and others have stated similar, often lower-end figures. Beginning with the research of Lewontin (1972), it has further been implied that there is more variation within populations, especially between sexes, and that the remainder is more attributable to geographic distance. Assuming this variation inherent in the structural DNA, rather than not non-coding or regulatory, this translates to between 300 and 3,600 genes of the

estimated 30,000 total genes carried by humans. Without knowing which structures or how many proteins these polygenic outliers code for (some seem to regulate blood serum attributes, blood cell structure, and sugar synthesis; see Cavalli-Sforza *et al*., 1994), or what the relative variation for these genes are in other mammals, there is little context to discuss what this percentage of variation means practically for human diversity research.

This uncertainty has not stopped a number of researchers from proposing the abandonment and discarding of the biological race concept in its entirety.[1] It has been well-documented that anthropologists, human biologists, and geneticists have distanced themselves from the eugenics-centered science of pre-World War II, and in doing so have sought every opportunity to deconstruct the concept and usage of biological races. This is not meant to reflect any incredulity on my part in the anatomical and genetic research to date; indeed, a diversifying and increasing number of results are failing to disprove that genetic variation among human populations is minimal when compared to differences within populations.

Nevertheless, the historical effects on contemporary science should be acknowledged. Few researchers would now agree with the sentiments of the First Race Betterment Conference, which published the deterministic sentiment that "we have reason to believe not only that one's mental character is due largely to heredity, but…that for any particular trait or complex in [a] child there is likely to be found a similar trait or complex in the ancestry" (Popenoe and Johnson, 1918). Ignoring the existence and impact of such thinking on modern investigations and biases, however, would be myopic. Although I believe that many scientists, among whom I humbly count myself a junior member, are striving to find the objective nature of human biology, it would be difficult to deny that many think that their research might positively affect society, whether through more precise medical procedures or by ridding ourselves of what is considered racist baggage to encourage greater equality. Changing race into the recognition of the human blend and clinal evolutionary history on a widespread scale is the intention, whether or not it is appropriately expressed.

So, assuming that the troubled head of biological race is severed by methodical research, it may turn out that the beast is really a hydra; ridding ourselves of "race" will inevitably create more problems. For example, though he tries to develop an impassioned model of education reform in his book, Graves only emphasizes that changing the social concept of race cannot be as simple as removing a term from children's vocabularies, textbooks, and the media (2001). There are historical, ethical and self-identification concerns that must be contemplated and resolved. I would not presume to discuss these issues here; they are the concern of more experienced individuals including social reformers and politicians. Washing our collective hands of these implications within the scientific community, though, is irresponsible to the general populace and could, inevitably, encumber our desires to rid ourselves of the classic race idea in general.

There are two facets of the post-biological race era that I will address here that have practical impacts on the future of human biological research: how can we, as researchers and educators, revise the enculturation of the next generations away from the biological race concept; in future analyses, how should we group people if there is so much diversity within the groups traditionally analyzed? Both are already critical to the future of human biological studies. Though further work may continue without the wholesale reeducation of non-specialist students, the second point could lead to a minor crisis in the biological sciences if it is not soon resolved. This is not a question of terminology; it is an issue of analytical methods.

If one were to follow the advice of authors like Joseph Graves, Jr., then the changes to be made in United States and eventually worldwide, education should be adopted universally, applied to all of society, and focused at the grade school and early college levels. This is ideal for altering both the social and biological concepts of race, but I will assume that, for aforementioned reasons, the social revisions will take much longer. There are, in my opinion, some simple means to alter race in biology before these sweeping cultural changes would occur. The first question is where we start to teach; do we keep concepts "simple" for grade school children and continue to teach them that people are just superficially different because they come from different places? Or rather, should we teach them the more "complicated" history of continuous variation of populations and ethnic plurality, beyond the overly simple idea of having mixed parentage? Richard Feynman, the noted Nobel Prize physicist, once spoke about this issue when teaching physics; should he teach the simple but incorrect principles of Newtonian and Euclidian physics, or should he introduce topics by giving the much more complicated modern quantum and relativistic perspective? He realized that much of the latter was out of the mathematical grasp of beginner students, but he also wanted them to know that the other models, while once correct in principle, were incorrect in the modern synthesis. His solution was to teach the concepts of the more complicated physics, without all the mathematics, to expose students to the concepts earlier, rather than spend lessons in later years revising ideas that had since become entrenched in his students' minds. Similarly, the solution for children might be to give them the plurality perspective, backed up with some concept that human migration is a complicated but eventually attainable matter, and leave the details (i.e., population genetics and genetic theory) to self-exploration and more mature coursework. As a potential college educator, I would prefer to have students entering who are familiar with the modern paradigm of the post-

[1] I use the term "biological race" to distinguish it from "social race;" historically, the terms "biological race" and "sub-species" are regarded as synonymous when describing humans, whereas "social race" tends to be as much a cultural construct as one based on biological principles. They are inherently aspects of the same idea, but biological definitions can be disassociated from individual and emotional investments more easily with fewer cultural complications.

biological race concept. Then efforts could be emphasized upon delivering the details previously left out instead of fighting the emotions of disbelieving students.

The implementation of this revision in the education system would take a rigorous, coordinated effort. Revising the paradigm for post-schooling adults might be much more difficult, as it would entail changing entrenched social beliefs though it should be possible, and as such, educating children against what they are taught at home and in society will be the principle challenge. However, just presenting the children with the alternative, and correct, perspective would give them the tools to challenge what current societal norms. The exposure would also make it possible for these children, when they reach college, to encounter the more complete model of human variation without the need for an intellectual transformation (as was so well discussed in Goodman's 2000 paper in the *American Journal of Public Health*). Therefore, the changes should begin at the grade school level, and all educational resources—from children's programming to textbooks to interactive media—would have to make the shift simultaneously. More importantly, teachers would have to be educated in the proper dissemination of the paradigm, and also be taught how to deal with the cultural contradictions. This would also mean that all students entering college should be presented with the evidence for the new human biological variation model, and it would have to be emphasized in educator training. Though the argument that biological race is a myth has existed since Darwin, and has clearly been stated since the 1940s, there has not been a concerted effort to educate children of this. Only by giving children and young adults the tools by which to assess human variation from a young age can the desired societal change be made a possibility.

Before changes are made to the manner in which the next generation is taught human biodiversity, alterations must be made within the disciplines that study human biological variation. A consensus, based on the competing hypotheses' results, must be agreed upon and set as a standard from which all future research will progress. I do not know if enough evidence exists to clearly obliterate all population categorization, but there is enough evidence that human biodiversity is continuous, changing, and not concordant in trait variance (Goodman, 2000). The unchanging biological races, altering only as people develop new population delineations, cannot be supported by this evidence of a dynamic genome. Human biodiversity should, naturally, continue to be tested, but without the predetermined rigidity of races.

Yet there seems to be an inherent contradiction in this adopted model: if biological race is nonexistent, empirically, and populations are indicated as possessing more internal variation than that which exists among other populations, how can any research into the variability of humans proceed? Would this not make groupings—comparing Yamana Fuegians with the Toba of Argentina, for example—artificial constructs? If indeed the new paradigm is taken to its extreme, group resolution for analytical purposes would have to be reduced to genetically, highly similar persons, if not to the individual level. At this point, statistical analysis would become unreliable, and practical research would cease to operate for human biodiversity research, as general patterns and comparisons would be irresolvable among clans, families, or individuals. The solution would then be to not take the model to this extreme. Perhaps comparing the Yamana Fuegians and Toba might ignore this internal variation, but it would give useful results about a more general population affinity and history in southern South America. In order to correct for the additional confounding factor of intra-population dissimilarities, testing for variation within the defined populations would be a crucial component to this research methodology. So long as the assumptions concerning the populations grouped are thoroughly tested, there should be no need for the apparent paradox in future human biological research.

The changes made to the understanding of human biodiversity since Darwin struggled with anthropologic evolutionary theory have mainly been augmentations of knowledge and the magnitude of human variability; the idea that humans are clinal and commingled in their characters has existed for over a century. Rather than continue to argue about how to reject a hypothesis that lost supporting evidence decades ago, as well as live in the shadow of a racist history, the science and education of human biodiversity must move to the next stage. Human variation should be understood on a practical scale (i.e., what 1-12% variance exactly means). More importantly, the "new" paradigm must be supported by the scientific community, and strong pressure should be placed in education reform if a post-biological race concept era is to emerge from the scientific literature and laboratories into society.

West Nile Virus Arising in the United States

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Key Words: West Nile Virus, encephalitis, virology, epidemic

In August of 1999 when birds suddenly started dying in New York City and people began showing up in hospitals with encephalitis, health officials simply believed that an outbreak of St. Louis encephalitis (SLE) had occurred (Preston, 1999). SLE is endemic in the southeastern United States with minor, sporadic outbreaks occurring in the region on a routine basis, so the appearance of SLE in New York would be unusual. However, a more detailed laboratory analysis found that the virus causing the New York outbreak was a new strain of West Nile virus known as NY99 (Roehrig, 2002). The appearance of an exotic virus in North America was particularly frightening since experts were uncertain how the virus would respond to new environment and population of immunologically naïve hosts.

Historical Perspective

West Nile Virus (WNV) was first isolated in 1937 from a native of the West Nile Province of Uganda, Africa. The first epidemic occurred in Israel in the region south of Haifa in 1951. One hundred twenty three cases were reported with no fatalities. Children, especially those under three years of age, were particularly susceptible to the strain. The outbreak prompted a four-year study (1951-1955) into the WNV by the United States Navy Medical Research Unit (US-NAMRU), which demonstrated that the life cycle of this virus uses both mosquitoes and birds as hosts. It was shown that there is a correlation between the percentage of crows and percentage of humans with anti-WNV antibodies (Murgue, 2002). Even with the new emerging strains, the best predication of a human outbreak is the crow mortality rate (Roehrig, 2002). In addition to the serological and ecological studies that led to the discovery of the transmission cycle, the US-NAMRU team also conducted experimental infections in humans, equines, birds and insects. These studies showed that virus could be detected in the blood of infected humans as soon as twenty-four hours after inoculation and an active viremia lasted up to twelve days in ten percent of the subjects (Murgue, 2002).

The next major WNV outbreak also occurred in Israel. The 1957 epidemic was the first in which severe neurological symptoms developed in some infected individuals. After this WNV infection seemed to return to its endemic level. Serological surveys in Africa still detected antibodies to the virus, but no outbreaks were reported barring a 1962 incident with horses in southern France. In 1972, a WNV outbreak appeared in South Africa following an exceptionally wet monsoon season. No fatalities were associated with the virus although 18,000 confirmed cases were reported. (Murgue, 2002).

After the South African outbreak, there were no further significant epidemics until the mid-1990s. At this time WNV reemerged with an increasing frequency and severity of epidemics in both human and avian populations (Petersen, 2002). In 1994, an outbreak in Algeria resulted in fifty cases with neurological symptoms and eight deaths. In 1996, there were 393 confirmed cases in Romania, approximately half of which had neurological symptoms, with eighteen deaths. In 1998, thousands of geese were destroyed in Israel when the commercial flocks tested positive for the virus. In 1999, 826 patients were admitted to local hospitals in the Volgograd area of Russia for acute aseptic meningoencephalitis, and 58% of these patients tested positive for the WNV. This epidemic resulted in forty deaths, with 75% of the mortalities occurring in patients older than sixty years of age (Murgue, 2002). The Russian outbreak was later identified as a strain most closely related to the one that caused the Romanian outbreak (Rom96) (Roehrig, 2002). This same year, a WN variant most closely related to the one involved in the Israel 1998 outbreak (Isr98) was isolated in New York City, which marks the first time the virus was found in the Western Hemisphere (Petersen, 2002). In 2000, another outbreak occurred in Israel, resulting in 417 confirmed cases and thirty-three deaths. All but one of the deaths occurred in individuals at least sixty-eight years old. This outbreak was unique because two strains of the virus were isolated from patients (Murgue, 2002). One was nearly identical to the variant that caused the Russian epidemic, while the other was similar to the one that had destroyed the geese flocks in 1998 (Isr98) (Petersen, 2002).

The introduction of WNV to the United States provided the pathogen with a set of naïve hosts, and experts were uncertain about what the outcome of the outbreak would be. In 1999, sixty-two human cases were reported with seven fatalities in the New York City area. Roughly four to eight weeks prior to the human cases, there were widespread bird deaths. This massive crow mortality has proven to be an effective predictor for outbreaks among humans during the spread of the NY99 variant. It was hoped that the pathogen would not be able to survive the New York winter; however, this was not the case. In 2000, only twenty-one human cases were reported with two fatalities but these cases occurred throughout a larger geographic region than prior regions. In 1999, WNV had been isolated in New York, New Jersey, Connecticut and Maryland. In 2000, the virus spread along the eastern seaboard from Vermont to North Carolina with human cases in New York, New Jersey and Connecticut (Roehrig, 2002). By 2001, the virus had reached the Mississippi River and was responsible for a total of eighteen deaths (CDC, 2002a). In 2002, the worst WNV epidemic to date occurred in the United States. There were 3,852 confirmed cases with 232 deaths. Ohio, Michigan, and Louisiana each experienced over 300 cases. Illinois was the

hardest hit with almost 800 cases and fifty-two deaths. Before the end of the summer WNV infections had been reported in thirty-nine states and the District of Columbia, including states as far west as California (CDC, 2002c).

Biological Perspective

WNV has been divided into two groups: lineage 1 and lineage 2. Lineage 1 WNV is the only one to have been associated with human encephalitis. WNV-1 has been isolated in Africa, India, Europe, Asia and North America. The Kunjin virus from Austraila, which also causes mosquito-borne encephalitis, appears to be related to this lineage. It has been hypothesized that the emergence of a new variant from this group has led to the recent increases in WNV outbreaks worldwide and an increase in the severity of human disease associated with the virus. Lineage 2 WNV is still centered in Africa where it is maintained in the local bird population. Lineage 2 virus is sometimes isolated from surrounding areas such as France or Israel, where it has been carried by migrating flocks (Petersen 2001).

WNV has two distinct transmissions cycles. The primary cycle is within the avian population by a set of mosquito vectors that prefer birds. The second cycle is transmission to mammalian hosts by what is potentially a different set of vectors. These cycles are maintained through differential efficiency in the ability of mosquitoes to pass on the virus. *Culex mosquito* species, which appear to be the most efficient at spreading the disease, preferentially feed nocturnally on birds. However, there is concern that the introduction to North America will allow passage of WNV to a mosquito that has more potential to cause human disease. For example, *Aedes albopictus* feeds diurnally and does not have a preference between mammals and birds. Laboratory experiments show that this insect is an extremely efficient transmitter of WNV, but only one positive member of this species has been discovered in the wild. However, the *A. albopictus* has the potential to be an important bridge vector between the primary and secondary transmission cycles (Turell *et al*., 2002).

For a mosquito to spread WN a specific sequence of events must occur. First, it must feed on a viremic (containing virus particles in the blood stream) animal (Turell *et al.*, 2002). Active viremia usually lasts around a week in birds (Malikinson, 2002) and up to twelve days in humans (Murgue 2002). Second, the mosquito must possess the appropriate receptors in its midgut for the virus to bind to. If the virus fails to bind to the midgut, no infection is initiated and the virus is digested and excreted from the insect. If binding occurs, the virus begins to replicate. The next stage, referred to as the *midgut escape barrier*, involves the virus particles passing from the midgut into the insect's hemocoel. This allows the virus to spread throughout the body of the mosquito and reach the salivary glands where replication continues. In some mosquito species the virus is either unable to pass into the salivary glands or into the saliva. However, these cases appear rare, which leaves midgut escape as the last real barrier to creating an infectious mosquito. All that is left is for the mosquito to bite a susceptible host (Turell, 2002).

Until the emergence of the NY99 and Irs98 strains that were associated with massive avian mortality, infection of birds with WNV rarely caused any apparent disease. Birds, depending on species, would contract varying titers of the virus in their blood (McLean, 2002). This active viremia would last about a week after which the host would develop lifelong immunity (Malikinson, 2002). Almost all avian species are susceptible to WNV, but to varying degrees. For example, most domestic birds, such as chickens, do not develop virus titers at levels high enough to pass the disease to mosquitoes. However, geese are extremely sensitive to WN (McLean, 2002). Crows, jays and raptors appear to be particularly susceptible to the NY99 strain. In the United States, WNV has been isolated from 138 different species of dead birds (CDC, 2002d). The secondary transmission cycle of WNV, from mosquito to mammal, usually results in the infection of a dead-end host. Experiments with sheep, and dogs have only shown the development of low-titer viremias below the ID_{50} for *Culex* mosquitoes, while experiments with cattle failed to generate anything. These animals produced an antibody response, but showed no disease symptoms. Equines appear to be the only mammalian species, other than humans, that routinely experience severe effects from WNV infection. Symptoms in equines include high fever, variable degrees of paralysis and an inability to rise (McLean, 2002). Although likelihood of infection is low, the equine mortality rate is approximately forty percent with the NY99 strain. As of 2001, the only other animals that CDC has received reports of WNV infections in are bats, a squirrel, a chipmunk, a skunk and a domestic rabbit (CDC, 2002d).

The risk of a human death from WNV is extremely low. In endemic areas in Africa, WNV is an early childhood illness denoted only by a mild fever (Murgue, 2002). However, the recent outbreaks in Romania, Russia, Israel and the United States have been associated with a higher morbidity. Serological surveys of the NY99 strain shows that approximately 20% of infected individuals suffer from West Nile fever (Petersen, 2002). Rash, headaches, vomiting, anorexia, muscle pain and weakness can accompany the fever (CDC, 2002b). Less than one percent of infected individuals develop West Nile encephalitis, but 5 to 14% of these patients die (Petersen, 2002). The biggest risk factor for the development of encephalitis is advanced age. However, a stressed or compromised immune system, such as people with AIDS, diabetes, or organ transplants , can be at risk. Encephalitis symptoms include altered mental state, ataxia, and seizures in addition to those symptoms seen with West Nile fever. As the disease is caused by a viral agent, only supportive care can be given. Patients are generally hospitalized and may be treated to prevent secondary infections. Interferon alpha-2b is being considered as a possible treatment but has not passed FDA regulation (CDC, 2002b). During the end of the 2002 outbreak in the U.S., hospitals began seeing patients with sudden-onset paralysis and polio-like muscle weakness. Unlike the traditional encephalitis, WNV in these patients attacked the gray matter in the spinal cord instead of only affecting the brain. Furthermore, these patients are younger

and apparently healthy. This suggests that the NY99 may have undergone an additional mutation last summer (Pearson, 2002).

In addition to the vector and host competence, environmental characteristics also play a role in the transmission of WNV. Outbreaks tend to occur in the late summer to early fall months when mosquito density is at its highest (Malkinson, 2002). This is compounded by increased evening human activity during this timeframe, such as barbeques and school sporting events Furthermore, an unpublished study by Dohm has shown that warmer temperatures, those about eighty-six degrees Fahrenheit, significantly increase the efficiency of viral replication in *Culex pipens*, the main avian cycle vector (Turell, 2002). Hot, dry summers seem to correlate with more severe human outbreaks. The summer of 1999, the first year of the WN outbreak, most of the northeastern U.S. was in the middle of a drought. However, the following two summers were relatively mild and outbreaks during these years were fairly small (Petersen, 2001). The outbreak this past summer corresponded to record high temperatures and a nationwide drought. These conditions could increase the intensity of WN outbreaks, because of increased stress on the host to maintain homeostasis.

Currently there is no human vaccine for WNV, but there is one under development. The best method to prevent WNV infection is through control of exposure to the vector. Local governments are sponsoring environmental spraying programs in order to reduce the mosquito populations. In addition there are public awareness campaigns in order to promote repellent use and reduced outdoor activity during the morning and evening hours for the period of an outbreak (CDC, 2002f).

Conclusions

The recent introduction of WNV into the Western Hemisphere has allowed scientists the unique opportunity to study the epidemiology of a disease from its very beginnings. Since the virus was most likely introduced through a single infected individual or animal (Preston, 1999), the epidemic provides an excellent model for the spread of a mosquito-borne disease. It is a rare opportunity to be able to map an outbreak without the complications of endemic infections and resistances. Disease models that have only had a chance to be assessed in theory could now be put to the test and improved.

Another benefit of the WNV epidemic was the ability to test some of the medical communication systems and disaster plans for disease containment and control on a relatively benign arbovirus (insect-transmitted disease). The number of deaths WNV caused in the United States last fall pales in comparison to the mortality that would have accompanied widespread outbreaks of malaria, dengue or eastern equine encephalitis (EEE). EEE has a case-fatality rate of thirty to seventy percent of infected individuals and survivors can continue to suffer relapses of the neurological symptoms throughout their lifespan (Roehrig, 2002). Arboviruses have recently started to become globalized. Like WNV, dengue has also expanded its endemic area to include even more of Asia and the Caribbean. Since the vector for the virus is prevalent in the southeastern United States there is a fear that it could spread to there. Furthermore, even more virulent strains of dengue, such as that causing dengue hemorrhagic fever, have emerged (Tortora, 1998). These trends are likely to continue as food importation, worldwide travel and encroachment of humans into previously unpopulated areas increases. It is hoped that information gathered from the West Nile virus outbreak will lead more effective prevention strategies and communication between animal and human health officials for zoonotic diseases.

After the conclusion of last summer's outbreaks in the United States, some have questioned whether the situation was handled optimally. Was there some way in which more lives could have been saved? The key to improving the reaction to the WNV epidemic would have been better communication. During the initial emergence of WNV in New York, the lack of communication between health authorities responsible for animal disease and those responsible for human disease delayed discovery of the cause of the outbreak (Preston, 1999). Further research should be performed in order to continue to find an optimal way of containing a disease and communicating causes and effects between disciplines.

Garlic (*Allium Sativum*): An examination of phytochemical composition, medicinal effects of garlic's phytochemicals, and human-garlic coevolution

Seth Sheffler-Collins

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Keywords: garlic, Allium sativum, phytochemicls, coevolution, medicinal herbs

Garlic (*Allium sativum*) is one of the most popular, commonly consumed plant foods worldwide. Perhaps due to its strong, pungent flavor or its "folkloric familiarity" garlic has been widely cultivated, eaten, and studied for its nutritive qualities, strong flavor, and medicinal values (Blumenthal et al). Traditionally garlic has been used to cure a huge range of ailments such as toothaches, coughs, colds, catarrh and rhintitis, as well as recently believed to have anti-cancer, anti-fungal and perhaps cardiovascular benefits (Blumenthal et al).

The significance of this folklore and believed medicinal properties of garlic are the very inspiration that catalyzed the research into garlic as both a nutritious and medicinal plant. The immense amount of folklore and prescribed medicinal properties from all over the world was in many ways, the cause of western medicine's interest in an age old remedy.

While historically garlic is believed to have grown wild over a large area perhaps spanning from China to India to Egypt to Ukraine, today Garlic only grows wild in Central Asia (Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) (Simon). The region of Central Asia is suggested as garlic's center of origin, yet the region could have been historically larger than believed today. While some claims are made of "wild garlic growing elsewhere in the world, this is the only region where true garlic routinely grows in the wild without the assistance of human propagation (Simon). Often other members of the Allium genus are mistaken for wild garlic, and while they may be the same genus, they are not the species *Sativm* (Simon).

Very little information is known about what specific type of garlic first domesticated. This lack of information is due to the lack historical records as to what type of garlic was being cultivated. Since garlic is normally cultivated 'vegatively' meaning that the reproduction is not done through the spread of seeds, rather it is done using bulbs and cloves (Simon). This method reproduction is significant because wild garlic reproduces sexually.

This difference between the reproductions of wild versus domesticate garlic causes some scientists to consider the type of garlic we eat as "clones" of wild garlic (Simon). Vegetative reproduction also "assures a uniform crop", thus in some senses reducing the genetic diversity of domesticated garlic that we consume, thus affecting human exposure to a more homogenous phytochemical load (Simon). The impact that domestication is having on our exposure to specific phytochemicals in garlic is immense. Reproduction through the use of clones greatly decreases biodiversity. Reduction of biodiversity greatly affects humans in many detrimental ways because as generalists, we rely on diversity for survival. Furthermore, the wild garlic consumed before domestication may have had a different phytochemical composition; potentially it could contain phytochemicals that could cure present diseases.

Sexual reproduction is in many ways the driving force of evolution. When this force is pacified through artificial selection reproduction and cloning, the naturally occurring evolutionary adaptations of both humans and garlic are limited. Under conditions of prolonged contact, there is some evidence of human-plant coevolution where each species relies on the other for survival, thus influencing the biology of the other species as well as having their own biology altered.

Due to the continuum of food and medicine, when discussing the medicinal values of a "food" it is first important to define our terms. According to Dr. Paul Lachance, a food can be defined as "any substance that is eaten or otherwise taken into the body (because we can feed people through ostomy tubes intravenously and in other ways these days) and it does three things: it sustains physiological and psychological life" (Lachance, 2). Lachance emphasizes not only the biological affects of eating, but in his opinion even more important is the psychological aspect of food. He believes there are "12 reasons we eat food" and "nine are psychological" (Lachance, 2). The psychological reasons are not going to be discussed in this paper, but it is important to note their prescribed importance on affecting the human diet and consumption patterns.

All plants contain 'phytochemicals' (bioactive, non nutritional secondary compounds in plants) that protect plants against herbivorous predation. Interestingly, besides the nutritional value of foods phytochemicals are being studied heavily because they seem to provide equally valuable non-nutritive health benefits. Such medicinal benefits come from bioactive non-nutritive compounds called 'phytochemicals'. Phytochemicals are often referred to as "Neutraceuticals", a term coined by Stephen DeFelice of the Foundation for Innovative Medicine referring to "any substance that's considered a food or part of a food, which provides medical or health benefits, including the prevention and treatment of disease." (Lachance, 2). Garlic is one of the three specified neutraceuticals that have been labeled "designer foods", a term coined by the National Caner Institute referring to "one or more phytochemical

component(s) acting individually, additively, or synergistically, usually as component(s) of whole foods, that have the characteristic of providing protective, preventative, and possibly curative roles in the pathogenesis of caner and other chronic disease prevention" (Lachance, ix). Garlic is one of the three primary "designer foods" amongst licorice and soy (Lanchance, ix).

Most studies of garlic have focused on the sulfur compounds of garlic particularly the 'thiols' and the 'flavanoids' (Lewandowski and Beecher, 8). The 'thiols' are largely responsible for strong odors, suggesting that perhaps high "olfactory profile" caused them be more extensively studied than other chemical compounds (Lewandowski and Beecher, 8). The 'flavanoids' are notorious for their antioxidant and anti-inflamatory compounds. The *Allium* family has a particularly high flavanoid content, along with onions (*Allium cepa*) as perhaps "the largest source of known flavanoids in the human diet" (Lewandowski and Beecher, 8).

An interesting phytochemical group that has only recently been studied on a surface level are the phytochemical group called 'saponins'. While *Alliums* are not commonly notorious for their saponin content, Alliums do contain significant levels of saponins. Such significant levels of saponins were found in alliums that the "allium species were originally examined as possible commercial sources for the steroid precursor *diosgenin* until the yam was found to be more economical (Lewandowski and Beecher, 8). While very little is conclusively known about the biological activity of saponins, many of their "close related compounds have been shown to be anti-inflammatory, decrease blood cholesterol, strengthen veins, and increase their permeability" (Lewandowski and Beecher, 10). This close relationship suggests that saponins in garlic are likely to possess these beneficial capabilities as well. Another important reason to further study sapoinins is that they may "explain the variability of the published results since different preparation protocols will either concentrate or remove them from the final product" (Lewandowski and Beecher, 10).

Like all plants the phytochemical retention of garlic is greatly affected by its processing before ingestion. This variation of phytochemical retention due to different preparations and processing is essential to understanding different results from studies is food processing and preparation procedures because many "result in the degradation, oxidation, geometric changes, and/or formation of secondary phytochemicals" (Zhou and Erdman Jr., 23). All these results directly affect plant's phytochemical retention, and in some cases new compounds are formed as a result of modification procedures

A raw unprocessed clove contains "only a few biologically active compounds" namely alliin (S-allyl-L-cysteube S-oxide) (Zhou and Erdman Jr., 29). Once the clove is chopped or crushed numerous thiosulfinates are created. This occurse when the compound alliin is converted into thiosulfinates "enzymatically" with the predominant thiosulfinate 'allicin' – the main compound causing garlic's unique, powerful odor found in chopped garlic (Zhou and Erdman Jr., 29). The enzyme that converst alliin is alliinase (Brace, 34).

Allicin is a particularly unstable compound that converts itself into polysulfides such as diallyl sulfide (DAS) dislyl disulfide (DADS), diallyl trisulfide (DAT) amongst others (Zhou and Erdman Jr., 30). Some very interesting studies have been conducted contesting claims of Allicin as a bioactive substance. The studies claimed that once inside the body Allicin does not seem to be bioactive. These studies looked at the pharmacokinetics and metabolism of organosulfur compounds in garlic finding that while aliin is converted to Allicin under certain preparation methods (particularly crushing and chopping), this conversion does not occur once in the digestive system (Zhou and Erdman Jr., 30). These findings stress the importance of further studies on the methods of processing and preparing garlic due to the profound effect the different methods can have on the garlic's phytochemical composition after alteration.

Chopping along with steaming and processing garlic as an ingredient in food causes the production of over 100 sulfur containing compounds. Many of these created compounds are believed to be related to garlic's medicinal uses (Zhou and Erdman Jr., 30). When cooked through conventional ovens, the main phytochemicals produced are DADS and DAT (Zhou and Erdman Jr., 30). When Garlic is fried, cooked in oil, or microwaved, mainly DADS, AMD, and vinyldithiins are formed. (Zhou and Erdman Jr., 30).

The importance of examining processing effects of garlic is that "each phytochemical may have a specific bioactivity" thus "food processing procedures may plan an important role in influencing medicinal functions of processed foods " (Zhou and Erdman Jr., 30). Different garlic preparations may produce different sulfur containing compounds. "Researchers must be particularly aware of prior processing history and the phytochemical profile of the products they are testing" (Zhou and Erdman Jr., 30)

Brace elaborates on this explaining the over complication of comparing results from different studies due to their inconsistency in garlic processing and preparations for use in studies. "Thus, the interpretation of the results of clinical studies must always be done with the knowledge of the method by which the garlic preparation used in the study was made" (Brace, 34).

The most common form of garlic consumption is cooked garlic (Brace, 34). Due to the significant chemical composition differences in consumed garlic preparation, it has been suggested that using supplements may not even simulate normal garlic consumption. Supplements further complicate things because they can be made with several different types of processed garlic (Brace, 34). Even the differences between garlic powder and garlic oil as the constituents of the supplements can cause the supplements to contain different bioactive compounds

No less important, but less widely studied are the cultural and storage effects on garlic's chemical composition. One study reported that the alliin content of garlic increased continuously until the bulb stopped growing" (Matsurra, 58). In terms of storage, alliin has been shown to increase with storage time (Matsurra, 58). In a study where garlic was

stored at four degrees Celsius for two months, the concentration of y-Glu-SAC decreased while other SACs were not affected (Matsurra, 58). As far as the increase in alliin concentration, it is believed to "be a result of sprouting during storage, as a similar situation occurs in onion" (Matsura, 58).

In terms of actual scientific studies conducted, as of 1996 over 1,808 studies had been conducted investigating various aspects of garlic and human ingestion (Blumenthal et al, 139). Of these studies, the main "types of scientific enquiry" were: anti-microbial effects of garlic, anti-carcinogenic effects, effects on blood sugar levels, immune stimulation, anti-inflammatory, and antioxidant properties of garlic (Blumentha et al, 139). The different ascribed cardiovascular benefits are: effects on blood lipids, blood pressure, blood fibrinolysis, coagulation, and flow, along with platelet aggregation and atherosclerosis (Blumenthal et al, 139). The various reputable health organizations that have made vague but assertive conclusions are: The Commission E who gave garlic a positive evaluation, distinctly recognizing studies suggesting the LDL cholesterol-lowering effects of garlic preparations. The European Scientific Cooperative on Phytotherapy (ESCOP) recognized the following uses of garlic: for prophylaxis of atherosclerosis, treatment of elevated blood lipid levels insufficiently influenced by diet, and the improvement of arterial blood flow (ESCOP, 1997). The World Health Organization (WHO) also supports research suggesting the use of garlic as an adjuvant therapy in the treatment of hyperlipidaemia, and in the prevention of atherosclerotic (age-dependent) vascular changes, and treatment in mild hypertension (WHO, 1999).

Perhaps the lack of conclusive results for the medicinal benefits of garlic can be attributed to the lack of uniformity of the methods for preparations and processing of the garlic used in the studies. As was adequately demonstrated, the processing and preparation methods of the garlic can significantly alter the phytochemical load depending on the method. This seems like what should be a controlled variable, yet many of the studies test the effectiveness of garlic supplements currently on the marketed steroids which vary significantly in terms of phytochemical composition of the garlic used to make the supplements. Garlic powder is often the least bioactive form of garlic, yet it is one of the most widespread methods of preparation for garlic supplements. This lack of uniformity can also be attributed the FDA's lack of investigation of garlic's medicinal properties.

Garlic and humans have an interesting coevolutionary relationship. While artificial selective reproduction of garlic clones is very detrimental to overall biodiversity, there is some evidence of a coevolutionary relationships. This relationship is suggested by Dr. R. Thomas Palo and Dr. Charles T. Robbins in terms of looking at phytochemicals as they were originally intended, as plant defenses against mammalian herbivorous consumption (Belovsky and Schmitz, 1). They divide phytochemicals into two main categories of compounds: "quantitative" and "qualitative" (Belovsky and Schmitz, 13). "Quantitative secondary compounds tend to reduce the herbivore's ability to digest or assimilate nutrients (e.g. tannins may reduce protein assimilation" (Belovsky and Schmitz, 13). On the other hand, "qualitative secondary compounds" are dosage dependently toxic after a certain quantity is consumed (Belovsky and Schmitz, 20).

Examined from an evolutionary perspective, "if the fitness cost of producing the secondary compound is not excessive, a mutation producing a morph with the compound will always be favored by natural selection (Belovsky and Schmitz, 14). The toxicity of particularly "qualitative" phytochemicals greatly alters human consumption patterns, adding the new "potential goal for herbivore foraging: toxin intake minimization" (Belovsky and Schmitz, 20). In achieving this goal, the mammalian herbivore (human in this case) seeks to "maximize its nutrient intake with the least intake of the toxin" (Belovsky and Schmitz, 20). The coevolutionary aspect of this relationship involves the dosage dependency, and the potential of the plant to produce higher amounts of the phytochemical once it is domesticated. Since the phytochemical's main purpose is defense, coevolution seems to come into play when the phytochemical not only defends the plant against predation, but when the chemical itself is found to have medicinal value for humans. According to Simon, "a strict definition of domestication is the process of selective breeding of a plant or animal to better meet human needs" (Simon).

Once domesticated, plants are usually selectively bread to decrease their toxicity, and to increase the nutritive value. Perhaps in the case of garlic and other alliums, once conclusive evidence supporting the medicinal value of phytochemicals such as organosulfur compounds and flavanoids, the plants may be breed to produce higher levels of these and other phytochemicals. This potential increase in phytochemical load would better defend the plants against other herbivores since they are more vulnerable to pesticides for example in an agricultural setting than in the wild. The increased phytochemical load could also help humans if those phytochemicals have medicinal value for human health.

The effects of the intensification of agriculture have been felt by both garlic and humans. Besides garlic's change in reproductive methods due to domestication, agriculture generally reduces dietary diversity. With the decrease of biodiversity comes an intensified interaction between garlic and humans, thus increasing the chance of coevolution due to the induced specialization resulting from habitat destruction and artificial fragmentation (Class notes). While wild species of garlic may have had higher, more diverse phytochemical composition, the intensification of agriculture also can be seen as a driving force behind the wheel of interspecies coevolution. Human modification of plant foods prior to consumption can also effect coevolution because it allows humans to consume greater quantities of different combinations of phytochemicals. This also leads to intensified contact, regional specialization and of course a coevolutionary relationship.

In conclusion, garlic has great potential medicinal uses. Conclusive evidence is still greatly needed to determine

exactly how garlic should be prepared and what phytochemical combinations to use. Much of this lack of uniformity of results is due the methods of processing and preparing the garlic used in the study. This differentiation of methods can significantly alter the phytochemical composition of garlic, thus the studies are in many senses studying the effects of different combinations of phytochemicals in different studies, rather than studying the effects of the phytochemicals on different types of people. Uniformity in the processing methods is absolutely necessary for the advancement of the understanding of garlic's medicinal properties. Maybe someday garlic treatments will replace chemotherapy.

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