ANCIENT MAYAN

“DEFORMITY”

Student Author

Michael H. Lockman is a 2015 dual-degree graduate from the College of Liberal Arts, where he earned a bachelor of arts in anthropology, and the College of Health and Human Sciences, earning a bachelor of science in psychological sciences. The genesis of the research herein was borne from personal experience with deformity and intolerance in adolescence, an experience from which this research served as great catharsis in collegiate study. More broadly, his research interests focus on using archaeology as anecdote to explore solutions to contemporary social issues of marginalization through investigation of power, agency, and inequality in antiquity.

Abstract

Research investigates ancient Mayan sociopolitical practices regarding individuals with congenital physical anomalies, including dwarfism, acromegaly, clubfoot, and polydactyly. Research endeavors to determine if social marginalization of individuals with such traits is a human universal and to explore the potential existence of more amicable alternative paradigms. Analysis of pathology, as identified via clinical diagnostic criterion from modern medical literature, determined that the pre-Columbian Maya represent a model by which social mobility was facilitated, or at the very least not hindered, by physical variation: elites appear to have acquired and maintained status by means of their atypical physical traits. Subsequent cross-cultural ethnohistoric comparison of this paradigm with modern cultures may yield interesting anecdotal implications for contemporary social issues regarding the perceived marginalization of individuals with similar afflictions. As evidenced by the Maya, an effective method of normalizing human variation may be through incorporation of the aforementioned traits into the existing cognitive framework of society's collective conscience.

Mentors

Michele R. Buzon has degrees in anthropology from Loyola University Chicago (BS) and University of California, Santa Barbara (MA and PhD). She currently is an associate professor of anthropology at Purdue University. With support from the National Geographic Society and the National Science Foundation, she has been investigating ancient identity and health in people buried at archaeological sites in the Nile Valley of Africa. Specifically, her work has researched the consequences of Egyptian-Nubian interaction on the lives of individuals who lived during the New Kingdom and Napatan periods at the site of Tombos in northern Sudan.

Lockman, M. H. (2015). Ancient Mayan “deformity”: Cultural accommodation of congenital physical anomaly in Mesoamerican prehistory. *Journal of Purdue Undergraduate Research*, 5, 56–63. <http://dx.doi.org/10.5703/jpur.05.1.07>

Keywords

bioarchaeology, deformity, Maya, dwarfism, achondroplasia, acromegaly, gigantism, clubfoot, polydactyly, Palenque

ANCIENT MAYAN “DEFORMITY”:

Cultural Accommodation of Congenital Physical Anomaly in Mesoamerican Prehistory

Michael H. Lockman, Liberal Arts

INTRODUCTION

Human variation has long been a subject of interest, its documentation almost as old as writing itself (Warkany, 1959), and its iconography as prominent as Rafael’s polydactyl papal portraiture in the *Sistine Madonna* (Robertson, Scandizzo, & Scandizzo, 1976). In vivo, the incidence of irregular physical characteristics is impacted significantly by the plasticity of reproductive social customs, further consecrating the relationship between genes and social environment. Only recently, however, has this phenomenon been scrutinized in the framework of broader social contexts. Interpretation of pathology is dependent on traditional beliefs and values, collective knowledge and experience, social and economic organization, as well as access to resources, and thus frequently manifests the essential tenets of culture (Tilley & Oxenham, 2011). Coined the bioarchaeology of care, this method assumes a means-end analytical approach and works backward, using the archaeological record to augment understanding of life in the past. Lorna Tilley (2012) asserts that, theoretically, this care can be delineated as either direct support or accommodation (see Figure 1). Utilizing the quadripartite methodological framework proposed by Tilley (see Figure 2), accommodation of congenital physical anomaly, defined by Stamm (2004) as being a structural difference due to an inherent developmental idiosyncrasy, in Mayan prehistory will be examined.

EVIDENCE OF PATHOLOGY

Although little to no writing exists to document pathology in Mesoamerica prior to Spanish contact, there is a wealth of iconography from which we may draw inference. This

wealth of iconography is particularly evident in Mayan motifs, especially in the case of dwarfism (see Figure 3). Dwarfism is defined by Dasen (1988) as short stature greater than three standard deviations below population age-sex average, calculated via upper-to-lower body segment ratios as measured from the cranium to the pubis and the pubis to the heel, respectively. As such, dwarfism is a frequently depicted feature of Mayan art. As art would imitate life, the most frequently depicted form is that of short-limbed achondroplasia (Miller, 1985), which compared to other forms of dwarfism presents the highest incidence rates in contemporary epidemiological surveys. Although no physical remains have been recovered, the accuracy of portrayal in conjunction with the motif’s endurance through time have led to a confident expert consensus that dwarfism was present in prehistoric Mayan populations (Miller, 1985). Similarly, depictions of individuals displaying diagnostic characteristics of acromegaly (often associated with gigantism), clubfoot (structural rotation of the foot inward), and polydactyly (having superfluous phalanges and/or metatarsals) are evident in Mayan iconography (Robertson et al., 1976). These traits correspond, respectively, to rulers Lady Zac-Kuk, who was succeeded by her son Lord Shield Pacal (see Figure 4), who was thus succeeded by his son Chan-Bahlum (Robertson et al., 1976). Although dates of each ruler’s accession are muddled by regencies and apparent discrepancies in the record, identification of pathology is relatively straightforward, as visual investigation provides substantial evidence when compared to diagnostic criteria from modern medical literature. Indeed, such use of contemporary medical text is not novel practice, as has been done with consistent accuracy in Old World archaeology (see Bourke, 1971; Dasen, 1988; Salib, 1962).

Figure 1. Proposed hierarchical organization for model regarding bioarchaeology of care; dark labels extrapolated from Tilley (2012), and Tilley and Oxenham (2011).

Figure 2. Adapted from Tilley (2012) model of investigation in the bioarchaeology of care to fit the definition of accommodation.

Figure 3. Image of a dwarfish figurine (Miller, 1985, p. 141) recovered from a Mayan archaeological context. Note that the proportion of the limbs and torso in conjunction with facial features are evocative of achondroplastic dwarfism.

Functional Impact of Pathology

Aside from short stature, achondroplastic dwarfism imbues relatively few detrimental health effects aside from often-concomitant physical irregularities, which are also of little to no functional impact. Although joint mobility at the shoulders may be mildly restricted, there is no evidence of internal organ obstruction, as development occurs otherwise regularly: mental capacity remains unimpaired, physical strength is undiminished, and sexual maturity is achieved (Dasen, 1988). Indeed, some prehistoric dwarfs are depicted as successfully procreating (Salib, 1962) and with regular secondary sexual characteristics (Dasen, 1988), although it is unknown whether this reflects artistic license or reality. Only acromegaly may imbue maladaptive features, as it has been known for those afflicted with what was commonly known as gigantism to experience premature deaths via otherwise natural causes. Even so, it is suggested that the pathology does not manifest as physically evident until middle age, and changes are subtle (Robertson et al., 1976). Aside from mobility impairment, clubfoot is similar to dwarfism in that it merely limits dexterity, which can easily be compensated for by modified mechanics, albeit a decidedly altered gait (Robertson et al., 1976). Polydactyly appears to be no more a nuisance than anything else, as digits are either fully functional or superficial and removed. Common to all the physical anomalies discussed is a pervasive aesthetic component, with minimal functional impairment in acculturated daily life.

Model of Accommodation

The feature of minimal functional impact is perhaps the most fundamental to a model of accommodation, with conceptualization of pathology as described in the next section a good alternative candidate. Conceivably, one must only accommodate for what is functionally necessary, either in terms of perception or practicality. This being said, there are several archetypes of accommodation presented in Old World archaeological literature that are worth unpacking here, as they inevitably color the lens through which subsequent archaeological identification of pathology is viewed. Perhaps the most relevant example is that of prehistoric Mediterranean cultures, as they comprise a related culture-area but run the gamut of intolerance to exaltation of these traits.

In Ancient Egypt, those with physical anomalies appeared not to be excluded from higher levels of social prominence. Whether it be the clubfoot of Pharaoh Siptah or the high-ranking dwarf Seneb, these individuals were typically occupants of “important and respectable positions” (Salib, 1962, p. 944). There were even dwarfish-gods in Egyptian theology, most notably Ptah, guardian

Figure 4. Portrayal of Lord Shield Pacal (colored in red) from the lid of his sarcophagus found in a mortuary context at Palenque. Note the rotation of the right foot inward, perhaps suggestive of a clubfoot (photo courtesy of Wikimedia Commons).

of children and women (Dasen, 1988). Given the divine status often attributed to high-ranking officials and most certainly to gods in Egypt, I will refer to this tolerant model of accommodation as *deification*. Consideration must be taken that Egyptians had an astounding wealth of medical knowledge, as evidenced by the Edwin Smith Papyrus (Bourke, 1971), and perhaps this influenced their perception of physical variation as either defect or disability. Even so, the Greeks had a similarly firm grasp of medical knowledge, as demonstrated by Aristotle. Yet, infanticide was still strictly enforced by law in states such as Sparta, which upheld a strict eugenic standard. Nevertheless, physical variation persists in their iconography, such as that of dwarfs in Greek art. This suggests that not all those who were clearly physically atypical at birth were disposed of. However, it has been suggested that Greeks merely depicted the features of achondroplastic dwarfism from a collective conscience, and many of them had never seen a dwarf, and only knew of dwarfs via their association with Dionysus, in which they fulfilled a role similar to satyrs (Dasen, 1988). Nonetheless, this represents a sort of intermediary between Egyptian deification of those with physical anomalies and the treatment of Romans, who upheld a strict eugenic law of infanticide and only later erred to the enslavement of those with the aforementioned traits, using them as a form of macabre entertainment (Dasen, 1988; Stamm, 2004). Thus, I shall refer to the Grecian model of accommodation as *intermediate* and the Roman model of accommodation as *demonization*. To reiterate, inevitably these widely accepted and classic archetypal interpretations of prehistory, binary opposites of deification and demonization, pose a bias to subsequent interpretation of often-ambiguous iconography and the proverbial “gray area” that is inherent to almost any diagnosis.

In light of these analytical paradigms, and the markedly low level of functional impairment accrued by these pathologies, a model of accommodation, rather than care, emerges in Mesoamerica regarding these physical variations. Indeed, it is in a select lineage of rulers at Palenque that the traits diagnostic of acromegaly, clubfoot, and polydactyly are most iconographically pronounced

(Robertson et al., 1976). This model of authority in conjunction with physical anomaly, presented as visual fact in artwork, is congruent with the *deification* model of accommodation. Thus, it becomes conceivable to engage in cross-cultural comparison with the high-ranking Egyptian officials characterized by such atypical physical characteristics, namely that of the clubfooted Pharaoh Siptah. Drawing upon modern Mayan perception of dwarfs as having varying degrees of supernatural significance (Miller, 1985), it is also conceivable to conclude that the frequency with which dwarfs are depicted in artwork, in conjunction with modern ethnographic analogies, is due to religious significance. Indeed, many dwarfs are depicted adorned with attire reminiscent of deities, and their proximity to other known deistic individuals further confirms a model of *deification*—even if those with these traits were only pseudo-deified in practice (Miller, 1985).

Strong evidence exists for a model of accommodation based on *deification* among the Maya in Mesoamerican prehistory. In any case, it is apparent that physical anomalies did not exclude individuals from auspicious roles, and thus models of accommodation including the *intermediate* and *demonization* models are inapplicable in this instance. Although there is no direct evidence to absolutely disqualify these models in all instances, extrapolating from Tilley (2012), such an absence of evidence to confirm these hypotheses can be considered potentially indicative of accommodation in another direction. That is to say, there is no evidence of *intermediate* paradigms or paradigms of *demonization*; this negative data provides two null hypotheses, which by process of elimination indicates a model of *deification*, a theory that is further corroborated/substantiated by the evidence previously discussed.

Analysis of Accommodation

A model of accommodation via *deification* has ramifications beyond just those of practicality in the socioeconomic sphere. First and foremost, one must understand the evolution or genesis of a model of accommodation in order to make sense of it. In the case of acromegaly, it is implied by Robertson and colleagues (1976) that the

Figure 5. Paradigmatic continuum of accommodation as extrapolated from the literature. Deification of atypical phenotypic expression (far left) is distinctive of the Egyptian paradigm; the Roman paradigm (far right), on the other hand, features the demonization of atypical physical characteristics. The Grecian paradigm (middle center) presents as an intermediary between the two aforementioned paradigms, with that of the Maya at Palenque aligning more closely with the construct of deification.

rampant growth resultant from a tumor on the pituitary gland likely made individuals with this condition literally larger-than-life. Their large stature could be attributed as an intimidation factor that imparted leadership qualities, further justifying their right to rule. Indeed, it seems that Lady Zac-Kuk, the individual with features reminiscent of acromegaly, was the first of three in short succession with anomalous physical traits among this ruling lineage at Palenque (Robertson et al., 1976). Following Lady Zac-Kuk, her son Lord Shield Pacal, whose portrayal features rather prominently a clubfoot, evidently aligned this trait with the serpent motif, already a powerful symbol of divinity in Mesoamerican ideology. Lord Shield Pacal's clubfoot was sometimes depicted as a serpent in relief, and it is suggested that this was thus a claim of divine right to rule (Robertson et al., 1976). Following Lord Shield Pacal, his son Chan-Bahlum is presumed to have been depicted by a particular image of a child with six digits on one hand and a serpentine leg, as Chan-Bahlum is the only known individual at Palenque to have been afflicted with polydactyly (Robertson et al., 1976). Thus, it is suggested that Chan-Bahlum, having erected this sculpture in the final construction phases of Pacal's tomb, made an attempt to claim divinity and subsequent right to rule as justified by his father on account of his serpentine leg (Robertson et al., 1976). Thus, in this dynastic image, Robertson and colleagues (1976) effectively suggest a model of accommodation based on *deification* in which physical anomaly is incorporated into the larger belief system often as a direct indicator of leadership or divinity.

Similarly, it is suggested that dwarfs were closely associated with the Earth and considered useful companions in the afterlife (Miller, 1985). This proposition appears suspiciously reminiscent of Ptah's role in the Egyptian underworld, often replacing the scarab beetle responsible for traversing the sun through the underworld each night (Dasen, 1988). Thus, this assertion must be considered with a degree of skepticism given the interpretive biases imbued by classical archaeology as delineated earlier, although it remains that this association may still hold true in the case of the Maya. Miller (1985) expresses that the long-term perseverance of the dwarf motif in Mesoamerican material art, though functioning in a variety of different roles, indicates a cultural theme whose meaning had been forgotten and/or highly individualized between regions over time. Miller (1985) also posits that dwarfs served as surrogates for children in iconography and ceremonies, as they likely had a higher level of intelligence and maturity than children and could be better trusted to fulfill special ceremonial duties, albeit representative of a child. Dwarfs also are argued to possess some sort of mythological association, although this is an assertion of which one should be equally cautious of interpretive biases imbued by classical archaeology,

as this linkage is reminiscent of dwarfs' association with Dionysus in Greece (Miller, 1985). In any case, it is true that the majority of dwarfish figures are correlated positionally with the ruling elite in iconography. Whatever role they fulfilled, divine or otherwise, it can be determined by this proximity that dwarfs held a special status in ancient Mayan society.

Holistically it seems reasonable to conclude that the *deification* method of accommodation was prevalent in the Maya world, and thus those with physical anomalies were appropriated privileged status specifically on account of their physical features. Let it be assumed *prima facie* that those with elevated social status receive preferential sexual selection and enhanced reproductive success. This is generally accepted as fact in various fields of social science, and has indeed been referenced in cases such as that of Hopi albinism (Woolf & Dukepoo, 1969). Thus, in Mesoamerica, those who were afforded special status on account of outwardly expressed genetic variation would likely be culprit for flooding the gene pool with genetic material responsible for such traits. This could account for the frequency with which such individuals are depicted in Mayan art, serving to propagate the continued subscription to the belief that they wielded special status.

Consequently, we can construct a model of accommodation's effect on the gene pool through these basic and widely accepted suppositions. The incidence of anomalous traits in a given population is determined by reproductive customs, though also impacted by environmental factors. Incidence, in turn, influences social norms insofar as traits and their incidence are interpreted and understood through the lens of a culture's collective knowledge. Thus, social norms share a reciprocal relationship with reproductive customs, each influencing the other, mediated by institutional regulation (see Figure 6). In the case of the Maya people, as evidenced through their iconography, rather than society accommodating those with variant physical features, those who possessed these traits altered cultural beliefs, and thus social norms, such that they were no longer being accommodated in the traditional sense, but revered. This interesting model of accommodation is contrary to the popular belief of societal tolerance and simultaneous marginalization of those outside the standard of deviation.

CONCLUSION AND DISCUSSION

Pathology was clearly present in prehistory, as it is presented as visual fact in a variety of mediums across an expansive period of time, enduring cultural shifts and spanning regional political regimes. Mayan iconography presents an interesting case in the bioarchaeology of care: as it relates to physical variation, accommodation as

Figure 6. Reproductive customs directly influence incidence of atypical phenotypic expression, also mediated by environmental factors, which in turn enact upon social norms through the lens of collective knowledge. Social norms in turn share a synergistic relationship with reproductive customs, mediated by institutional regulation.

defined by Tilley (2012) is constructed by those with the pathology, rather than those within the standard of deviation. This was possible, fundamentally, due to the low level of functional impact accrued by those with these pathologies. Thus, marginalization is not evident, as it appears that the cultural construct was in fact constructed around those with these traits. This was in part due to the fact that those with these traits were born into privileged positions that they utilized, capitalizing upon withstanding regional ideology.

Such an understanding is reminiscent of Pierre Bourdieu's theory of praxis, in which, as summarized by Moore (2012), "culture is neither the exclusive product of free-will nor underlying principles, but is actively constructed by social actors from cultural dispositions and structured by previous events" (p. 326). Instead, one must consider the interplay of individual motivation and strategy. Vaughn (2009) writes that a result of postprocessual critique in archaeology has been the consideration of individual action and motivation as impetus for social change; indeed, society is dynamically driven and shaped by its constituents. Vaughn (2009) proposes the inequality that often arises therein is effectively a function of power relations, which he posits are determined largely by access to resources. Vaughn further delineates between allocative and authoritative resources: "Allocative resources are those resources that comprise the material world—food, water, and raw materials, for example—while authoritative resources comprise the social world, religious knowledge, speech-making ability, charisma, and so forth" (2009, p. 16). He thus concludes, "Elites and upper classes in states are in their position because they have allocative resources and can usually justify this status through authoritative resources" (2009, p. 16).

Vaughn further writes that a particularly effective strategy of institutionalizing differential social strata is through the manipulation of authoritative resources. Specifically, Vaughn refers to ideology, writing that "The most important aspect of ideology here is that it creates a means to justify developing inequalities because of unequal exchange and production relationships, especially in societies where physical and economic forms of power are lacking" (2009, p. 23). While a powerful force of homeostasis in established relations of inequitable power, ideology can be powerfully transformative in the initial negotiation of social hierarchies (Vaughn, 2009). Bourdieu writes, "the symbolic power to impose the principles of the construction of reality—in particular social reality—is a major dimension of political power" (1977, p. 165). Moore (2012) follows Bourdieu to say that the generation of epistemology or ideology is thus an inherently political endeavor, as it makes the arbitrary nature of the proposed social order seem both natural and inevitable. It is in this sense that the innovation of iconography by a ruling elite as evidenced herein may be considered reminiscent of Bourdieu's concept of habitus. In this particular scenario, physical anomaly performed a significant role in the justification of power structures through iconography, and it is thus that we may draw conclusions about the social nature of such conditions in antiquity.

However, one must beware the trappings of entrenched interpretative paradigms of the archaeological record; this pattern of deification, or even pseudo-deification, of those with physical anomalies who rank highly in the ruling elite is reminiscent of models seen in Ancient Egypt (Dasen, 1988; Salib, 1962). Nonetheless, the preponderance of physical variation herein reinforces the proposed model by which the incidence of such traits in a given

population is determined by reproductive customs, though also impacted by environmental factors. Incidence, in turn, influences social norms insofar as traits and their incidence are interpreted and understood through the lens of a culture's collective knowledge. Thus, social norms share a reciprocal relationship with reproductive customs, each influencing the other, mediated by institutional regulation (see Figure 6). It is important to note that institutional regulation may be either formal or informal and direct or indirect. Similarly, one must consider that environmental factors can potentially influence reproductive customs, though this effect may be considered limited at best. Indeed, there are undoubtedly a battery of extraneous factors that may affect any of these variables with a concomitant degree of bidirectionality to each relationship. Likewise, each relationship will likely vary in strength; herein are presented some of the stronger of those associations.

Naturally, without physical remains in situ to corroborate iconographic evidence, it is difficult to confirm definitively any null hypotheses, and thus discussion takes the form of theoretical conjecture until more data is amassed. That being said, the ancient Maya seem to present a strong case by which social mobility was facilitated, or at the very least certainly not hindered, by physical anomaly. As such, perhaps an effective method of normalization of human variation lies in incorporation of variant traits into the preexisting cognitive frameworks of society's collective conscience. Thus, the Maya may serve as an interesting archaeological anecdote by which we may address contemporary social issues insofar as they regard the perceived marginalization of individuals with atypical physical characteristics. However, serious discussion would first require extensive and systematic cross-cultural ethnohistoric comparison of the cultures in question, in which the working theory proposed herein may be revised and adapted necessarily to achieve maximal efficacy.

FINAL NOTE

An important point, which was iterated upon several presentations of this work, is the prudence of not referring to the traits described herein as they are colloquially known: by the term “deformity.” Denoting conditions frequently fraught with negative stigma, the term is potentially pejorative, and thus the author has largely refrained from its use herein. Furthermore, there is a tendency to suggest that individuals *suffer* from their pathology. Suffering,

however, is an entirely personal and subjective experience, and in the interest of not projecting our own views upon interpretation of pathology in antiquity, in some cases one cannot reasonably begin to ascertain whether an individual suffered from their pathology. This is especially pragmatic in cases such as those investigated herein, in which there is relatively substantial reason to infer high levels of functionality from evidence that the individuals adequately met the demands of their environment. While this approach as adopted herein often makes for unorthodox phraseology, it serves as a sincere attempt to mitigate tacit propagation of negative stigma concerning this often-sensitive subject.

ACKNOWLEDGMENTS

Special thanks to Dr. Michele R. Buzon, who facilitated this project through her outstanding instruction, and especially the Department of Anthropology and the College of Liberal Arts Honors for providing the opportunities to make this research possible.

REFERENCES

- Bourdieu, P. (1977). *Outline of a theory of practice*. Cambridge: Cambridge University Press. <http://dx.doi.org/10.1017/CBO9780511812507>
- Bourke, J. B. (1971). The palaeopathology of the vertebral column in ancient Egypt and Nubia. *Medical History*, 15(4), 363–375. <http://dx.doi.org/10.1017/S0025727300016914>
- Dasen, V. (1988). Dwarfism in Egypt and classical antiquity: Iconography and medical history. *Medical History*, 32(3), 253–276. <http://dx.doi.org/10.1017/S0025727300048237>
- Miller, V. E. (1985). *Dwarf motif in classic Maya art*. San Francisco: Pre-Columbian Art Research Institute.
- Moore, J. (2012). *Visions of culture: An introduction to anthropological theories and theorists* (4th ed.). Lanham, MD: AltaMira Press. <http://dx.doi.org/10.3366/cult.2012.0022>
- Robertson, M. G., Scandizzo, M. S. R., & Scandizzo, J. R. (1976). Physical deformities in the ruling lineage of Palenque, and the dynastic implications. In M. G. Robertson (Ed.), *The Art, Iconography and Dynastic History of Palenque, Part III* (pp. 59–86). Pebble Beach, CA: Robert Louis Stevenson School.
- Salib, P. (1962). Orthopaedic and traumatic skeletal lesions in ancient Egyptians. *Journal of Bone and Joint Surgery*, 44B(4), 944–947.
- Stamm, H. (2004). Deformity and disability: A Graeco-Roman perspective. *Proceedings of the 13th Annual History of Medicine Days* (pp. 25–31). Calgary: Faculty of Medicine, University of Calgary.
- Tilley, L., & Oxenham, M. F. (2011). Survival against the odds: Modeling the social implications of care provision to seriously disabled individuals. *International Journal of Paleopathology*, 1(1), 35–42. <http://dx.doi.org/10.1016/j.ijpp.2011.02.003>
- Tilley, L. (2012). The bioarchaeology of care. *The SAA Archaeological Record*, 12(3), 39–41.
- Vaughn, K. J. (2009). *The ancient Andean village: Marcaya in prehispanic Nasca*. Tucson: University of Arizona Press. <http://dx.doi.org/10.1111/j.1470-9856.2010.00521.x>
- Warkany, J. (1959). Congenital malformations in the past. *Journal of Chronic Diseases*, 10(2), 84–96. [http://dx.doi.org/10.1016/0021-9681\(59\)90024-4](http://dx.doi.org/10.1016/0021-9681(59)90024-4)
- Woolf, C., & Dukepoo, F. (1969). Hopi Indians, inbreeding, and albinism. *Science*, 164(3875), 30–37. <http://dx.doi.org/10.1126/science.164.3875>