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Denham, Woodrow W

Publication Date
2011-09-15

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MATHEMATICAL ANTHROPOLOGY AND CULTURAL THEORY:
SERIES: MACT LECTURE NOTES AND WORKING PAPERS

FAMILIAL GENERATIONS TUTORIAL

VERSION 1.0, SEPTEMBER 15, 2011

WOODROW W. DENHAM, PH. D.
RETIRED INDEPENDENT SCHOLAR
WWDENHAM@GMAIL.COM

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MATHEMATICAL ANTHROPOLOGY AND CULTURAL THEORY:

SERIES: LECTURE NOTES AND WORKING PAPERS

ISSN 1544-5879

FAMILIAL GENERATIONS TUTORIAL

WOODROW W. DENHAM

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Abstract ***This tutorial explores the dimensions and contours of Australian Aboriginal generations focusing on the implications of asymmetrical generation intervals with regard to bilateral cross cousin marriage, circulating connubia, senior/junior marriage systems and generic age biased marriage systems. It is based on recent data showing that on average men in Australian Aboriginal societies are 14+ years older than their wives, much greater than the worldwide mean wife-husband age difference of 3 to 5 years. The resulting highly asymmetric generation intervals (maternal = 28 years, paternal = 42 years) have important biobehavioral implications for the structure of Australian Aboriginal societies. People who work well independently and have some background in kinship studies can use the tutorial alone, or instructors can use it as a multi-session segment of an upper-level kinship course.***

Introduction

This tutorial is an exercise in pattern detection that examines measurable biological aspects of a selected set of human familial generations, ultimately focusing primarily on mechanisms that enhance inbreeding avoidance. It describes their structures, then considers biological problems and solutions associated with the structures. In the process, it examines diverse mechanisms that push marriages outward, away from close kin and toward remote kin, in societies in which everybody is related to everybody else. It does not explain where specific types of generations came from, or how they may develop in the future. It adopts a global perspective but makes no attempt to be encyclopedic, focusing primarily on Australian Aboriginal generations in the context of selected examples from Europe, North America, Sub-Saharan Africa and Islamic countries.

The point of view is biobehavioral, exploring generational structures mainly through data on biological descent, demography and marriage practices while touching only briefly on kinship terminologies and related cognitive matters. It deliberately avoids most complexities associated with Dreamings, moieties, sections and subsections, the minutiae of cognitive kinship systems, and historical controversies concerning descent theory, alliance theory and cognitive anthropology. Alternative, classic approaches to the study of familial generations and related topics appear in the works of A.R. Radcliffe-Brown (1931), E.E. Evans-Pritchard (1940), Claude Levi-Strauss (1949/1969), Edmund Leach (1954), Floyd Lounsbury (1964) and many others, and

[1] I am grateful to John R. Atkins, Douglas R. White, Dwight W. Read and David B. Kronenfeld for their guidance and patience, to the Alyawarra speaking people of Central Australia for their wisdom and humor, to David Montague a non-anthropologist who read multiple drafts to help insure that the vocabulary and argument were clear to general readers, and to the many scholars, cited and uncited, whose data and interpretations shaped the tutorial. Of course I am fully responsible for its many deficiencies.

in Bohannan and Middleton's (1968) challenging, perplexing and entertaining edited exchange entitled "Murngin Social Organization".

The tutorial is addressed, no doubt imperfectly, to two rather different audiences: first to general readers, students, and non-specialists in the biological and social sciences who probably will benefit from introductory materials contained here; second to specialists in genetics, demography, kinship and evolution who may skip the introductory materials.

Disambiguation

The word **generation** (n.) has its origin in the English language at about 1250–1300 AD from ME *generacioun* from MF from L *generātiōn* "bring forth" (www.dictionary.reference.com). The Indo-European root *gen-* or *gena-* "kind" from which generation ultimately derives is also the ancestor of English words such as gender, genealogy, generate, genesis, generic, genital, genius, genocide, genome, genre and genus (Pickett, J.P, et al, 2000).

"Generation" is used in three distinctly different senses in 21st century English.

A biological generation is one parent-child stage in the descent of a family of any group of people, animals, or plants, or the individual members of that stage. Hence a biological generation, as a biological property of asexually and sexually reproducing organisms and their populations, pertains broadly to all of life on Earth. It has its foundations in population genetics, demography and related disciplines within biology.

A human familial generation is a complex synthesis of biological generations plus concepts and traditions that are associated with uniquely human systems of descent (parent/child), marriage (spouse/spouse) and kinship (cousin/uncle). It has its foundations in population genetics and demography, genealogical studies of human families and anthropological studies of kinship.

A human cultural generation is a named, age-based group of people who were born during the same period, often about 30 years in European societies, and refers loosely to everyone of approximately the same age living at approximately the same time in approximately the same place, such as the "beat generation" and the "baby boom generation" in the United States. The concept is related to life stages (infant, child, adolescent, etc.) as well as to demographic and statistical cohorts in the English language, and to age grades and age sets in African societies (Kenyatta 1938/1965; Evans-Pritchard 1940; Morton, R.F., n.d.). With its foundations in statistics, sociology and anthropology, this concept is only tangentially related to biological and familial generations.

This tutorial focuses on biological and behavioral properties of human familial generations.

Basics

It probably is fair to say that people in most societies view their own concept of generation as natural, proper, obvious and simple, while viewing foreign concepts of generations as unnatural, problematic, not at all obvious and devilishly difficult to understand. In societies with European roots – perhaps especially English speaking societies - people may be intensely interested in their own family trees, but the concept of "generation" itself may be taken as something whose

meaning is intuitively obvious, so people have little to say and few words to use concerning generations. Elsewhere, as in some Australian Aboriginal societies, generations may be regular topics of conversation and the vocabulary available for discussing them may be enormous.

Theoretically speaking, generations form much of the deep infrastructure of human societies. Insofar as they determine what individuals and societies can and cannot do, their dimensions and geometric forms may be quite distinctive and are to some extent behaviorally comparable to physical structures like skeletons and honeycombs (Thompson 1917/1961).

Practically speaking, human genealogies are systematic extensions of generations. Human families in all their diversity rest upon generations as do residential groups including nuclear and extended family households and villages. Inheritance of wealth, power, prestige and responsibility typically depends upon relations among generations, and a society's kinship terminology rests on generations but is a superstructure that may lie far above them.

Biological generations serve as the starting point for human systems of descent, marriage and kinship, but people go beyond the biological basics in creating ways to organize and operate their societies. In human societies, a generation is a "social construct" devised by people using human intellectual abilities, speaking human languages, elaborating and modifying human cultural traditions over many thousands of years. Human biological generations are just as "physical" as generations in all other life forms, but human familial generations are embedded in and are products of human cognition and cultures.

The following review of part of what is known about human familial generations outlines the diversity of human notions of generations in "simple" patterns (mainly present-day European and North American societies) and in far more complex and challenging patterns (mainly Australian Aboriginal societies). The rest of this section introduces some basic concepts and diagramming conventions used in the remainder of the tutorial. The Links to the Web section near the end of the tutorial provides access to other online tutorials associated with the analysis of kinship systems.

Generations and kin types

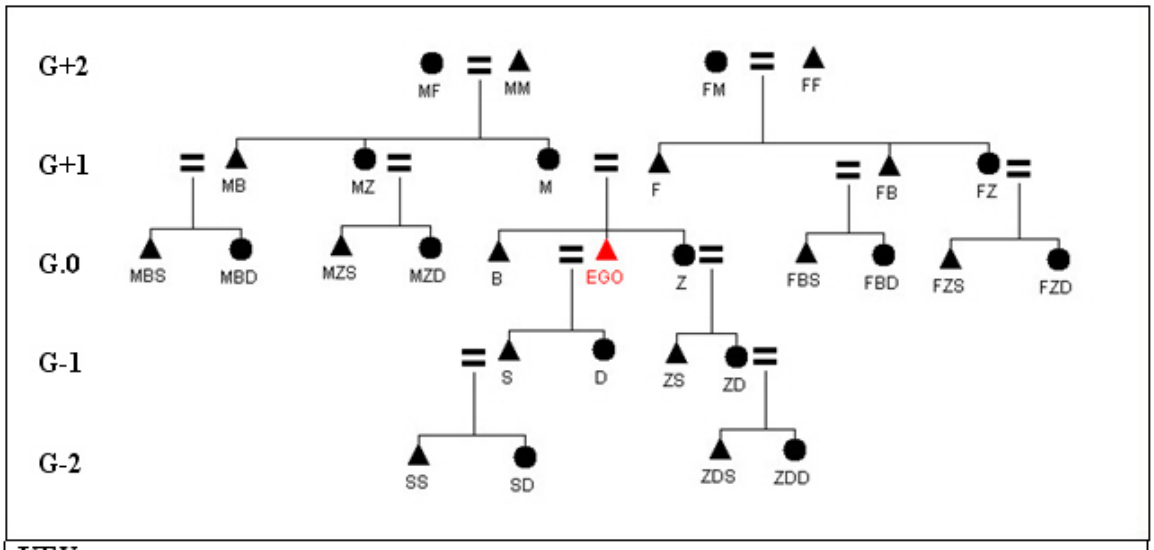
Figure 1 depicts the field of relationships in which human generations typically occur. The diagram shows a stylized minimal genealogy of Ego (meaning "I", me, myself), the person at the center from whose perspective the diagram is labeled. Ego may be either male (Δ) or female (O). In fact, any person in the diagram can be designated as Ego; in this case Ego is a man (Δ) near the center of the diagram.

Standardization facilitates comparison. The symbols are defined in the key. The default layout or orientation of the diagram is as follows: past is at the top and future is at the bottom; male Ego is located near the center; Ego's wife is to the right of Ego. Alternative logically equivalent symbols and layouts may serve special purposes.

G.0 is Ego's own generation. G+1 is his parent's generation and G+2 is his grandparent's; G-1 is his children's and G-2 is his grandchildren's.

The "=" between M and F signifies both the marriage of Ego's mother to his father, and the establishment of a marital relationship between Ego's mother's family and his father's family. In the English language, Mother would refer to Father's relatives (FB, FZ) as her in-laws, and *vice versa*. Every "=" links a husband and a wife, but to reduce the clutter and improve the legibility of the diagram, the symbols for most spouses have been omitted.

Thus in the context of the kin type diagram, the concept of generation is used in two "directions". On the one hand, it is defined vertically as a descent generation in terms of biological descent from parent to child as is true of all sexually reproducing organisms. On the other hand, it is defined horizontally as a marital generation that appears in the diagram as a level or stratum that minimally includes siblings, their cousins and their spouses. This tutorial deals with both descent and marital generations.



KEY						
Symbols	**O**	**female**	**△**	**male**		
	|	**descent**	**┌┐**	**siblings**	**=**	**Marriage (most spouses omitted)**
Text	**Ego**	**focus**				
	M	**Mother**	**F**	**Father**		
	Z	**Sister**	**B**	**Brother**		
	D	**Daughter**	**S**	**Son**		
	W	**Wife**	**H**	**Husband**		**(Not used here)**
Usage	**MF**	**Mother's father (a "grandfather")**				
	MB	**Mother's brother (an "uncle")**				
	MBD	**Mother's brother's daughter (a "first cousin")**				

Figure 1. Kin Types and Symbols Key. This and subsequent genealogical diagrams were prepared using Michael Fischer's *KinshipEditor 3031*(Fischer 1994; n.d.1; n.d.2).

Descent generations

A descent generation as used here is the "vertical" link between parents and their children. In Figure 2 a series of generations is represented minimally by the members of a single descent line forming a vertical chain with time as the vertical dimension, past at the top and future at the bottom. Each position in the chain typically contains one or more sets of siblings. For example, all the people in Ego's position (G.0) in the descent line are Ego's brothers, sisters and cousins in Western kinship terms. They constitute a single generation, one generation "below" their parents and parents' siblings in G+1, and one generation above their own children in G-1. Ego's grandparents and their siblings and cousins are in G+2 and Ego's grandchildren are in G-2. This description and the accompanying diagram are schematic representations of an ideal, highly simplified series of human generations that do not overlap or become intensely entangled with each other as real generations almost always do.

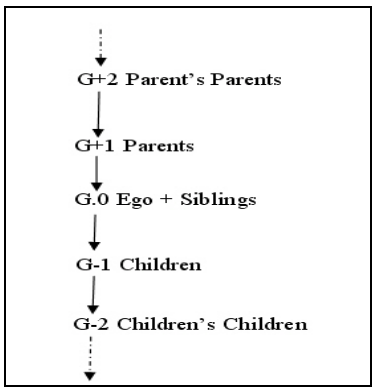


Figure 2. Descent Generations. Five generations in a single, ideal line of descent.

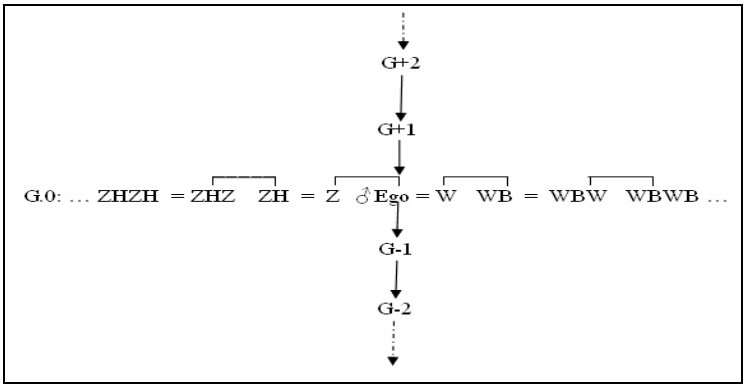


Figure 3. Marital Generation. G.0 in the form of a single, compressed sibling-in-law chain centered horizontally on a male (♂) Ego. Z (Sister), H (Husband), W (Wife), B (Brother), = (marriage), ⊓ (sibling set). The theoretically endless sibling-in-law chain appears at the left margin with ego's sister's husband's sister's husband, continues through ♂Ego and his sister, and disappears at the right margin with Ego's wife's brother's wife's brother.

Marital generations

A marital generation as used here is the "horizontal" relationship among siblings and their spouses (or mates if unmarried). In Figure 3 it is represented minimally by the members of a single point on the vertical descent generation (G.0) with all of their spouses/mates in a horizontal sibling-in-law chain (reverse it for a female Ego) where Z:Sister, H:Husband, W:Wife, B:Brother, = marriage, and ⊓sibling set. Since each sibling set can contain an indefinite number of people, the accompanying diagram is a highly simplified, idealized representation in which a cluster of parallel horizontal lines has been collapsed for convenience into a single horizontal line that represents all of the marriages of all of the siblings in the group.

Figure 2 displays only a small portion of a potentially endless descent line that does not rejoin itself to affect any kind of closure in time; it is a "straight line" that begins in the past with the beginning of life on Earth and continues into the future until the particular descent line becomes extinct. It is adequately represented in two dimensions on a flat surface as it appears in the Descent Generations diagram.

But Figure 3 is different. It too displays only a small portion of a chain, but the chain may have only a single link if husband and wife have no siblings, it may be indefinitely long if large sibling sets intermarry, and it may rejoin itself as a loop or circle, possibly forming a helix as well, it which case it would be represented best on a curved surface in three dimensions. In other words, the absence of limits on the intermediate length horizontal chain depicted in Figure 3 is another simplification that is potentially misleading. Three-dimensionality is indicated minimally as needed in the following diagrams, but for technical reasons the diagrams are not executed properly in three dimensions.

Classificatory kinship

Dravidian and Dravidian-like kinship terms such as those used in most Australian Aboriginal societies apply to three distinctly different kinds of kin that are implicit in Figure 1: a) consanguineal or proper kin who are related within a standard biological genealogy, b) affinal kin who are kin-by-marriage, known in the West as spouses and in-laws, and c) classificatory kin who are functionally and socially equivalent to consanguineal and affinal kin but are not related to each other biologically. Something similar to classificatory kinship occurs unsystematically and informally when an English speaking child says his foster-mother, step-mother or adoptive-mother is his "mother" even though "mother", strictly speaking, is defined much more narrowly as a woman's relationship to a child to whom she gave birth. Australian Aboriginal societies generally use kinship terms to establish close or distant classificatory kin relationships between every pair of people in a society, regardless of whether they are related to each other biologically.

Taken to an even greater extreme, remote classificatory kinship includes, for example, a situation in which man X applies the term for Brother to man Y from an alien Aboriginal society, previously unknown and presumably unrelated biologically, when both of them stand in the same relationship to a specific Dreamtime Being from whom both of them claim descent. Thus descent is traced from an ancestral Dreaming rather than from a biological ancestor, but brothers are brothers regardless of which starting point is used to compute the relationship. Classificatory

kinship is a key concept to which the tutorial refers frequently below, but it lies outside the focus of the tutorial and is not pursued further here.

Measurement of familial generations

The simplicity that characterizes Figures 2 and 3 is in part an illusion that results from a tradition of disregarding the age structure of actual human populations and dealing only with strict monogamy (one marriage for each spouse, to each other for their entire lifetimes) as is the ideal in European and North American societies. The typically simple structure of European and North American generations fosters a belief within those societies that generations by their very nature are fundamentally simple as in the accompanying diagrams. But that simplifying assumption is misleading. By world standards European and North American generations are anomalous because of their exceptional simplicity. Capitalizing on that simplicity for analytical purposes is useful, but acting as if it were typical of real human societies is ethnocentric.

Here we introduce more complexity by examining the structure of generations in terms of generation intervals, birth intervals, age spread, polygyny, consanguineous marriages and the concomitant risk of congenital health problems, and population size and closure. Binford (2001) provides some ethnographic data for Aboriginal Australians and other hunter-gather societies around the world, but other sources cited in this section deal with nation-level statistics from governments, non-governmental organizations and scientific publications. The objective here is to introduce a wide range of quantifiable properties of societies - worldwide and in Aboriginal Australia - that have a direct bearing on the forms of generations.

Generation intervals

The duration of a generation interval, defined as the age difference between a parent and a child, is a major determinant of the age structure of populations and is a key parameter when using genetics to date population divergence events such as mutations and migrations (Weiss 1973). However, no consensus exists regarding the length of human generation intervals, and a wide variety of interval lengths have been used. For example, in 26 recent studies, 8 used 20 years, 13 used 25-29 and 5 used 30-35 years (Fenner 2005) and only one distinguished between male and female generation intervals. This lack of precision and/or standardization makes comparison between studies difficult, questions the accuracy of divergence date estimations and generally weakens research into human evolution.

Generation interval for individuals is defined as the birth year of a parent subtracted from the birth year of the child. In genealogical research, mean generation interval for a parent and all of his/her children is defined as the average age of the parent when the children are born, and the average generation interval for a particular multigenerational direct descent line is the time difference between the birth dates of the first and last members of the line divided by the number of generations (Lancaster 2007).

The average generation interval of a society as a whole (aggregate interval) can be measured collectively for all parent-child pairs, or separately for mother-child and father-child pairs. If measured separately for males and females, the weighted average of maternal and paternal generation intervals may be used as an overall estimate of the aggregate societal generation interval (Fenner 2005).

All approaches are problematic for obtaining accurate, complete data on parent-child and parent-parent age differences in non-literate, non-numerate societies with no birth records as was traditionally universal in Aboriginal Australia. The following three options may apply to analyzing generations in these societies in the 20th and 21st centuries. a) A relatively strong approach focuses exclusively on generation intervals based on birth dates (where obtainable) of living children and their living parents, and yields potentially verifiable parent-child and wife-husband age differences. b) Wife-husband age differences, perhaps estimated, can serve as a first proxy in cross-cultural comparisons where data on parent-child differences are missing. c) An even weaker second proxy is provided by data on age at first marriage which, like data concerning deceased people and any events that occurred in earlier years or decades, sometimes can pose intractable problems due to accidental and deliberate data distortions. Broadly speaking then, we can very cautiously approach the problems at hand by way of mean parental generation intervals, mean wife-husband age differences and mean age at first marriage.

Figure 4 shows the distribution of ages at first marriage in 191 nations while Table 1 summarizes recent data concerning parent-child generation intervals and wife-husband age differences in 151 More Developed Countries (MDC), 40 Less Developed Countries (LDC), 132 non-Australian hunter-gatherer societies and 25 Australian Aboriginal hunter-gatherer societies (UN 2000, Binford 2001, Helgason et al. 2003, Tremblay and Ve´zina 2000, Fenner 2005).

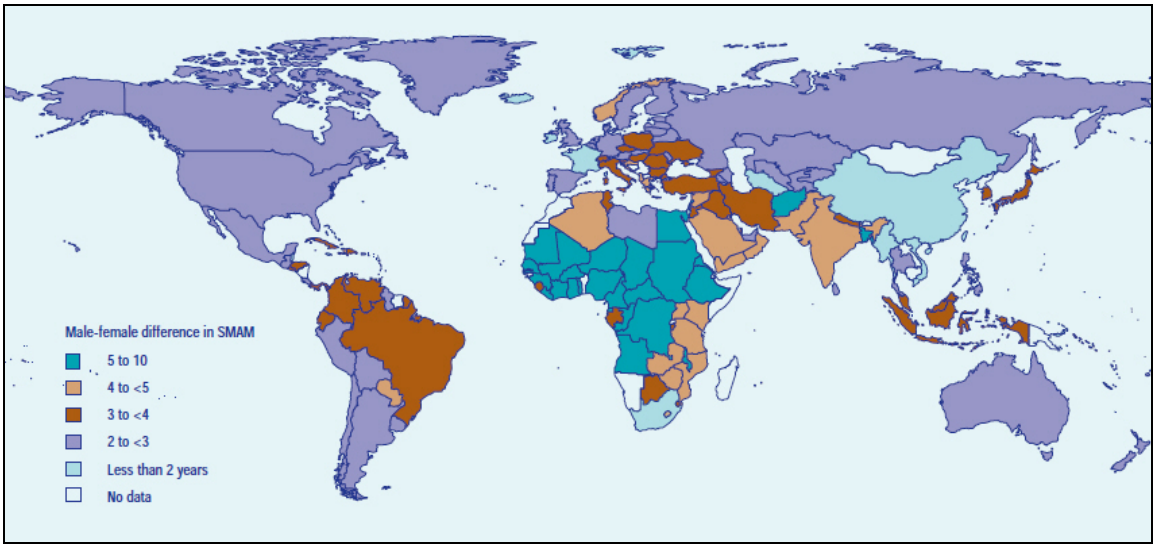


Figure 4. Differences in average age at first marriage for women and men in UN member states (UN 2000).

Recent genealogy-based research shows Icelandic female/male/aggregate generation intervals to be 28.7/31.9/30.3 years (Helgason, et al. 2003) and French Canadian intervals to be 28.9/34.5/31.7 (Tremblay and Ve´zina 2000), both of which are greater than values commonly used in genetics studies. Expanding on the detailed Icelandic and French Canadian studies by using data from World Marriage Patterns (UN 2000) for 191 nation-states, Fenner (2005) shows that mean female/male generation intervals for less developed countries (LDC) are 28.3/31.8 years and for more developed countries (MDC) are 27.3/30.8 years.

Mean wife-husband age difference varies across societies and may be anywhere from -2 years (wives on average 2 years older than husbands) to +28 years (husbands on average 28 years older than wives) (UN2000). Fenner's (2005) analysis of Binford's (2001) data on mean wife-husband age differences at first marriage in 157 hunter-gatherer/forager societies shows husbands on average to be 5.35 years older than their wives worldwide (n=132) outside of Aboriginal Australia, but within Aboriginal Australia (n=25) the mean wife-husband age difference is 14.64 years, approximately 14 years depending on which data are used (Table 1). The very large mean wife-husband age difference in Aboriginal Australia, combined with a mean maternal generation interval of approximately 28 years, yields a paternal generation interval of about 42 years. In other words, Australian Aboriginal female/male/aggregate generation intervals are approximately 28/42/35 years. These computations include unknown and variable numbers of married women both below and above reproductive ages (i.e., infant bestowals and elderly widow remarriages) whose impact on mean generation intervals presumably is zero.

Only 2 of 348 societies considered in Table 1 show a negative wife-husband mean age difference (UN2000, Fenner 2005). Thus the positive age difference is almost universal in human societies, but is highly variable and seems to be most extreme among the Aboriginal societies of Australia. Figure 4 and Table 1 together place Binford's collection of Australian Aboriginal data in a clear context.

	Maternal Generation Interval	Paternal Generation Interval	Wife-Husband Age Difference	Number of Cases
More Developed Countries	27.3	30.8	3.5	151
Less Developed Countries	28.3	31.8	3.5	40
Non-Australian Hunter-Gatherers	28.0	33.4	5.4	132
Australian Aboriginal Hunter Gatherers	28.0	42.6	**14.6**	25

Table 1. Mean male-female generation intervals and wife-husband age differences. Approximate values based on data from 191 nations (Fenner 2005) and 157 hunter-gatherer societies (Binford 2001, Table 4.07).

Fenner's (2005) article notes that asymmetric generation intervals have obvious and unavoidable implications for studies of human origins and migrations focusing independently on the descent of females (mtDNA) and males (Y-chromosome). The tutorial argues that the striking sexually based difference, wherein the female generation interval is approximately .667% of the male generation interval in Australian Aboriginal societies, has had major implications for the structure and operation of those societies in the ancient and recent past and into the present.

This sexually dimorphic behavior (Gay and McEwen 1980), which is manifested in a sex based mean difference in generation intervals and is virtually universal in human societies, appears to be maximized in Australian Aboriginal societies by cultural factors that sharply delay the onset of socially recognized mating by men. Factors that determine the measurable contours of this delay in Australian Aboriginal societies are discussed at length below.

Birth intervals

The birth intervals that separate a mother's children from each other determine part of the age structure of her children's generation. Human birth intervals are determined in part by reproductive biology (gestation period, lactational amenorrhea, etc.) and in part by birth spacing decisions that people make on a daily basis with regard to cultural factors including restrictions on sexual behavior, use of contraceptives, infanticide, sometimes infant mortality, etc. Average human birth intervals are computed by subtracting the date of birth of a woman's last child from that of her first child and dividing by the number of her children. The median birth interval in 55 developing countries at the end of the 20th century was 32 months, with average birth intervals across human societies ranging from less than two years to almost five years (USAID 2002).

Generation age spread

The maximum age spread of a woman's children is about 35 years, beginning after the onset of her menstruation at or before age 15 and ending at the onset of her menopause at or about age 50. Regardless of the number of men with whom a woman mates, the maximum age spread of her children remains at about 35 years and the number of children that she can produce rarely exceeds twenty because of normal birth intervals and other female reproductive constraints.

The maximum age spread of a man's children is approximately 65 years, again beginning at or about fifteen years of age and continuing until the man's death at 80 years or more, and the maximum number of children that he can sire may reach at least into the hundreds. In societies where serial monogamy is practiced, a man may have children by a series of often progressively younger wives in marriages separated by deaths or divorces. In societies where concurrent polygyny is practiced, a man may have children by multiple concurrent wives of a wide range of ages. In both cases, a man can sire children in concurrent relations with women to whom he is not married such as courtesans, mistresses or concubines, perhaps in a harem or some other comparable residential arrangement.

Polygyny

Reaching the upper limit in generation intervals and age spreads generally occurs in conjunction with polygyny, defined as the marriage of one man to two or more women. Such feats are rare in human societies, but the limits are important because they apply to a few people in most societies, to several influential men in human history including Genghis Khan (Zerjal et al. 2003) of the Mongol Empire, some sultans of the Ottoman Dynasty (Peirce 1993), King Abdulaziz al-Saud (Lacy 1981; El-Tahri 2005) of Saudi Arabia, and Brigham Young (Porter and Rex 2001) of the Mormon Church, and to almost everyone in Australian Aboriginal societies.

Figure 5 shows the worldwide prevalence of polygyny expressed as the percentage of women living in polygynous households (WomanStats Project 2011). An alternative measure, percentage of men with multiple wives, is not available. There are two major limitations here. First, the organization that compiled the data and produced the map focuses on nations with populations of 200,000 or more. Their sources generally do not include comparable quantitative data for smaller nations or for classes, castes and ethnic minorities within nations. Second, by focusing on the more-or-less legalistic notion of polygyny which is relatively easy to count, their sources say nothing about sexual relations between men and concubines, courtesans, mistresses, prostitutes

and others to whom they are not married. The map, then, shows a highly conservative representation of the many ways in which one man may sire children with anywhere from two to dozens or even hundreds of women. Despite its limitations, it shows the highest concentrations of polygyny in countries of Sub-Saharan Africa and the Moslem world, but necessarily omits data on polygyny in Australian Aboriginal societies.

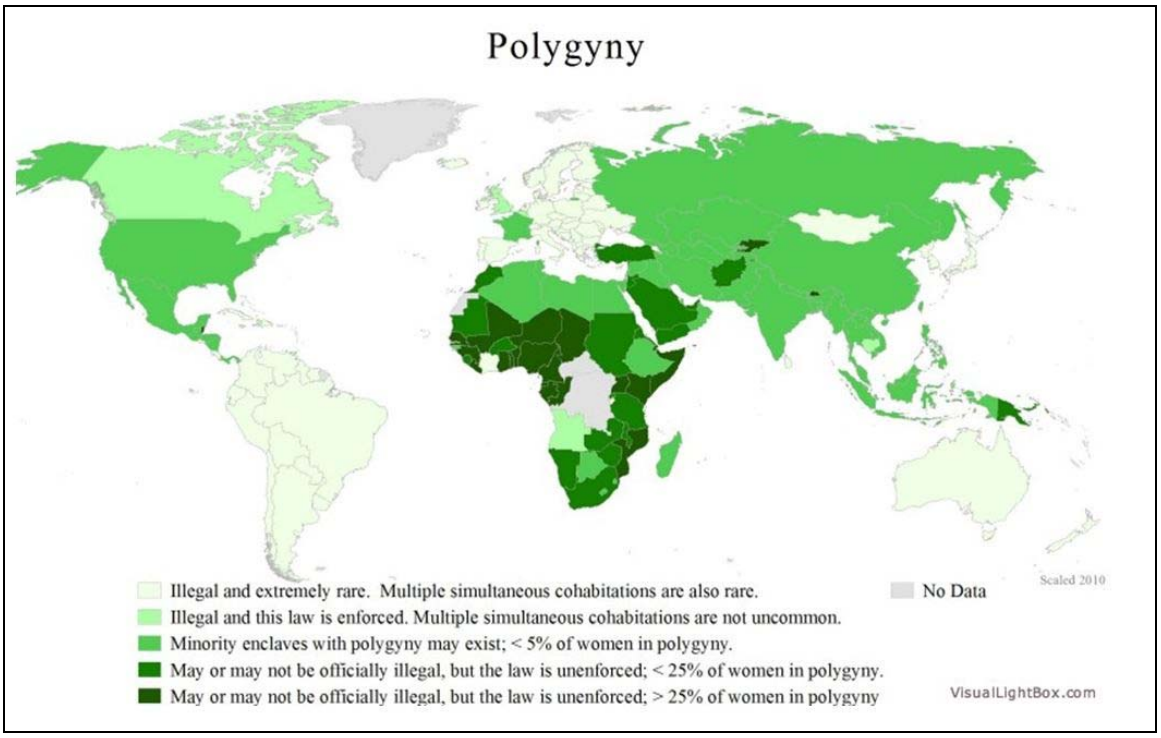


Figure 5. Worldwide prevalence of polygyny in nations with populations of 200,000 or more (WomanStats Project 2011).

In European societies where polygyny generally is prohibited, female and male generation intervals have long varied geographically, historically and with social class preferences, often with higher class men being optionally and significantly older than their wives who may or may not be MBD. Demographic, genetic and social impacts of differences in female-male generation intervals in European societies have been investigated extensively in recent decades by Goody (1983), Herlihy (1985), Helgason et al. (2003), Laslett (1971), Shorter (1977), and Tremblay and Vezina (2000). The frequency and magnitude of differences in generation intervals seems to be low enough in Western European and North American populations (UN 2000) that they probably have little effect on the overall shape of generations. In other words, polygyny is prohibited and sex based differences in generation intervals appear to be minimized by cultural factors in European societies.

Arabic Islamic marriages (Pickthall 1938 trans.: *Qu'ran,* Sura An-Nisa 4:3, The Women) do not require significant age differences between husbands and as many as four wives concurrently, but are biased in favor of older men having multiple wives, preferably FBD cousins (Barth 1954;

Murphy and Kasdan 1959), some of whom may be considerably younger than their husbands. Statistics on generation intervals and polygyny in Islamic societies are highly fragmentary, and their impact on the shape and complexity of Muslim generations is unknown. Suffice it to say that King Abdulaziz al-Saud's 30+ sons and an unknown number of daughters born to 22 wives is anomalous by Moslem standards.

The combination of polygyny with significant differences between female and male generation intervals is important in Sub-Saharan Africa where on average women are estimated to marry at age 20 and men at age 28 (UN 2000), and between 12 and 38 percent of married African men are reported to be in polygynous marriages (Goldman and Pebley 1989). These are systematic and widespread cultural features whose impacts on the shapes of African generations are unknown but probably are significant.

Table 2 summarizes worldwide data on polygyny in hunter-gatherer societies (Binford 2001, Table 8.04), and provides a relevant context for examining polygyny in Aboriginal Australia. Historically in most parts of the world, hunter-gatherer polygyny rates in societies where polygyny is practiced seem to have ranged from 3 to 13 percent at or shortly after initial European contact, while mean age difference between wife and husband at first marriage ranged from 3 to 8 years, with no clear correlation between the two. The only significant exceptions with regard to polygyny rates are the Native American Great Plains Horse Tribes at 29.3% and Aboriginal Australians at 33.6%, and the only significant exception with regard to mean difference in age at first marriage is Aboriginal Australian societies at about 14 years.

Geographical + cultural areas	Cases Polygyny	Mean Polygyny Rate	Cases Age at First Marriage	Mean Diff. Age at First Marrige
ASIA: Tropical + subtropical	23	3.71	18	5.03
NORTH AMERICA: Calfornia and Northern Mexico	20	5.55	19	3.16
AFRICA: Tropical + subtropical	17	8.91	11	4.54
NORTH AMERICA: Arctic	21	9.42	12	8.05
NORTH AMERICA: Desert and desert scrub	23	9.55	12	3.01
NORTH AMERICA: North Pacific coast	9	10.56	13	4.27
NORTH AMERICA: Subarctic	32	12.35	36	5.74
SOUTH AMERICA: Tropical-subtropical	17	13.01	13	4.01
NORTH AMERICA: Plains horse tribes	9	29.27	12	7.83
AUSTRALIA: Tropical + subtropical	31	33.61	32	13.76
Total	202		178	

Table 2. Mean polygyny rates and mean differences in age at first marriage. Data from hunter-gather societies with known polygyny rates and known wife-husband ages at first marriage (from Binford 2001, Table 8.07); grouped by geographical/cultural regions, sorted by mean polygyny rate.

Thus in Australian Aboriginal societies, the exceptionally high difference between maternal and paternal generation intervals co-occurs with an exceptionally high polygyny rate. The data in Table 2 is just as imperfect as that in Figure 5, but the problems are different. Especially with regard to polygyny in Aboriginal Australia, there has been no consensus concerning how to

record and interpret data concerning infant bestowal and widow remarriage, both of which are common in some parts of Australia. We return to these topics below.

Consanguineous marriage and inbreeding avoidance

Cousin marriage offers yet another important perspective from which to measure familial generations. It is both rare and illegal in most of North America; it is common and legal throughout much of the world; it is preferred in some Muslim and Australian Aboriginal societies.

Both inbreeding and outbreeding have costs and benefits (Pusey and Wolf 1996; Bijlsma et al. 2000; Charlesworth and Charlerworth 1987). When inbreeding is unsystematic and intermittent, it can yield a wide range of significant congenital health problems typically brought together under the heading of inbreeding depression. When it is persistent, inbreeding depression may diminish but not disappear as a result of unmasking and purging of severely deleterious recessive alleles. But as Darwin noted so long ago (Berra et al. 2010), carefully controlled selective inbreeding among very closely related organisms is the method of choice for producing new breeds and outstanding individuals of existing breeds, albeit with a concomitantly increased risk of congenital health problems. Likewise outbreeding can be genetically beneficial in moderation, but extreme forms of it yield hybridization with other species or failure to reproduce.

In general, cousin marriage within human societies tends to lie near the random end of the continuum, but in some Asian societies where precision breeding of thoroughbred horses and camels is a universal art form and a source of great prestige and wealth, the principles of selective breeding or artificial selection may in some cases be applied effectively to cousin marriage among humans as well.

At their lowest, the rate of consanguineous mating and the inbreeding coefficient can approach 0% in large panmictic populations. At their highest, they could equal or approach 100% in cases of identical-twin or parent-child incest if that were the norm across multiple generations. Ordinarily human societies fall somewhere between these extremes.

In Figure 6, Bittles (2001) summarizes the best available data on the prevalence of consanguineous marriages in UN member nations. Worldwide, the highest rates at the national level in human societies (generally with first cousins) occur in Persian Gulf Muslim Arab States including Saudi Arabia, Kuwait, Qatar and the United Arab Emirates where the prevalence of consanguineous marriages equals or exceeds 50%, and in adjacent predominantly Muslim regions of Central and South Asia, and North and Sub-Saharan Africa. In the region centered on Saudi Arabia, a number of ethnic minorities and subpopulations omitted from the map have consanguineous marriage prevalence rates that exceed 70% (Bittles 2009).

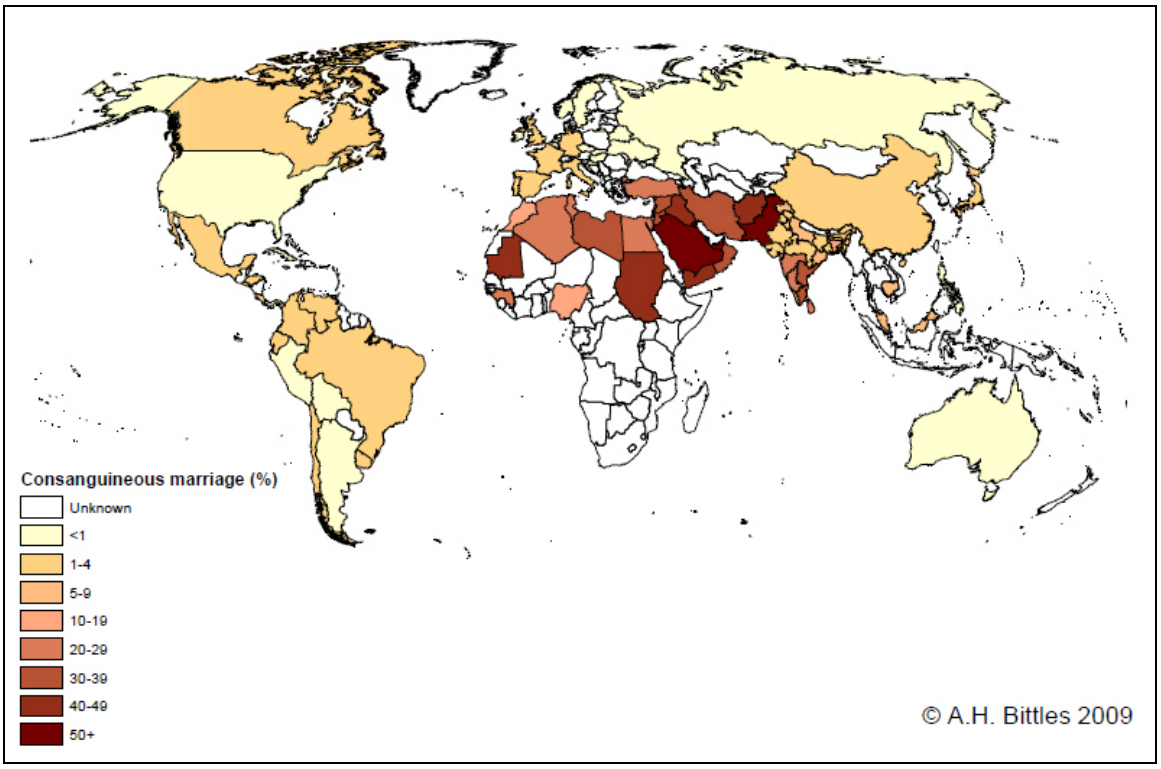


Figure 6. Prevalence of consanguineous marriages (Bittles 2009).

In Figure 7, Christianson, Howson and Modell (2006), building in part on Bittles' (2001/2009) data on consanguineous marriages, report that the world's highest incidence of birth defects due to genetic abnormalities occurs in Saudi Arabia and the adjacent predominantly Muslim regions of Central and South Asia, and North and Sub-Saharan Africa referenced above. Bener et al. (2009) and many others have substantiated these findings.

Different models using different assumptions and algorithms yield different results, but Bittles (2001) summarizes the situation as follows:

> "In a study based on combined data from 38 populations in eastern and southern Asia, the Middle East, Africa, Europe, and South America, with average coefficient of inbreeding values ranging from 0.0005 to 0.0370, mean excess mortality at the first cousin level was 4.4% (Bittles and Neel 1994). This estimate appears to be valid for all of the large human populations so far examined."

Comparable prevalence data concerning consanguineous marriages, birth defects and mean excess mortality are not available for traditional Australian Aboriginal societies. However, their increasing availability for UN member nations, national subpopulations and ethnic minorities empirically substantiate longstanding theoretical and experimental concerns about the harmful effects of inbreeding.

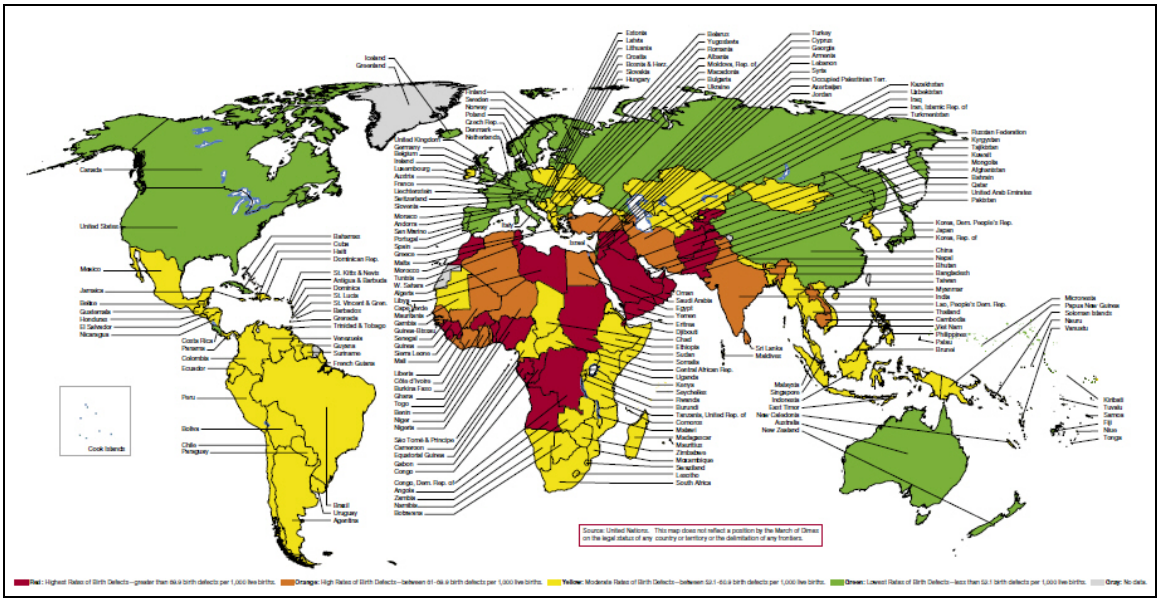


Figure 7. Prevalence of birth defects per 1000 live births (Christianson, Howson and Modell 2006)

RED	Highest: >69.9 birth defects / 1000 live births
ORANGE	High: 61-69.9 birth defects / 1,000 live births
YELLOW	Moderate: 52.1-60.9 birth defects / 1,000 live births
GREEN	Low: <52.1-60.9 birth defects per 1,000 live births

Population size and closure

Endogamy, defined as marrying within the limits of one's own community (nation, town, tribe, caste, religion, language group, species), contrasts with exogamy, marrying beyond the limits of one's own community. Linked but different concepts as noted above are inbreeding of related individuals within an isolated or closed group, often associated with a genetic load expressed as genetic abnormalities and birth defects, and outbreeding of distantly related or unrelated individuals at its highest value leading to hybridization or failure to reproduce.

Inbreeding is inversely related to population size and boundary closure; the smaller the population and the less permeable are its boundaries to gene flow, the more likely are individuals within it to mate with increasingly closer kin. Inbreeding and inbreeding avoidance (Pusey and Wolf 1996), especially in endogamous societies, may or may not be serious problems in Aboriginal Australia, and their importance may vary from time to time.

For much of the 20th century, it was accepted, commonly but not universally, that the apparently small mean population size of Aboriginal societies, estimated at around 500 people, was tentatively reasonable as a first approximation, and that Aboriginal societies, called tribes or language groups, were isolated from each other by cognitive and behavioral boundaries that were impermeable or of very limited permeability, yielding societal closure.

But societal closure was a simplifying assumption or convenient fiction that was invalidated by mobility and intermarriage among language groups (e.g., Spencer and Gillen 1899/1968; Meggitt 1962; von Brandenstein 1982; Dousset 2005; Keen 2004; McConvell, in prep.) and by group fission-fusion as a result of demographic changes. The resulting exogamy at a rate of approximately 15% (Birdsell 1968, 1970, 1976; Tindale 1953, 1974, 1976; Adams and Kasakoff 1976) meant that the mean population estimate of 500 people may have been accurate with regard to cognitive matters such as language group sizes but was too conservative with regard to behavioral and biological groups that indeed were exogamous at a low rate. Nevertheless the assumptions dictated that kinship models constructed during the period would treat societies as if they were closed endogamous units.

In fact, population sizes and exogamy rates in Aboriginal Australia most likely are variable rather than static, with both measures typically being near values at which inbreeding could be problematic. When population sizes and exogamy rates drop below the averages, they may increase the genetic load associated with inbreeding; when they rise above the averages, they may decrease the genetic load, thereby buffering the potentially lethal effects of environmental, demographic and genetic stochasticity among small, closed populations (Bener 2009; Bijlsma et al. 2000; Brook et al. 2002; Charlesworth and Charlerworth 1987; Morton et al. 1956; Morton et al. 1971; Tanaka 1997, 2000; Bocquet-Appel and Masset 1982; Fix 1979; Saether et al. 2004; Traill et al. 2007).

Perhaps the safest assumptions are that precise numbers are not available now and never will be, and that an understanding of Aboriginal descent, marriage and kinship is on a sounder footing if it takes into consideration the potential oscillation around means that constitute “tipping points” into and out of inbreeding depression. Perhaps the best approach is to build models that accommodate both endogamy and exogamy - both inbreeding and outbreeding - but at different times and places.

Together the quantitative data reviewed above provide an incomplete background against which to view what is known about biobehavioral aspects of generations in Australian Aboriginal societies without emphasizing cognitive issues.

Shapes of familial generations

In addition to disregarding the age structure of generations, Figures 2 and 3 suggest that generations have a simple shape - regular, symmetrical, vertical and horizontal with no twists and turns. Once again, that simplicity reflects an ideal version of European and North American generations, but it seriously misrepresents the full range of topographic diversity in human generations. To escape the ethnocentric assumptions of those simple diagrams, the tutorial examines generations in symmetric and asymmetric marriage systems, generations in polygynous age-biased societies, and generation moieties. The diagrams that accompany this section are generic or basic in that they lack the frills and embellishments that often characterize such diagrams, they do not represent specific societies and they certainly do not represent all societies.

The goal of this section is to suggest a broad analysis of generations that stimulates new research over the long term, not to frame a narrow hypothesis that passes or fails specific statistical tests in the short term.

In Figure 7, Christianson, Howson and Modell (2006), building in part on Bittles' (2001/2009) data on consanguineous marriages, report that the world's highest incidence of birth defects due to genetic abnormalities occurs in Saudi Arabia and the adjacent predominantly Muslim regions of Central and South Asia, and North and Sub-Saharan Africa referenced above. Bener et al. (2009) and many others have substantiated these findings.

Most importantly, the topics in this section appear in a logical sequence that simplifies the task of describing them, but the order does NOT represent either a historical sequence or a causal sequence. This matter receives greater attention at the end of the tutorial.

Levi-Strauss (1949/1969) based a highly influential structural study of kinship on the contrast between restricted and generalized exchange. Restricted exchange is based on complex positive rules that specify which people one can marry. It yields "elementary" systems that may leave little discretion to individuals, and typically are found in societies such as those of Aboriginal Australians that Levi-Strauss characterized as "primitive". Generalized exchange is based on simple negative rules that specify which people one can not marry. It yields what Levi-Strauss called "complex" systems that leave much discretion to individuals, and typically are found in societies such as those of present day China, India and Europe that Levi-Strauss characterized as "modern". Although Levi-Strauss's technical language may be accurate, some people find it to be counter-intuitive, confusing, ethnocentric or racist. This tutorial often draws on Levi-Strauss's work but, using ordinary language, simplifies his jargon by referring only to systems with negative rules as in European societies and positive rules as in Australian Aboriginal societies.

Generations in symmetric marriage systems

To understand asymmetric generations in Aboriginal Australia, it is essential first to understand symmetric generations in those societies, for they pose the basic problem to which asymmetric generations may be a partial solution.

Open symmetric generations

Symmetric marriage systems encompass some of the least rigid and most rigid generational structures. In open symmetric generations, common in North American and European societies today, opposite sex siblings marry and begin to reproduce at approximately the same mean age, women on average only 3 years younger than men (Fenner 2005). Individuals have considerable freedom in selecting their own spouses/mates, typically but not always selecting from families other than their own. The marriage rules generally are negative, specifying that one should not marry too closely (one's opposite sex parent, sibling, child; some cousins; often a person of one's own sex) or too distantly (unacceptable race, religion, class or caste). In these societies a marital generation commonly consists of one or many nearly horizontal sibling-in-law chains as in Figure 5, with the marriages generally linking otherwise unrelated families to each other. Often in these societies, people have knowledge of only a few links in the chains (acquainted with in-laws, but not with in-laws of in-laws), and the chains generally are open ended; i.e., they are not

connected with each other and do not form closed loops. These are among the least rigid generational structures. Not surprisingly, Figure 3 is a passable representation of them.

Closed bilaterally symmetric generations

Closed bilaterally symmetric generations, an extreme example of which appears in Figure 8, are quite different. Generally speaking, cousin marriage is a defining feature of closed bilaterally symmetric generations. All first cousins are the same genetic distance from Ego, and in European societies Ego generally classifies all of them as cousins and treats them interchangeably. But many societies make finer distinctions between parallel cousins (MZD and FBD) who are classificatory equivalents to one's own biological sisters by virtue of the same-sex sibling linkage between their parents, and cross cousins (MBD and FZD) who are entirely different from one's sisters by virtue of the opposite-sex sibling linkage between their parents, and may be preferred as wives. The remainder of this tutorial deals almost exclusively with MBD marriage for that is the standard – but not exclusive - form in Australian Aboriginal societies.

Figure 8 is based on a preference or prescription that men should marry women who are cousins in every sense of that term: biological kin; simultaneously double first (e.g., MBD) and double second (e.g., MMBDD) cousins (cousins on both mother's and father's sides of the family); simultaneously parallel (FBD and MZD) and cross (FZD and MBD) cousins; with reiterative cousin relationships reaching back many generations into the past. In this case, and in all of the following examples, marriage rules are positive, favoring marriage with certain categories of people, generally within one's own family (Levi-Strauss 1949/1969).

Assume in Figure 8 that the Adams family on the left always gets its wives from the Bakers on the right, and *vice versa* through the generations, each man's wife being his MBD. One of the implications of the diagram is that sibling exchange marriages can occur; i.e., one man gives his sister to another man and the second man reciprocates by giving his sister to the first man. Ego's W is simultaneously his MBD and his FZD. Everybody is related to everybody else in the diagram via multiple genealogical pathways some of which appear in the diagram with compound labels designated by a "/" between two or more kin types (e.g., MBD/W).

Due to systematic bilateral intermarriages among cross cousins, each generation forms a sibling-in-law chain with spouses flowing in both directions in a densely packed horizontal layer represented by the closed bidirectional loop at the upper right corner of the diagram. One sex (blue) flows clockwise and the other (black) flows counterclockwise. Within each generation, virtually all members are related to each other as siblings, cousins, spouses or spouse's siblings. Generations among Kariyarra (Radcliffe-Brown 1913; 1931), Arrernte (Spencer and Gillen 1899/1968) and many other Aboriginal Australia societies with two, four or eight descent lines can be depicted in diagrams of this kind.

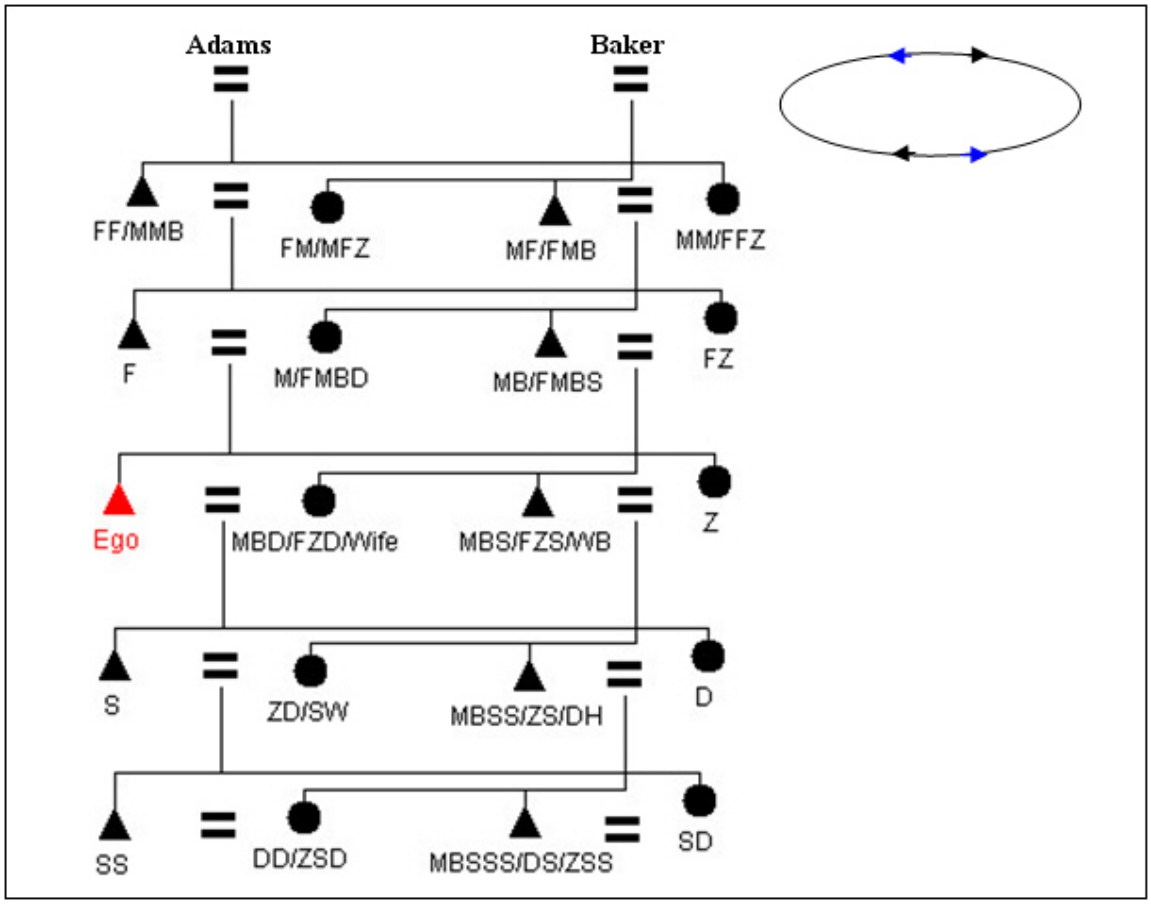


Figure 8. Bilateral Cross Cousin Marriage. In this idealized Kariyarra representation, all generations are identical and contain two sets of siblings; e.g., G.0 has Ego and his Z in one set, Ego's W and his WB in the other. Ego's father's descent line (FF, F, Ego, S, SS) is to the left (Adams family), and his wife's father's descent line (MF, MB, MBS, MBSS, MBSSS) is to the right. Everyone marries into the opposite descent line but within his/her own generation. In this example, every man is married to a woman who is his MBD, FZD and Wife, every woman is married to her FZS, MBS and Husband, and it is possible for brother and sister to marry sister and brother. Each generation is an endless bidirectional chain of Ego, W, WB and Z that repeats in a closed loop. Spouses flow in both directions as shown by the two-headed arrow at top right, with one sex (blue) flowing clockwise, the other (black) flowing counterclockwise. Kin relations may be biological or classificatory or both.

Figure 8 is an ideal representation of an important cognitive pattern that has been perceived and represented in the idiom of consanguineal marriage by Western observers, and may or may not have been expressed in that idiom by Aboriginal people. In some manner, it seems to underlie many or even most Australian Aboriginal systems of descent, marriage and kinship. Yet in its most basic form it embodies a high degree of inbreeding. The remainder of the tutorial deals in various ways with the problem of inbreeding avoidance.

Generations in asymmetric marriage systems

Symmetric or restricted marriage systems assume that there are no significant differences between the forms of father's and mother's sides of the family, so marriages can go back and forth in both directions at the same time. But asymmetric systems are based in part on distinct differences between those two sides. Representative examples from Australian Aboriginal societies include circulating *connubia* that are horizontally asymmetric only, plus several increasingly unlikely systems that are both horizontally and vertically asymmetric. Unlike symmetric systems that require an even number of descent lines to sustain bidirectional exchange, asymmetric systems operate properly with even or odd numbers of descent lines. They progressively reduce the long term cumulative effects of inbreeding that might occur under conditions illustrated in Figures 6 and 7.

Circulating connubia

A circulating *connubium* is an arrangement in which women move sequentially from one family to another in a circle (Adams men marry Baker women, Bakers marry Coles, Coles marry Adams). The form generally occurs when marriages are restricted to cross cousins on mother's side of the family (MBD). If the society is small and endogamous, and everybody consistently follows the same MBD marriage rule, the sibling-in-law chain that constitutes each marital generation forms a closed unidirectional loop as shown in the upper right corner of the diagram. Women (or men) flow horizontally from family to family in one direction or the other (Tjon Sie Fat 1983a; Shapiro 1969).

According to the diagram, marriages occur with spouses of approximately one's own age, so the pattern is incompatible with the 14+ year mean wife-husband age difference. Again the default option is societal endogamy, but exogamy that does not appear in the diagram is possible and, at least in principle, the structure itself can expand to accommodate more descent lines. Furthermore the degree of inbreeding declines when classificatory kin substitute for consanguineal kin. The Murngin Yolngu (Warner 1937/1958) are a classic example in Australia, and the pattern is widespread throughout East and South Asia (Levi-Strauss 1949/1969).

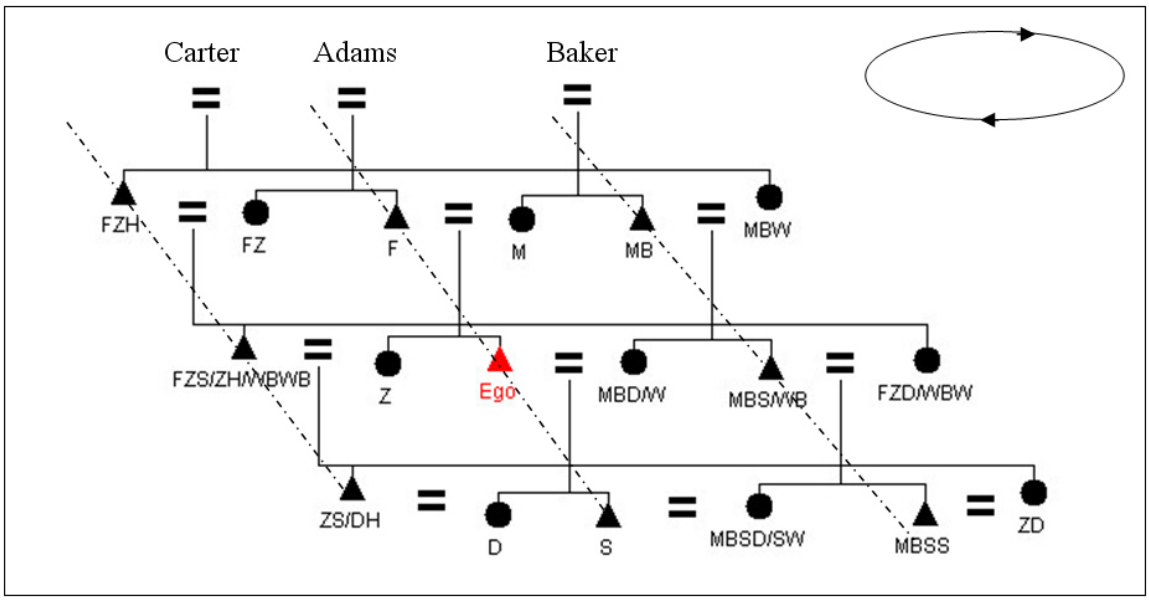


Figure 9. Circulating Connubium. This diagram, like the Bilateral Cousin Marriage diagram, represents an idealized endogamous society with husbands and wives of approximately the same age yielding an indefinite number of stacked age constant circular generations. The light dashed lines identify Carter, Adams and Baker patrilineal descent lines. Adams men marry Baker women, Baker men marry Carter women, Carter men marry Adams women. The sibling-in-law chain that forms each marital generation is a closed loop in which women flow horizontally in one direction from family to family.

Age biased generations

Age biased generations occur when a unidirectional, generally MBD, marriage rule is combined with mean female and male generation intervals that are significantly different from each other as in so-called "May-December marriages". Such marriages may be acceptable and encouraged in some places and times, and unacceptable and prohibited in others.

Australian Aboriginal descent and marriage systems that are both horizontally and vertically asymmetric have unidirectional flows that characterize circulating connubia combined with traditional and significant differences in mean female and male generation intervals.

This sexually dimorphic behavior (Gay and McEwen 1980) manifested in a sex based mean difference in generation intervals appears to be maximized in Australian Aboriginal societies by cultural factors that sharply delay the onset of socially recognized mating by men. Factors that determine the measurable contours of the delay in Australian Aboriginal societies lie beyond the scope of this tutorial but are addressed in Denham (n.d.a).

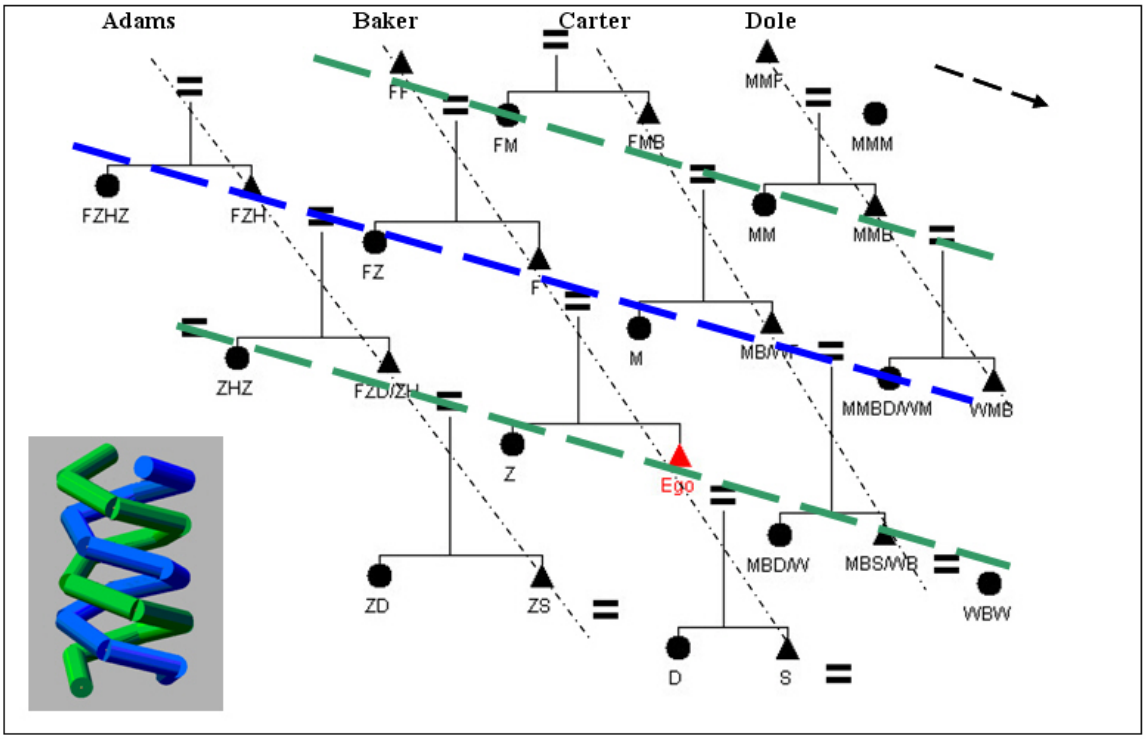


Figure 10. Age Biased Generations. Idealized generations such as this can occur with senior/junior marriage systems that prohibit marriage with MeBD (e=elder) and encourage it with MyBD (y=younger), and with systematic marriage with any MBD combined with the ubiquitous 14+ year difference between female and male generation intervals. This diagram shows only a portion of the 6-patriline lattice for the Alyawarre language group. Dashed gray lines identify Adams, Baker, Carter and Dole patrilines or families. Ego, in the Baker family, marries a woman in the Carter family who is his MBD. The 14+ year age bias means that generations, indicated by heavy blue and green dashed lines, no longer form closed loops in horizontal strata, but instead are biased (inclined or tilted) downward toward the future as shown by the single-headed arrow at top right. Women and men at the edges of the 6-line lattice may marry each other, in which case the diagram rolls around on itself to form a closed three-dimensional helix as shown at bottom left (unlike the bidirectional and unidirectional horizontal flows of women in previous diagrams), or they may marry into a potentially endless series of additional families that reach beyond the edges of the lattice. Both options seem to be possible in Australian Aboriginal societies. ("Helices". Image from Sandor Kabai 2010. The Wolfram Demonstrations Project).

Senior/junior marriage systems

Senior/junior marriage systems introduce systematic May-December marriages into some Australian Aboriginal societies by distinguishing between older and younger siblings of one's parents (McConnell 1950; McConvell in prep.). In circulating connubia husbands and their wives (MBD) are presumed to be of approximately the same mean age so that sibling-in-law chains form closed loops. But if men in those systems are forbidden to marry mother's elder (e) brother's daughter (MeBD) but permitted or expected to marry mother's younger (y) brother's daughter (MyBD), generations based on the resulting sibling-in-law chains become age biased. In this case, men generally marry their MyBD who tend to be considerably younger than the men, and women generally marry their FeZS who tend to be considerably older than the women.

The distinction between MyBD and MeBD is coded into the kinship terminology with separate kinship terms for the two kin types (Read 2004).

Restricting marriage to MyBD disrupts the circular flow of women that characterizes circulating connubia. While women continue to flow in one direction, the loop no longer closes. As shown in Figure 10, the flow is inclined diagonally so that older men "reach downward" and to the right to recruit younger women as wives. This pattern supports Hammel's (1976) theoretical argument that it is logically impossible for a generation to form a closed loop when men systematically marry much younger women and their sisters systematically marry much older men.

Generic age biased marriage systems

Generic age biased generations constitute a second and perhaps more widespread mechanism for generating May-December marriages in Aboriginal Australia. These generations derive from the fact that opposite sex siblings generally begin to marry and reproduce at sharply differing ages even when senior/junior terminologies and marriage systems are absent. Continent-wide, women begin to marry and have children when they are about 15 years old and their brothers begin at or after they are about 30 years old. This is the practice that yields the average continent-wide Aboriginal wife-husband age difference of approximately 14+ years (Binford 2001; Fenner 2005) as reported above. Just as Figure 10 illustrates the general shape of generations produced by senior/junior marriage systems, it also shows the results of combining a) systematic marriage with any MBD and b) a 14+ year difference between female and male generation intervals. Here again, marital generations form the same diagonal sibling-in-law chains reaching from the indefinite past to the indefinite future with no possibility of forming closed loops.

Cognitive aspects of age biased systems may appear to be symmetric when Aboriginal people describe them to European anthropologists, but behavioral aspects seem to be asymmetric when statistical data on marriage practices are considered. For example, kinship terminologies from Anindilyakwa (Rose 1960) and Alyawarre (Denham and White 2005) systems appear to be symmetric thereby permitting or encouraging sibling exchange marriages, but in fact both societies have approximately 14 year age biases, and both are characterized by MBD marriage with FZD marriage being considerably less common. Cognitively they seem to be symmetric, but behaviorally they are asymmetric.

Emergence of a helical or lattice form does not require top-down planning or amazing feats of memory over six or seven descent generations spanning 250-300 years. Rather, if everyone were to "act locally" by marrying a consanguineal or close / distant / remote classificatory MBD or MMBDD in accordance with a common Aboriginal injunction to that effect, making no reference whatsoever to extended kinship chains, the end product over a period of several ordinary generations would be a perfectly shaped emergent asymmetrical geometric structure that would look as if it had been planned from the top down even though it had not been planned at all. Alas, perfection is rare in the real world, and among the Alyawarre for whom the best data are available (Denham 2001/2007), the idealized form in Figure 10 appears imperfectly in Figure 11 due to incomplete data, classificatory links that are not detectable in genealogies, a FZD/MBD ratio of 1/3, and an exogamous marriage rate of 27%. For a more complete explanation of Figure 11, see Denham and White (2005) and Denham (n.d.b).

Keen (1982:637, Figure 3), whose Figure almost captures the age biased generational structure described here, describes an interesting variation on the age biased theme, perhaps midway between senior-junior and generic age biased systems:

> "The Yolngu sort all those women likely to be younger than a man from those likely to be older, classifiying MBD, MMBDD, and MMMBDD (matrilateral cross cousins) as *galay*, but FZD, MFZDD, FFFZDDD (patrilateral cross cousins) as *dhuway*. Yolngu marriage rules therefore consistently specify marriage with a woman likely to be younger, optimizing conditions for age-related polygynous marriages" (Keen 1982:640).

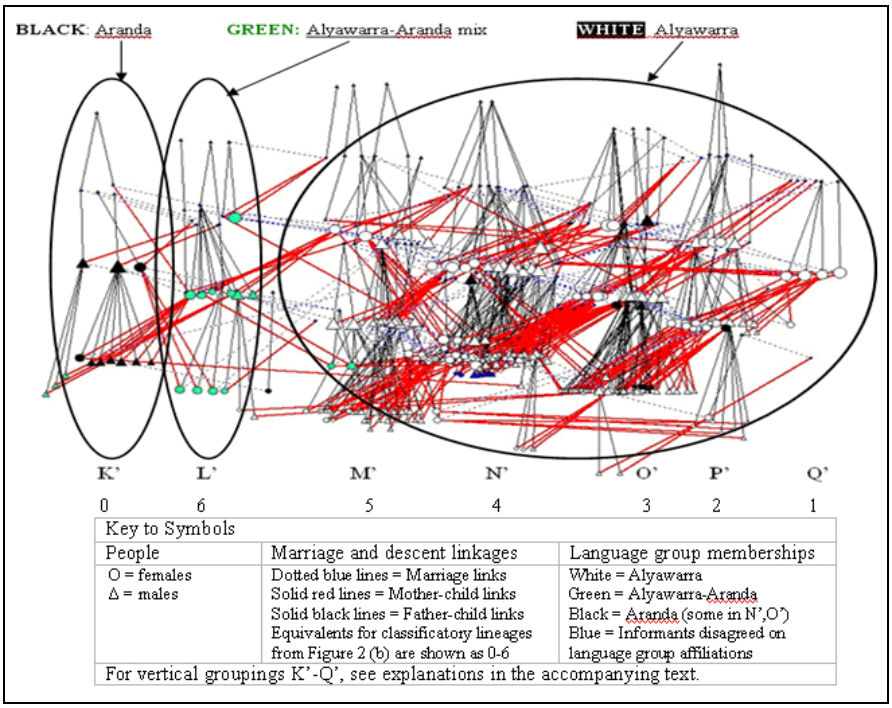


Figure 11. Network showing imperfect age biased generations formed by 113 Alyawarra marriages (Denham 2001/2007, Denham and White 2005).

In Figure 10, Adams women and Dole men on the left and right margins of the diagram have a problem that is missing from Figure 9. The lattice formed by descent lines and generations may remain open, flat, two dimensional, in which case the Adams women and Dole men may marry into families that lie beyond the edges of the diagram, perhaps in their own society, perhaps in neighboring societies (see upper right). Alternatively the Adams women and Dole men may marry each other, in which case the diagram must roll around on itself to form a helix with the strands extending downward through time, displaced by an amount determined by the number of descent lines and the difference between female and male generation intervals. The example at the lower left corner of the diagram has 2 strands, blue and green, but it could have anywhere from 1 to 8.

The three-dimensional helical structure is similar to but quite different from the stacks of two dimensional circles that are associated with two-way and one-way circular flows of women in

previous diagrams (Tjon Sie Fat 1983a). Both options, lattices and helices, are logical possibilities in Aboriginal Australia (Denham, McDaniel, Atkins 1979), but their absolute and relative frequencies of occurrence are unknown. If uninterrupted helical cycles are rare, as they probably are, then these structures tend to foster societal exogamy rather than endogamy as in the previous diagrams.

A rich but scattered and controversial literature deals with asymmetric generations in Australian Aboriginal societies where large husband-wife age differences are accepted, encouraged and even required, and where highly particularistic analyses of local variations on continent wide themes have preempted the analysis of larger patterns. Ethnographic accounts deal with societies including Wik-Mungkan (McConnell 1930, 1939-40, 1950, 1951), Anindilyakwa (Rose 1960), Aranda (Guhr 1963), Ngarinyin (Blundell and Layton 1978), Tiwi (Hart, Pilling and Goodale 1988; Goodale 1962, 1971), Alyawarre (Denham, McDaniel, Atkins 1979; Bell 1993), and perhaps Murngin Yolngu (Warner 1937/1958; Keen 1982, 2004). Theoretical works include De Josselin de Jong (1962), Needham (1962, 1971), H. White (1963), Shapiro (1969), McKnight (1971), Hammel (1976), Atkins (1981), Tjon Sie Fat (1981, 1983a, 1983b) and Denham and White (2005) and Denham (2010). From the perspective of kinship terminologies, Lévi-Strauss (1949/1965) put most of these societies except Murngin Yolngu into a residual category of puzzling phenomena that he called "aberrant systems", but from the generational perspective adopted here, they are not aberrant.

Polygyny and age biased generations

The complexities that are visible in these idealized Australian generational diagrams are further amplified by additional complications including polygyny. The internal structure of a generation can appear to be simple, limited mainly to birth intervals and sex ratios, when two people practice strict monogamy. But polygyny disrupts the appearance of simplicity in any generational structure regardless of whether it is symmetric or asymmetric, age biased or not. Such a structure can become extraordinarily complex and confusing in a society that combines age biased generations with polygyny in which a man typically marries or mates with several or many younger women either concurrently or serially (Orians 1969; White 1988). This consideration of the biobehavioral shape and internal complexity of age biased generations combined with polygyny further challenges the ethnocentric assumption that generations by their very nature are fundamentally simple.

In Australian Aboriginal societies, the 14+ year mean difference between maternal and paternal generation intervals is very strongly associated with a constellation of factors including the late initiation of males at or beyond the onset of puberty and ubiquitous polygyny accompanied by infant bestowal and widow remarriage. It is not yet clear whether polygyny generates the large age bias, the large age bias generates polygyny, or both features are simply “two sides of the same coin”.

The combination of high age bias with high polygyny rate dramatically impacts the shape of Australian Aboriginal generations with regard to generation intervals and age spread. Consider an artificially simple example from any polygynous Australian Aboriginal society in which women begin to reproduce at about age 15 and men at about age 30 (Denham and White 2005).

In this example, a man of age 60 years has two wives, the 1st aged 45 years and the 2nd aged 15 years. By his first wife he has a daughter aged 30 years, a granddaughter aged 15 years and a great-granddaughter aged 1 year. By his 2nd wife, who is the same age as his granddaughter by his 1st wife, he has a daughter aged 1 year. Also he and his 1st wife have a son aged 30 who recently became eligible to marry and now has his first daughter aged 1 year; she is the older man's granddaughter. Thus the older man's direct descendants include three one year old girls, one his daughter, one his granddaughter and one his great-granddaughter. Of course the age factors outlined here ramify rapidly among future descendants and as descendants' spouses are integrated into the sibling-in-law chains.

If we apply the concept of generation exclusively to the parent-child descent relationship in a strictly biological sense, the man in this example has one son and two daughters in G-1. But the more broadly we attempt to define and apply the concept to accommodate cultural / marital as well as biological dimensions, the more problematic it becomes. As differences between female and male generation intervals increase and cascade downward, as age spans of sibling sets increase, and as sibling-in-law chains that define marital generations become increasingly intertwined and distorted through time, the elegant simplicity of Figures 2 and 3 vanishes.

Generation moieties

As if that were not enough, closed symmetric generations, circulating connubia and age biased generations in Australian Aboriginal societies almost always occur in conjunction with the further complication of moieties.

A moiety system divides an entire society into two linked groups of people that assume complementary positions and functions relative to each other. The two groups may be thought of as "halves" of a society. There are several different ways to divide an apple – or a society - into halves. For example, both patrilineal descent moieties (descent through father's and father's father's "vertical" descent line) and matrilineal descent moieties (descent through mother's and mother's mother's "vertical" descent line) divide societies into two different sets of halves (or "sides") on the basis of descent. Both are present simultaneously, either explicitly or implicitly (Houseman 1997; Houseman and White 1998), in most Australian Aboriginal societies and both are exogamous, taking husbands and wives exclusively from the opposite group in the same moiety pair. But generation moieties, unlike descent moieties, divide a society into halves based on "horizontal" layers as shown tentatively in the blue and green helix in Figure 10. They too are present in almost all Australian Aboriginal societies (White, I.M. 1981), often are unnamed and typically are endogamous; i.e., people take husbands and wives exclusively from within their own generations. All three forms of moieties are ubiquitous in Australian Aboriginal societies but are entirely absent from North American and European societies today.

In Australian Aboriginal generation moieties, also known as merged alternating generation levels, Ego's own moiety consists of himself, his brothers, sisters and cousins in G.0, **plus** his grandparents and their siblings and cousins in G+2, **plus** his grandchildren and their siblings and cousins in G-2, yielding a single "composite generation" or "super generation" that includes G+2, G.0 and G-2. The other moiety consists of his parents and their siblings and cousins in G+1 and his children and their siblings and cousins in G-1, yielding another composite generation that includes G+1 and G-1.

A generation moiety is not an age based group; in fact, it contains people of a complete range of ages from youngest to oldest. People are expected to marry within their own generation moiety (G+2, G.0 and G-2), and ordinarily marry within their own generation level (G.0). Members of grandparent and grandchild generations are acceptable as spouses when age differences are appropriate and may facilitate helical closure of age biased systems if it occurs at all. It goes without saying that nobody would ever actually marry his proper grandmother! Marriage into the opposite generation moiety generally is prohibited (Tonkinson 1979; White, I.M. 1981; Dousset 2005).

Isobel White (White 1981) has suggested that dividing societies into two horizontal generation moieties or "super generations" (mine and not-mine) is just as obvious as dividing them into two vertical patrilineal descent lines (mine and not-mine) or two vertical matrilineal descent lines (mine and not-mine). In fact, virtually all Australian Aboriginal societies have all of these kinds of moieties, often unnamed, with two endogamous alternating generation levels as the most widespread system of explicit societal divisions (see Radcliffe-Brown in Levi-Strauss 1949/1969, p.499).

Symmetric and asymmetric kinship terminologies

Scientific models (representations or explanations) of kinship terminologies focus mainly on linguistic properties of, and logical relations among, kinship terms such as father, daughter, mother-in-law and cousin. Kinship terminologies may be thought of as intellectual superstructures that rest "above" the biology of descent and inheritance, "above" the cultural embellishments of generations, and "above" the designations in the Kin Type diagram. Here we briefly touch on the subject and provide external links for further study. For a first encounter with, or a brief review of, kinship terminologies, consult Schwimmer's (2003) Kinship and Social Organization: An Interactive Tutorial listed below under Tutorials.

In four symmetric kinship terminologies (Eskimo, Hawaiian, Iroquois and Sudanese), the distribution of kinship terms on a genealogical diagram (Figure 12) is approximately balanced, equivalent and symmetric on both the patrilineal and matrilineal sides of the diagram. The terms may not be identical on both sides as they are in the English system (known technically as an Eskimo system), but they use the same logic on both sides, and their distribution vertically by generations and horizontally by descent lines on the diagram is basically symmetric on both sides.

Two asymmetric kinship terminologies (Crow and Omaha) are quite different from symmetric terminologies, and have effects similar to those shown in asymmetric marriage systems in Figure 13; viz., they make generations on mother's side of the family different from generations on father's side. In Omaha systems, Ego uses the same term for his mother's brother's son as he does for his mother's brother and the same term for mother's brother's daughter as for his mother (Lounsbury 1964). This results in a partial lumping of generations known as skewing. Often this pattern has the effect of stressing common membership of relatives in patrilineal descent lines. As such Omaha terminologies generally are associated with societies that have a strong patrilineal emphasis in their social organization (McConvell and Alpher 2002; McConvell, in prep.).

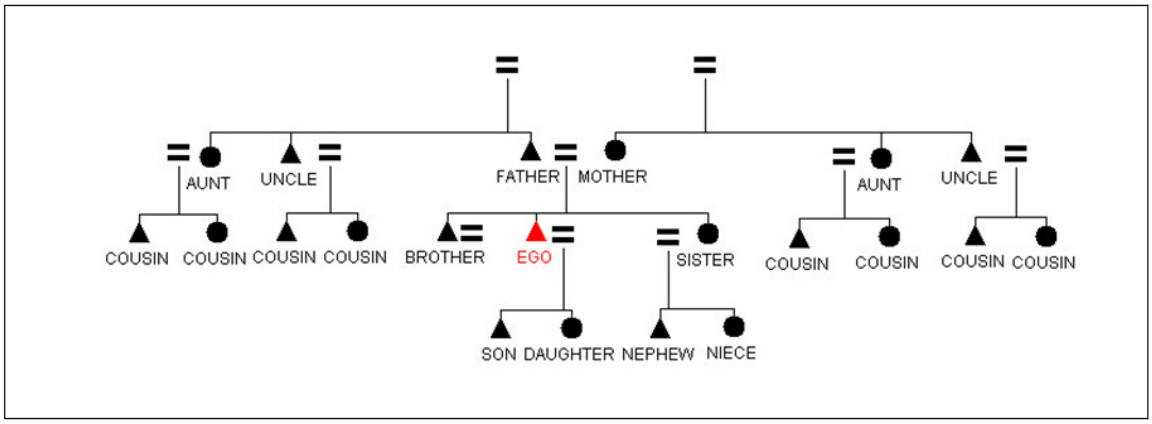


Figure 12. Symmetric English (Eskimo) Kinship Terms. In every case, the "=" represents a marriage even though most spouses have been omitted to reduce clutter in the diagram. The idealized distribution of kinship terms is approximately balanced, equivalent and symmetric on both sides of the diagram, with aunts, uncles and cousins being the same on mother's and father's sides of the family.

The Crow system is a mirror image of the Omaha. Thus father's sister's son gets the same term as father, and father's sister's daughter gets the same term as father's sister. This system generally is found in societies with strong matrilineal kinship emphases.

Omaha and Crow skews may characterize entire kinship systems, or they may be invoked optionally as overlays that temporarily or locally modify symmetric kinship systems (Kronenfeld, 2009; McConvell, in prep.). In principle they probably can co-occur with any of the Australian systems but are distributed discontinuously across the continent.

In both Omaha and Crow systems, skewing rules generally but not always alter the contours of G.0 and G-1 (and in some cases a much broader range of generations) such that cousins who ordinarily would be ego's potential spouses are labeled so that they become unmarriageable; e.g., MBD who could be a marriageable first cousin is re-labeled as "Mother" whom one cannot marry. In one sense, equating members of adjacent generations effaces generational distinctions. In another sense it expands and distorts the range of kin types that belong to a specific "generation", thereby creating "partially classificatory generations" that are in some sense equivalent to classificatory kinship terms in which one term (e.g., Father) applies to people in more than one kin type (e.g., own biological father, father's brothers, classificatory fathers with no known genealogical links to Ego, etc.). Since these systems may designate people Ego should not marry instead of ones he should marry, Levi-Strauss (1966) called them semi-complex systems, intermediate between systems with positive and negative rules.

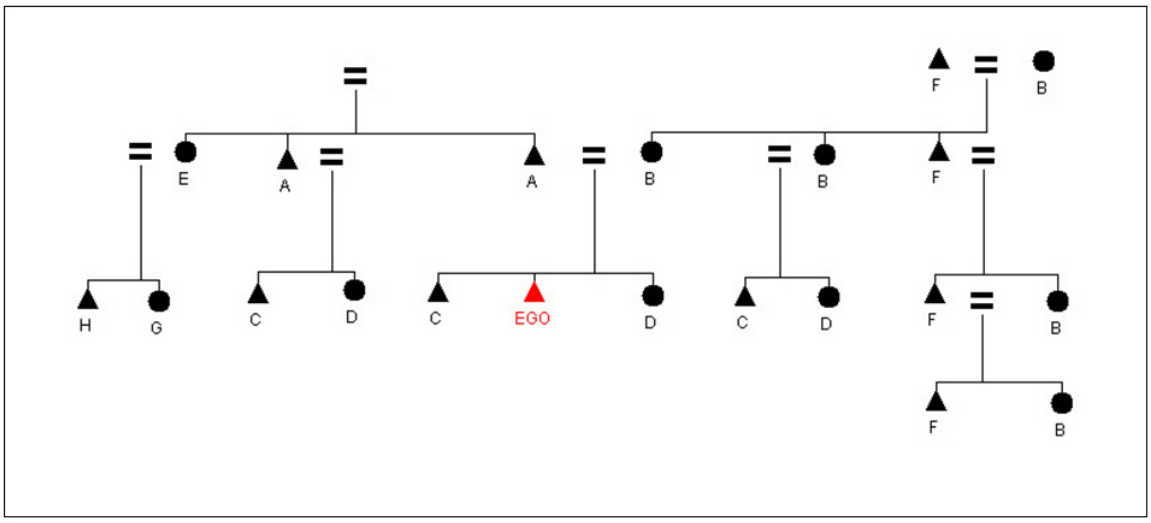


Figure 13. Asymmetric Omaha Kinship Terms. In this diagram, the letters are arbitrary codes representing kinship terms in the Omaha language; i.e., they are NOT abbreviations of kin types or of English language kinship terms. In every case, the "=" represents a marriage even though most spouses have been omitted to reduce clutter in the diagram. On the right side of the idealized diagram, Ego refers to his mother as B and to his mother's brother as F. In addition Ego uses the same term for his mother's brother's son (F) as he does for his mother's brother (F) and the same term for mother's brother's daughter (B) as for his mother (B), and in this example extends the range of the skew to include his mother's father (F) and mother's mother (B), plus his mother's brother's son's children (F, B). In other words, in this example Omaha kinship terminology classifies all of the males in mother's brother's patriline as mother's brothers, and all of the females as mothers, thereby effacing the distinction between generations on the right side of the diagram. Crow kinship terminology does the mirror image of this transformation on the left side of the diagram.

Societal exogamy

Figure 8, and to a lesser extent other diagrams in this set, have major problems that complicate their applicability to biobehavioral aspects of human societies. In general, the problems relate to alternative strategies that contribute to inbreeding avoidance.

First, as noted earlier, when consanguineal first cousins engage in bilateral cross cousin marriage - and especially when spouses are double, triple and quadruple first cousins - the arrangement can lead to significant inbreeding (Bittles 1994). However, members of traditional Australian Aboriginal societies whose generations may be portrayed this way can behave in ways that reduce potential inbreeding based on empirical knowledge of their own reproductive histories despite the fact that they have no theoretical knowledge of biological genetics. a) They can prohibit Ego from marrying FZD while preferring or prescribing that he marry MBD (Radcliffe-Brown 1931), which leaves the diagram more-or-less intact but reduces the density of interrelations among spouses by 50%. b) They can invoke Omaha kinship term overlays (McConvell, in prep.) that preclude marriages with certain MBD who otherwise would be potential spouses. c) They can transform the two-descent-line Kariyarra system that appears in the diagram into a four-descent-line Arrernte system (Spencer and Gillen 1899/1968) that prefers or prescribes that Ego marry a second cross cousin (e.g., MMBDD) instead of a first cross cousin (e.g., MBD), thereby doubling the complexity of the diagram while reducing the density of

interrelations among spouses. d) They can prohibit Ego from marrying any consanguineal cousin while preferring or prescribing that he marry a classificatory cousin with whom he has no known biological ties (*passim* and ubiquitous in the anthropological literature). These options leave the diagram of generations and marriages intact but redefine it as a metaphor rather than a literal map of biological relations among spouses, thereby reducing the density of interrelations among spouses by as much as 100%. Separately and together, these workarounds can significantly reduce the potential negative effects of frequent, close inbreeding by requiring that spouses be more distantly related to each other – pushing marriages outward, away from the core - thereby relaxing or nullifying constraints embedded in the diagram and increasing the robustness of the society.

Second, cognitive boundaries of traditional Australian Aboriginal societies may have been closed as Figure 8 suggests, but the large body of ethnographic data cited earlier demonstrates that their biobehavioral boundaries were open. The omission of exogamy - and of explicit mechanisms for facilitating exogamy - from 20th century diagrams means that the diagrams are silent with regard to vital biobehavioral connections among societies that enabled them to survive for perhaps 50,000 years (Hudjashov et al. 2007). This is not a problem for people who are interested primarily or solely in the logic of kinship terminologies, but it is a serious problem for those who are interested in the long term survival of Aboriginal people and societies.

Third, Figure 8 does not reflect the large mean age difference between female and male generation intervals that is ubiquitous in Australian Aboriginal societies and is much too large to be ignored in any biobehavioral representation of empirical generations. This too is a problem that may be ignored by people who specialize in the logic of kinship terminologies, but it is a much more serious problem for those who are interested in the long term survival of Aboriginal people and societies. Rose (1966), based on his own extensive quantitative data on wife-husband age differences and MBD marriages among the Anindilyakwa, combined with Radcliffe-Brown's (1931) and Spencer and Gillen's (1899/1968) frequent emphases on a strong preference for MBD marriage among Kariyarra and Arrernte, explicitly rejects symmetric representations of these systems on the grounds that they simply could not work in real Australian Aboriginal societies. Perhaps that position is too harsh. Perhaps they cannot work with exclusively consanguineal cousin marriage but can work with preferred or prescribed classificatory cousin marriage, but systematically analyzing those classificatory relationships is devilishly difficult.

The workarounds described here do not solve the problems built into Figure 8, but they enable societies to persist in spite of them.

The Circulating Connubium diagram (Figure 9) by default prohibits Ego from marrying FZD, and societies that use it may prefer or prescribe marriage with classificatory cousins, with or without Omaha overlays, to preclude marriage with selected MBD. So the density of genealogical ties between spouses is at least 50% less, and may be 100% less, than what appears in the Bilateral Cross Cousin Marriage diagram (Figure 8). However, Figure 9 too fails to reflect the large mean age difference between female and male generation intervals. Hence it is a representation of an ideal cognitive system, but by omitting great wife-husband age differences

that are known to characterize Murngin Yolngu (Warner 1937/1958; Keen 1982, 2004) societies, in provides a questionable representation of their empirical biobehavioral generations. It too makes no reference to structures and mechanisms that must have facilitated exogamy at a rate high enough to preclude extinction (Bocquest-Appel and Masset 1982).

The Senior/Junior Marriage System embedded in Figure 10 prohibits Ego from marrying FZD, and societies that use it may prefer or prescribe marriage with classificatory cousins, with or without Omaha overlays to preclude marriage with selected MBD. So, as is true of circulating connubia, the density of genealogical ties between spouses is at least 50% less, and may be 100% less, than what appears in Figure 8. Furthermore, the kinship terminology of senior/junior marriage systems explicitly incorporates the large mean age difference between female and male generation intervals. The result is that the senior/junior marriage system diagram with its built-in age bias is more complex than bilateral and circulating diagrams, but it seems to provide a more realistic representation of empirical biobehavioral generations within societies such as the Wik-Mungkan (McConnell 1950).

The Generic Age Biased Generations diagram in Figure 10 incorporates the idealized unidirectional flow of MBD or MMBDD as spouses, the option of preferring or prescribing marriage with classificatory kin, the optional Omaha overlay that precludes marriage with selected MBD, and the age bias that characterizes the diagram that it shares with senior/junior marriage systems. But senior/junior marriage systems such as Wik-Mungkan, with their recognition of the age bias built explicitly into their kinship terminologies, are quite different from the Anindilyakwa (Rose 1960) and Alyawarre (Denham et al. 1979) where the same generational structure is present but no trace of it appears in their kinship terminologies. In fact, both Anindilyakwa and Alyawarre have kinship terminologies that strongly resemble those of the Arrernte (and Murngin Yolngu), but in both cases statistical analyses of large bodies of biobehavioral data show that bilateral cross cousin exchange is absent and that the unidirectional, diagonal flow of MBD and MMBDD is comparable to that of senior/junior marriage systems. But societies with generic age biased generations possess a degree of statistical flexibility in arranging marriages that is missing from societies with deterministic senior/junior marriage systems.

Furthermore the diagram shared by senior/junior marriage systems and generic age biased generations is the only one in the set that refuses to close upon itself to form neatly stacked circles that characterize endogamous societies. Indeed the lattice can close inward in three dimensions to form a highly complex 2-, 3-, 4-, 5-, or 6-stranded helix with each complete endogamous cycle spanning as much as 250 years, or it can remain flat in two dimensions and metaphorically reach outward to attach exogamously to similar structures in adjacent societies. In other words, it seems to be the only generational structure in the set that defaults to exogamy and probable survival rather than endogamy and possible extinction for very small societies. It may be exceptional but it is hardly aberrant with the negative connotations ordinarily associated with that word.

Theme and variations

The Australian Aboriginal generation structures are introduced above in a sequence that is relatively easy to explain, but there is no convincing evidence to support an argument that the sequence is historical or causal (Allen 2007; Read 2004), or that it is linear or even two-dimensional. The structures and the workarounds that enhance their viability are quantitative, measurable variations on a common theme whose precise nature and dimensions remain under investigation. The diagrams (variations) seem to lie at four points in a complex "theme space", each with its own assets and liabilities. Those nearer the Kariyarra system are elegantly simple in form but because of their compactness and closure they are more vulnerable to genetic, demographic and environmental stochasticity and thrive best when they invoke the workarounds outlined above; i.e., the smaller these societies are, and the more strictly they follow the "rules" embedded in the diagram, the less robust they become. Those nearer the Alyawarre system are more complex in form and because of their openness may be more robust.

Does this contrast suggest that more robust forms are somehow basic and less robust forms are derived specializations; or that less robust forms are somehow basic and more robust forms are derived generalizations? Neither. If indeed these forms constitute labile variations on a theme rather than an evolutionary sequence, questions that imply cumulative, linear, progressive change are simply bad questions. The factors that determine what form a society takes at any point in time and space lie beyond the scope of this tutorial but are addressed in a sequel (Denham n.d.a). Suffice it to say here that incremental step-wise change from one form to any adjacent form is negotiable.

Summary

This tutorial adopts a global perspective to introduce major sets of topics that are important for understanding the great range of complexity in human familial generations worldwide, using examples drawn mainly from Australian Aboriginal societies. It focuses primarily on the forms of generations and some of the measurable factors that determine them. In the process it reviews some of the biological problems associated with various generational forms, and some of the many ways in which Aboriginal people address those problems.

Topics include: a) measurement of familial generations, including generation intervals, birth intervals, generation age spread, polygyny, consanguineous marriages with their concomitant birth defects, and population size and closure; b) shapes of familial generations, including open and closed symmetric generations, circulating connubia, senior/junior marriage systems, generic age biased marriage systems, polygyny and age biased generations, generation moieties, and symmetric and asymmetric kinship terminologies; and c) additional inbreeding avoidance strategies related to societal exogamy.

By emphasizing biobehavioral aspects of kinship and the topography of generations while de-emphasizing traditional concerns with cognitive issues, the tutorial addresses infrequently asked questions that may respond favorably to mathematical analysis in the 21st century.

Alternate spellings

Older spellings	Language codes and preferred spellings (AIATSIS 2011)	
Alyawarra	C.14	Alyawarre
Aranda	C.08	Arrernte
Kariera	W.39	Kariyarra
Murngin	N.116	Murngin Yolngu
Ngarinjin	K.18	Ngarinyin
Wanindiljaugwa	N.151	Anindilyakwa
Wikmunkan	Y.57	Wik-Mungkan
Yolngu	N.116	Murngin Yolngu

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