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A Time to Wean: The Hominid Blueprint for the Natural Age of Weaning in Modern Human Populations

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INTRODUCTION

The primary purpose of this chapter is to attempt to answer one specific question: At what age would human infants be weaned (cease breastfeeding completely) if the process were based only on physiological considerations? That is, acknowledging that humans are primates, and recognizing that lactation and weaning take place according to certain regular patterns in the nonhuman primates, then what do these patterns suggest would be the natural age of weaning in modern humans if these behaviors were not modified by culture? A secondary goal is to put current U.S. weaning practices, and pediatric advice that weaning should take place by 1 year of age, into a broader evolutionary and cross-cultural perspective. In particular, this chapter will evaluate two widespread pediatric "rules of thumb" for determining appropriate weaning age based on biological parameters: tripling of birth weight and equivalence to length of gestation. As will be shown below, both of these rules of thumb are inappropriate. The predictions for a natural age of weaning in modern human populations, based on the nonhuman primate patterns, range between 2.5 and 7.0 years of age. Weaning ages in many traditional[1] societies around the world fall within this range, with most children being weaned between 2 and 4 years of age, while almost all children in the United States are weaned well before 1 year of age. This chapter explicitly does not advocate that children should be nursed

for any specific length of time, but merely attempts to establish the biological "hominid blueprint" for weaning in an attempt to illuminate the mismatch between our evolutionary heritage as primates and current pediatric advice and practice in the United States. In the final section of the chapter, the data presented here are considered in terms of their implications for such issues as pediatric advice, child health, child custody, and assessments of maternal motives and competence.

A brief chapter has to limit its discussion of related issues. Several caveats concerning how I have limited the scope of the chapter follow. First, this chapter is written from the perspective of a middle-class, highly educated North American anthropologist of European descent. I have nursed three children of my own, the longest (so far) for 4 years, and have been active in breastfeeding promotion activities for 15 years. I am committed to the evolutionary perspective, and convinced that there are functional consequences to be considered whenever modern humans deviate from the lifestyle to which our hominid ancestors were adapted. When it comes to infant feeding decisions made by parents, I am an advocate of more thorough discussion of the advantages and disadvantages of different infant feeding choices, so that parents can make informed decisions based on what is currently known about the consequences of the different choices for their children and for themselves. I am assuming that the primary audience for this work consists of health care professionals in the United States, including obstetricians, gynecologists, pediatricians, nurses, and lactation consultants, as well as La Leche League leaders and members, again primarily in the United States.

Questions of *why* age at weaning in primates is correlated with various life-history variables, such as multiples of birth weight, fractions of adult body mass, or age at eruption of the first permanent molar, are beyond the scope of this chapter. Nor is it the purpose of this chapter to discuss age at weaning in terms of whether or not it constitutes a biologically meaningful developmental landmark (although I am convinced that it does). Rather, this chapter looks at the *culturally* meaningful—at least in the United States—developmental landmark of weaning, and asks what the correlations discovered among the nonhuman primates suggest might be the biological blueprint for this landmark in modern humans.

Finally, this chapter touches only briefly on a few of the possible implications of an abbreviated duration of lactation on the health of modern human infants. This topic is addressed at some length in the other chapters in this book, and will be illuminated fully only in the future, as the result of further research.

BACKGROUND

Beginning in the 1950s, ethnographic evidence has been accumulating that the systems of beliefs and practices surrounding infant feeding—breastfeeding, the addition of solids, and weaning—vary dramatically from culture to culture, just as systems of kinship and marriage, religious beliefs, subsistence strategies, and political orders vary. Cross-cultural studies of breastfeeding "came of age" in the 1980s, with the publication of a number of books and articles providing detailed descriptions of this most basic of human activities, based on careful, longitudinal field studies by anthropologists. Early on, it became clear that like every other human activity studied from the anthropological perspective, breastfeeding is both a biological process and a heavily *culturized* activity. As a biological process, it is firmly grounded in our mammalian ancestry and absolutely critical to the survival of the species. As a heavily *culturized* activity, it is modified by a wide variety of beliefs, not only about infant health and nutrition, but also about the nature of human infancy and the proper relationships between mother and child, and between mother and father. In addition, breastfeeding practices are affected by such disparate influences as religious beliefs, the structure of the mother's everyday work activities, and seemingly unrelated ideas about personal independence and autonomy.

Understanding of the complex relationships between culture and biology as expressed through the breastfeeding process is only beginning. Beliefs and practices can affect the frequency and length of breastfeeding episodes both during the day and at night; this, in turn, can affect both quality and quantity of milk production. Beliefs and practices can determine the duration of breastfeeding, whether or not the mother nurses into a subsequent pregnancy, and where the child sleeps at night. Beliefs about the appropriate length of time children should nurse affect birth spacing, maternal nutritional status, and children's physical and emotional health and growth.

As primates, humans are members of the class Mammalia, so named for their practice of providing nutrition to their young through the mammary glands of the mother. As members of the order Primates within the class Mammalia, humans have inherited a basic primate pattern of breastfeeding activity. The African Great Apes (gorillas and chimpanzees) are our closest primate relatives, sharing a common ancestor with humans some five to seven million years ago, as well as sharing more than 98% of their genetic material with humans today. It is reasonable to assume that our earliest hominid ancestors followed breastfeeding and weaning patterns similar to those seen among the African Great

Apes today. At the same time, since at least the time of the earliest *Homo* some two and a half million years ago, humans have been modifying the basic primate pattern to conform with beliefs. Indeed, the rise of the infant formula industry in Western industrialized countries during this century and the specifically American (U.S.) practice of solitary infant sleeping represent only the latest in a long line of cultural practices that have led us away from our primate heritage, which was molded by natural selection over millions of years to meet the specific needs of human infants. The enormous costs to children's physical health of *not* breastfeeding have been well documented for both third world and Western industrialized countries (Cunningham, Chapter 9, this volume; Cunningham, Jelliffe and Jelliffe, 1991; McKenna and Bernshaw, Chapter 10; Walker, 1993). The cognitive and emotional costs are more difficult to measure, but evidence is slowly accumulating that these costs may be as profound and far-reaching as the costs to physical health (Rogan and Gladen, 1993; Walker, 1993).

As a first step to understanding how far modern humans have strayed from the hominid blueprint for optimal physical, cognitive and emotional infant health, developed over millions of years of evolution as bipedal hominids foraging on the East African savannah, one can ask the following question: What would modern human breastfeeding and weaning patterns look like if they were not modified by beliefs? What is the "hominid blueprint," the underlying biological basis, for breastfeeding and weaning behavior in modern humans? This seemingly simple question is really quite complex, and includes several components: How often should infants nurse?[2] When should solid foods be added to the diet? Is it normal for infants to wake up often at night to nurse? And, perhaps most critically, at what age should infants be weaned (i.e., stop nursing altogether)? This chapter will be concerned primarily with the last question.

Where can we turn for evidence of this hominid blueprint? Unfortunately, we cannot go back in a time machine to the East African savannah during the Plio-Pleistocene and conduct participant-observation research. We can, however, examine the cross-cultural evidence from low-technology, nondairying human societies, as others have done (Short, 1984). Members of these societies modify the basic primate pattern with beliefs like all humans, but they have fewer options for replacing human breast milk with substitutes than do members of Western industrialized societies, and they still (for the most part) regard women's breasts as body parts designed exclusively for feeding infants, rather than as sexual objects.

A number of early ethnographic sources provide information about weaning age in "traditional" societies before the widespread use of artificial infant formulas. This early cross-cultural literature is fairly consistent in reporting that children are often weaned between 2 and 5 years of age across a wide variety of traditional cultures. For example, in 1931 Shelton reported a weaning range of 3 to 5 years among "so-called primitives and so-called backward-peoples who have no supplies of animal milk with which to supplant mother's milk" [Shelton, 1970:133 (1931)]. In 1945, Clellan Ford published the results of a systematic survey of human reproduction based on data from 64 societies, available from the Human Relations Area Files (Ford, 1964). He reported:

> The length of the nursing period varies markedly from society to society. The average age of weaning in our tribes is between three and four years. In a few societies complete renunciation of the breast is deferred until the age of six or even longer. . . . In the great majority of our tribes other foods are given to the baby, supplementing the breast milk. . . . Quite regardless of the availability and use of other suitable foods, weaning seems to be delayed as long as it is at all possible in the great majority of our primitive societies. (1964:78–79)

Finally, in a review of the literature on "primitive peoples," Wickes reported: "The duration of lactation varies considerably from one tribe to another but the average would appear to be from three to four years" (Wickes, 1953:151).

The data cited above were not collected by ethnographers specifically interested in breastfeeding and weaning patterns, and probably represent ideals or cultural norms, in contrast to the "hard data" on weaning age collected prospectively by modern ethnographers. At the same time, there is no reason to suspect that early ethnographers would have distorted or misrepresented these types of data, and no reason to suspect that informants would have any reason to mislead the ethnographers. The data suggest that prior to the widespread availability and promotion of Western artificial infant feeding products, children across the globe were routinely nursed for 3 to 4 years.

Unfortunately, utilization of the cross-cultural literature on duration of breastfeeding is often dismissed by health professionals because of widespread ethnocentrism—after all, those people are "primitive" and we should not base our modern infant care patterns on what people do in faraway lands (or so they say, as they dismiss years of careful anthropological research). We can, however, look at breastfeeding and weaning behavior among the modern nonhuman primates, our closest relatives in the animal world. Evidence based on the nonhuman primates should carry more weight than the cross-cultural data, as nonhuman primates are commonly presumed not to have beliefs that affect their breastfeeding and weaning behavior. In addition, health profes-

sionals routinely cite two "rules of thumb" for what an appropriate weaning age in humans would be, based on age at weaning in other mammals. What, then, *is* the "hominid blueprint" for breastfeeding and weaning behavior?

To answer this question, we can turn to the literature on life history studies of primates. Harvey and Clutton-Brock (1985) provide a compilation of data from studies of 135 primate species, providing information on such variables as length of gestation, age at weaning, and life expectancy, all based on primary field observations by primatologists. In addition to their summary work, there is a small but steadily growing body of literature on primate life history comparisons, which will be summarized below. Surprisingly, to date none of the researchers in this specialized field has made the connection between their studies and modern human behavior. Indeed, one of these researchers was unaware of the controversy in the United States surrounding the question of how long human infants should breastfeed (B. Holly Smith, personal communication).

The purpose of this chapter is to examine the literature on comparative primate life histories and make explicit the implications of this information for our understanding of the hominid blueprint for modern human breastfeeding and weaning behavior, by evaluating the various ways of arriving at a natural age of weaning for humans based on the comparative primate data.

NATURAL AGE AT WEANING IN HUMANS AS DERIVED FROM THE COMPARATIVE NONHUMAN PRIMATE LIFE HISTORY DATA

In this chapter, the term *weaning* refers to the time when the infant is no longer allowed to nurse from its mother's breast, i.e., to the complete cessation of breastfeeding. The use of the term *weaning* to denote complete cessation of breastfeeding recognizes that nonmilk foods will be added to the diet of the infant long before weaning takes place. In all primate species, and in all human cultures studied to date, children receive additional foods from an early age. In most cultures, in addition to various medicines, teas, and "tastes" of other foods given to children in the first few months of life, solid foods are added to the infant's diet gradually from about 6 months. The particular pattern in each culture depends on a number of biological and cultural factors including the baby's size, health, and interest in food, the number of teeth erupted, the kinds of foods available that are thought to be suitable for children

(often those that are easy to chew and digest), and beliefs about the appropriate age for solids to be offered. Nonhuman primates and children in traditional cultures worldwide normally experience several years of a transitional diet, with steadily increasing amounts of solid foods in addition to breast milk. The breast milk component of the diet continues to provide an excellent, uncontaminated source of protein as well as of immunological factors, and may be the only food the child desires or can tolerate during illnesses. In addition, the process of breastfeeding itself has consequences for the physical and emotional maturation of the child that cannot be met by other means.

Age at weaning in nonhuman primates and other animals is assumed to be primarily a function of genetics and instinct, with some environmental component relating to child growth thrown in for good measure. The ethnographic literature has revealed great variation in age at weaning among humans, from birth (no breastfeeding at all) to extremes of 15 years (Wickes, 1953), so we know that in humans, beliefs can modify this life history parameter out of all recognition. However, it should be possible to establish a "natural" age at weaning among humans by examining the relevant comparative primate data.

In the sections that follow, I will examine the comparative primate data with reference to the relationship between age at weaning and (1) tripling or quadrupling of birth weight, (2) attainment of one-third adult weight, (3) adult female body weight, (4) length of gestation, and (5) age at eruption of the first permanent molar. Where appropriate, determinations based on data from modern human populations of various adult body sizes are presented.

Researchers who study life history variables have documented a number of general trends among mammals in general, and primates in particular, relating body size to length of the various life stages. Compared to other mammals, primates tend to have longer periods of gestation and infant dependency, and longer life spans. They also tend to have relatively large brains for their body size. Within the order, primate subfamilies that have relatively large neonates (high birth weight to adult weight ratios) have relatively long gestation, late age at weaning, late age at sexual maturity, long life spans, and large neonatal and adult brain sizes, when compared to subfamilies that have relatively small neonates (Harvey and Clutton-Brock, 1985). Finally, "larger primates tend to wean their offspring later relative to their body size than is the case for other mammalian orders" (Harvey and Clutton-Brock, 1985:577). Thus, we would expect humans, as large primates with relatively large neonates, to have among the latest ages at weaning of the order. What, specifically, can we predict from the comparative primate data?

Weaning According to Specific Multiplication of Birth Weight

The idea that mammals generally wean their offspring when the offspring have tripled their birth weight is widely reported in the breastfeeding literature, from medical texts to paraprofessional and lay publications. This "rule" that weaning occurs naturally at tripling of the birth weight is widely accepted and has assumed almost the status of law. For example, Ruth Lawrence's book, *Breastfeeding: A Guide for the Medical Profession*, is consulted by many medical professionals for information on breastfeeding management. Lawrence writes:

> When weaning time is correlated with birth weight in placental mammals, a ratio of 3:1 is noted, that is, *weaning takes place when birth weight has tripled*. (1989:245, emphasis added)

More recent research has reexamined the evidence for linkages between age at 'weaning' and the attainment of "a critical or threshold body weight attained by offspring among large-bodied mammals: the anthropoid primates, ungulates, and pinnipeds" (Lee, Majluf and Gordon, 1991:99).[3] Contrary to earlier reports, which may have been influenced by the inclusion of many small mammals, Lee and colleagues found that 'weaning' occurred when offspring had *quadrupled* their birth weight, regardless of the length of time it took to achieve this milestone of growth. Specifically, they reported:

> Weaning weight appeared to be a relatively constant proportion of neonatal weight such that when a weight of around four times birth weight is reached infants are weaned, irrespective of the *time* taken to achieve weaning. (Lee, Majluf and Gordon, 1991:104)

Thus, a thorough study of the relationship between growth and 'weaning' in large mammals suggests that *tripling* of birth weight, so widely reported in the literature, is not an apparent "weaning trigger" for large mammals, but that *quadrupling* of birth weight may be. When do human infants quadruple their birth weight? Lee, Majluf and Gordon (1991) provide figures for both "captive/food enhanced" and "wild/food limited" human populations to see if the predicted relationship holds. Their data seem to show that weaning takes place in humans when infants reach about 9 kg of body weight, which takes 9 months for their "captive/food enhanced" population, and 36 months for their "wild/food limited" population. Unfortunately, the data they used for this comparison are inappropriate. If 9 kg represents a quadrupling of birth weight,

then these populations have very low birth weights (around 5 pounds). In addition, the two populations are assumed to have identical birth weights even though they grow into very different sized adults. The "wild/food limited" population cited is the !Kung, who are light and short as adults. Furthermore, they are not particularly food limited, according to the long-term research of Richard Lee (1993).

In view of the curiously inappropriate data for humans cited by Lee, Majluf and Gordon (1991), we can still ask the question: When would a quadrupling of birth weight typically occur in modern human populations? As they attempted to do, we can divide modern humans into those who come from generally healthy, well-nourished modern industrialized societies (represented by the World Health Organization/National Center for Health Statistics standards; Hamill, Drizd, Johnson, Reed, Roche and Moore, 1979) and those who live under third world conditions (represented by data collected by the author in a periurban community outside of Bamako, Mali, in West Africa; Dettwyler, 1985).

The WHO/NCHS standards are based on large samples of populations living in the United States. Most of these individuals have access to good medical care, including immunizations, and suffer from few diseases. They live under generally good sanitary conditions, and generally enjoy adequate (often more than adequate) diets. In particular, parents in the United States have easy access to a wide variety of nutrient-rich weaning foods, which come fully prepared in convenient, uncontaminated, individual servings (in the form of several brands of pureed baby foods in glass jars). According to the NCHS standards, the 50th percentile for birth weight for males is 3.27 kg (7 lb 3 oz). A quadrupling of that birth weight, to 13.08 kg (28 lb 12 oz), occurs at around 27 months of age (50th percentile). For females, the figures are 3.23 kg at birth, with a quadrupling of birth weight to 12.92 kg at around 30 months. Thus, for Western industrialized countries, a quadrupling of birth weight is achieved, in general, sometime between 2 and 3 years of age (Table 2.3).

The data from Mali are based on a much smaller sample from a periurban population living in West Africa. Most of these individuals have little or no access to modern medical care, have no access to immunizations, and suffer from many diseases, particularly measles, malaria, and gastrointestinal and upper respiratory infections. They live under generally poor sanitary conditions, and often have inadequate diets, especially for the children. In particular, parents in Mali have mainly nutrient-poor weaning foods, such as bulky carbohydrate-based porridges, to feed their children during the first few years of life. As in many other third world populations, growth in these children is gener-

ally good for the first 6 months of life, but falls away sharply from the NCHS standards during the latter part of the first year, and in the second and third years of life. According to data collected by the author in 1981–1983, average birth weight for males is 3.12 kg. A quadrupling of that average, to 12.48 kg, had not been reached by 36 months of age (Dettwyler, 1985:255), at which time the average weight was only 11.58 kg. For females, the figures are 2.78 kg at birth and 11.12 kg at quadrupling, an average value reached between 30 and 36 months. Thus, for one fairly representative periurban third world population, a quadrupling of birth weight is achieved, in general, after a minimum of 2.5 years for girls, and more than 3 years for boys (Table 2.3).[4]

Throughout the foregoing discussion, I have placed the word *weaning* in single quotes, for a specific reason. In their study, Lee, Majluf and Gordon did not use "cessation of breastfeeding" as their definition of weaning for primates and elephants. Rather, they defined weaning for these animals as "the average age of the offspring when reconception took place," noting that "duration of lactation as defined for these species relates to the period when the offspring is highly dependent on milk and is suckling at frequencies likely to inhibit a successful consecutive conception" (Lee, Majluf and Gordon, 1991:101). In other words, and as the authors admit, in many primates species "this time generally does not correspond to 'weaning' defined as the cessation of suckling, since suckling at low levels in many species continues through pregnancy until subsequent parturition" (Lee, Majluf and Gordon, 1991:101). Thus, any estimated age at weaning, if it is defined as complete cessation of breastfeeding, should include the time it takes for quadrupling of birth weight, plus several additional months of "suckling at low levels."

The time it takes to quadruple birth weight in humans is much more than the time it takes to triple birth weight. Growth in weight during the first year of life is relatively rapid. While tripling of birth weight in modern populations usually takes about 1 year, growth slows dramatically during the second year of life, and quadrupling of birth weight does not take place for at least another year. The evidence provided by Lee, Majluf and Gordon (1991) allows us to establish a natural age of weaning (complete cessation of breastfeeding) in humans as *some months after quadrupling of birth weight*, which would be close to 3 years of age for well-nourished, healthy populations, and between 3 and 4 years of age for marginally nourished populations dealing with multiple disease stresses.

While the old "rule of thumb" of weaning when birth weight had tripled was promoted based on knowledge available at the time, more recent examination of the data compels us to revise this estimated age of weaning upward to some months after quadrupling of birth weight.

Weaning According to Attainment of One-third Adult Weight

An alternative to looking at the correlation between weaning (complete cessation of breastfeeding) and multiples of birth weight is to look at weaning and progress toward attaining adult weight. The exact nature of the link between age at weaning and rate of growth is not known, but seems to be strong across a wide variety of mammalian species. According to Charnov and Berrigan: "On average, primates are like other mammals in weaning each offspring when they reach about one-third their adult weight" (Charnov and Berrigan, 1993:192, citing Charnov, 1991 and 1993). What does this mean for humans?

One problem is how to define "adult weight" for humans, since human populations occupy many different ecological niches, and exhibit greater variation in average body weight than nonhuman primate species living within a restricted geographic range. Rather than select one population as representative of all humans, it might be more instructive to use several human populations with a range of adult body sizes, and then examine the range of variation in predicted ages of weaning.

For extralarge Inuit (Eskimo) populations, average adult weight for males is 71.2 kg, and for females is 64.5 kg (Jamison, 1978). On the basis of these data, natural weaning for boys would occur at 23.7 kg, a weight that is reached by most boys between 6 and 7 years of age. Natural weaning for girls would occur at 21.5 kg, around 6 years of age.

For large-bodied human populations (healthy and well-nourished), we can use the WHO-NCHS data for 18 year olds to define "adult weight" and the WHO-NCHS growth data to determine when one-third of this weight is reached in large-bodied populations (Hamill et al., 1979). In this large U.S. sample, average adult weight for males is 69.0 kg, and for females is 57.0 kg. On the basis of these data, natural weaning for boys would occur at 23 kg, at around 7 years of age, and for girls at 19 kg, around 5.75 years of age.

For medium-bodied human populations (not as healthy, not as well-nourished), we can use data from rural Malian (ethnically Bambara) populations. In a rural Bambara sample, adult weight for males averaged 58.8 kg (N=121), and adult weight for females averaged 53.6 kg (N=320) (Dettwyler, 1992:314). Using these adult data, natural weaning for boys would occur at 19.6 kg, at around 7 years of age (Bambara males at 7 years of age have an average weight of 19.52 kg (N=25) (Dettwyler, 1991:452)). In this sample, natural weaning for girls is predicted to occur at 17.9 kg, at around 6 years of age (Bambara females at 6 years of age have an average weight of 17.98 kg (N=20) (Dettwyler, 1991:452).

For small-bodied human populations (similar in health and nutrition-

al status to the Bambara), we can use data from the !Kung. The !Kung adult body weight for males averaged 47.91 kg (N=79), and adult weight for females averaged 40.08 kg (N=74) (Truswell and Hansen, 1976:172). Using these adult data, natural weaning for boys would occur at 16.0 kg, at around 5 to 6 years of age. Natural weaning for girls would occur at 13.4 kg, at around 4 to 5 years of age.

The natural ages at weaning for Inuit, U.S., and Bambara children as determined on the basis of growth patterns and adult body size are remarkably consistent (Table 2.3). Across populations with very different adult body sizes, children reach one-third their adult weight at 7 years of age for males, and 6 years of age for females. In the smaller-bodied !Kung populations, one-third adult body weight is reached earlier, at 5 to 6 years for males, and 4 to 5 years for females. If Charnov and Berrigan (1993) are correct in their assertion that primates wean their offspring when they reach one-third adult weight, then 4 to 7 years of nursing appears to be the appropriate range for *Homo sapiens*, with boys generally being nursed longer than girls.[5]

Weaning According to Adult Body Size

In 1985, Harvey and Clutton-Brock published their compilation of comparative life history data for 135 primate species. They examined the relationships among such variables as adult body weight (by sex), gestation length, birth weight, number in litter, weaning age, age at sexual maturity, interbirth intervals, and neonatal and adult brain weights, as well as others. For humans, they used adult body weights from the !Kung (40.10 kg for females and 47.90 kg for males) as their weight data for representative humans. For weaning age in humans, they used 720 days, a figure that did not come from the !Kung, who generally nurse for much longer than 2 years. Shostak reports that 3 or 4 years is typical for the !Kung (Shostak, 1976), while Howell states that among the Dobe !Kung, "the mother breast-feeds the baby until either the baby dies, the baby outgrows the need or desire for breast milk (*which does not seem to happen before the age of 4 or 5 or even 6* [years]), or the mother becomes pregnant again" (Howell, 1976:145, emphasis added).

Harvey and Clutton-Brock (1985) found that most of the variation in the life history variables they considered occurred between subfamilies, with relatively little variation among species within a genus, or among genera within a subfamily. At the subfamily level in primates, including humans, the correlations between weaning age and the other variables were quite high (Table 2.1).

Harvey and Clutton-Brock also found that many of the life history

Table 2.1. Correlation of Weaning Age with Other Life History Variables in Primates, Analyzed by Subfamily Level Data[a]

Life history variable	*Correlation with weaning age*
Female weight	0.91
Male weight	0.92
Gestation length	0.84
Weight of individual neonates	0.94
Number of offspring per litter	−0.56
Length of estrous cycle	−0.17
Age at first breeding for females	0.90
Age at sexual maturity for females	0.92
Maximum recorded life span	0.70
Interbirth interval	0.89
Age at sexual maturity for males	0.93
Neonatal brain weight	0.89
Adult brain weight	0.91

[a] Data from Harvey and Clutton-Brock (1985).

variables were closely tied to average adult body size within each subfamily. From their data, they derived regression equations for the prediction of the various life history variables as a function of adult female body weight. Their equation for calculation of weaning age is

weaning age in days = 2.71 X adult female body weight in grams.[56]

Once again, several different human populations are examined to include the range of variation in adult body size in modern humans. For small-bodied humans such as the !Kung, with an average adult female body weight of 40.10 kg, the regression equation predicts an age at weaning of 1022 days (2.80 years). For medium-bodied humans such as rural Malians (ethnically Bambara), with an average adult female body weight of 53.6 kg, the regression equation predicts an age at weaning of 1205 days (3.30 years). For large-bodied humans such as people in the United States (NCHS data), with an average adult female body weight of 55.35 kg, the regression equation predicts an age at weaning of 1228 days (3.36 years). For extralarge-bodied humans such as the Inuit, with an average adult female body weight of 64.5 kg, the regression equation predicts an age at weaning of 1338 days (3.66 years).

Thus, using Harvey and Clutton-Brock's equation, a natural age at weaning in modern humans might be between 2.8 and 3.7 years, depending on average adult female body weight (Table 2.3). As a final note, it should be pointed out that because Harvey and Clutton-Brock

used the relatively young weaning age of 720 days for *Homo sapiens* in developing their overall regression equation for primate subfamilies, all predictions based on that formula will underestimate the weaning age for all primates, including humans. Thus, the numbers derived above for small-, medium-, and large- and extralarge-bodied humans should be considered minimum ages at weaning.

Weaning According to Gestation Length

It is often reported in the breastfeeding literature that weaning age is approximately the same as the length of gestation. For example, Lawrence (1989) writes:

> As a general rule, the smaller the animal, the shorter the time required for both gestation and maturation of the young. *The weaning process is a gradual one, terminating after a time approximately equal to the period of gestation.* The elephant's gestational period is 20 to 21 months, and the young are totally weaned at about 2 years of age. (Lawrence, 1989:245, emphasis added)

The clear implication for humans is that weaning should be expected to take place after only 9 months of breastfeeding, and this relationship is often cited by pediatricians to justify and legitimize their advice to mothers to stop nursing their children. While it is true that the duration of gestation is approximately equal to the time spent nursing for some mammals (e.g., laboratory rats and rabbits, John Bauer, personal communication), the relationship does not hold true across all families and orders. Harvey and Clutton-Brock provide data on life history variables for 135 primate species (1985:562–566, their Table 1); 36 entries include information on both length of gestation and weaning age. The data for weaning age and gestation length in these 36 species are presented in Table 2.2 (extracted from Harvey and Clutton-Brock, 1985), and Figure 2.1, arranged according to increasing adult female body weight.

Overall, the average weaning age/length of gestation ratio for these 36 species is 1.63. That is, on average, primates nurse for just over one and a half times longer than their length of gestation, rather than having weaning age be approximately equal to length of gestation. According to Harvey and Clutton-Brock (1985), the correlation between length of gestation and age at weaning is 0.84. However, a careful examination of Table 2.2 and Figure 2.1 shows that, because the range of variation in primates is extremely wide, the average figure of 1.63 is essentially meaningless.

For many of the small-bodied primates, the weaning age/length of gestation ratio is less than 1.00 (i.e., duration of breastfeeding is shorter than length of gestation). For example, species of galago, tarsier, callimico, and callithrix all have ratios in the 0.41 to 0.43 range (duration of breastfeeding less than half the length of gestation). *Aotus* is the smallest

Table 2.2. Comparison of Gestation Length (in Days) and Age at Weaning (in Days) across Primates Species[a]

Genus and species in order by adult female body weight	*Weaning age*	*Gestation length*	*Weaning/gestation ratio*
Microcebus murinus	40	62	0.65
Cebuella pygmaea	90	136	0.66
Tarsius spectrum	68	157	0.43
Galago senegalensis	75	124	0.60
Callithrix jacchus	63	148	0.43
Arctocebus calabarensis	115	134	0.86
Saguinus fusicollis	90	149	0.60
Saguinus midas	70	127	0.55
Callimico goeldii	65	154	0.42
Leontopithecus rosalia	90	129	0.70
Galago demidovii	45	111	0.41
Lepilemur mustelinus	75	135	0.56
Aotus trivirgatus	75	133	0.56
Perodicticus potto	150	193	0.78
Miopithecus talapoin	180	162	1.11
Nycticebus coucang	90	193	0.47
Galago crassicaudatus	90	135	0.67
Lemur fulvus	135	118	1.14
Lemur catta	105	135	0.78
Varecia variegatus	90	102	0.88
Propithecus vereauxi	180	140	1.29
Macaca fascicularis	420	162	2.59
Hylobates lar	730	205	3.56
Alouatta palliata	630	187	3.37
Lagothrix lagothricha	315	225	1.40
Hylobates klossii	330	210	1.57
Cercocebus albigena	210	177	1.19
Macaca nemestrina	365	167	2.19
Ateles fuscipes	365	226	1.62
Colobus satanas	480	195	2.46
Indri indri	365	160	2.28
Papio anubis	420	180	2.33
Theropithecus gelada	450	170	2.65
Pan troglodytes (chimpanzee)	1460	228	6.40
Pongo pygmaeus (orangutan)	1095	260	4.21
Gorilla gorilla	1583	256	6.18

[a] Data from Harvey and Clutton-Brock (1985).

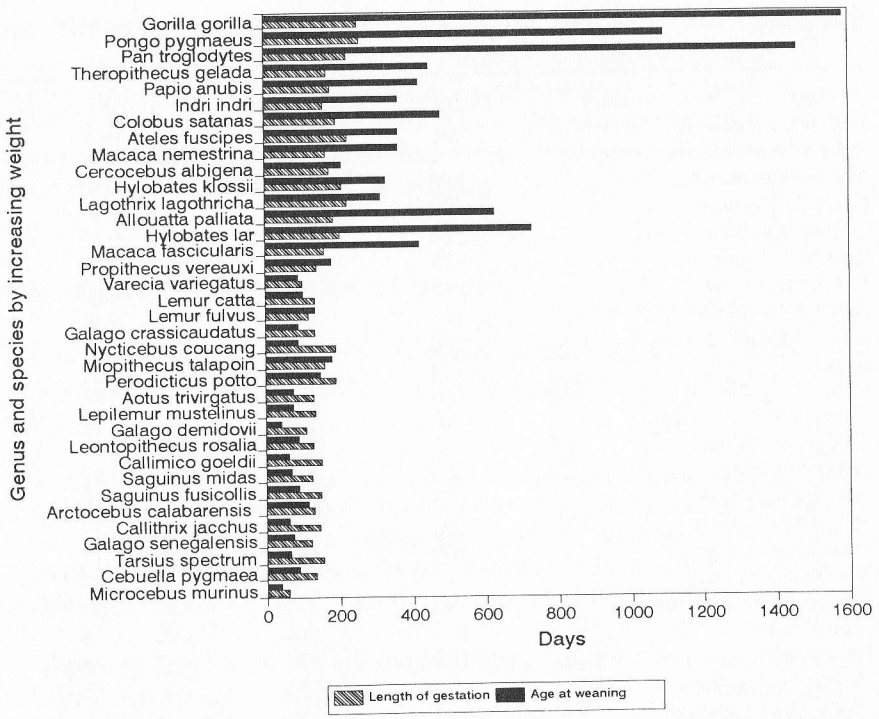

Figure 2.1. Relationship of gestation length to age at weaning in nonhuman primates.

of the New World monkeys, by weight, and has the lowest weaning age/length of gestation ratio (0.56) of the New World monkeys. For all of the larger primates, the weaning age/length of gestation ratio is greater than 1.00 (duration of breastfeeding longer than length of gestation). Among the Old World monkeys, and lesser apes, ratios range from a low of 1.11 for the relatively tiny *Miopithecus talapoin* (monkey) to 3.56 for the medium-sized *Hylobates lar* (gibbon). Among the Great Apes, the closest living relatives of humans, the ratios are 4.21 for *Pongo pygmaeus* (orangutan), 6.18 for *Gorilla gorilla* (gorilla), and 6.40 for *Pan troglodytes* (chimpanzee). Thus, among large-bodied primate species, the average duration of breastfeeding far exceeds the average length of gestation. For humankind's closest relatives, the chimpanzees and gorillas, the duration of breastfeeding is more than six times the length of gestation (Figure 2.1). Humans are among the largest of the primates, and share more than 98% of their genetic material with chimpanzees and gorillas. Interpolating from these comparisons, an estimated natural age at weaning for humans would be a minimum of six times gestation length: 54 months, or 4.5 years (Table 2.3).

The data presented in Table 2.2 and Figure 2.1 provide clear evidence against the commonly held notion that length of breastfeeding is approximately equal to the length of gestation for mammals in general, for primates across the order, and for humans in particular. The fact that laboratory rats, rabbits, and elephants exhibit a weaning age/length of gestation ratio of 1.00 does not mean that humans should also.[6] A more appropriate ratio for humans, based on the comparative primate data, would be close to 6.00.

Weaning According to Timing of Eruption of the First Permanent Molar

In a series of articles, Smith reported a very close correlation between age at first permanent molar eruption (M1) and weaning in 21 different primate species (Smith, 1989, 1991a,b, 1992). She states: "One variable, age at weaning, shows both a high correlation ($r = 0.9$) and isochrony with age of first molar eruption. Indeed, age at weaning is more than isochronic with age at eruption of the first permanent molar; these two variables are, in fact, approximately equal" (Smith, 1992:138). In other words, among many primates, offspring are weaned at the same time that they are erupting their first permanent molars. This relationship estimates a natural age at weaning of 5.5 to 6.0 years for humans (Table 2.3).

The timing of eruption of the teeth in humans is under strict genetic control, with only a small environmental component. Even under conditions of severe dietary and disease stress, children continue to erupt their teeth on schedule (Garn and Bailey, 1978). The isochronous relationship between age at weaning and eruption of the first permanent molar suggests that the factors that underlie age of weaning in nonhuman primates may have a strong genetic basis as well. Smith suggests that "It seems reasonable that weaning to an adult diet might be timed to coincide with appearance of the first permanent molar, for this tooth should enhance a juvenile's ability to process food" (Smith, 1992:138). Thus, Smith implies that eruption of the first permanent molar allows the juvenileto survive *nutritionally* without breast milk. This, in turn, would account for weaning at this time.

On the other hand, juvenile nonhuman primates, like young humans, have a full set of deciduous teeth to help them process food long before they are weaned from the breast. By 24 to 30 months, most human children have a full set of 20 deciduous teeth. It is more likely

that reaching a certain developmental age along the pathway to full maturity is marked in the primates both by eruption of the first permanent molar and by complete weaning from the breast.

In humans, achievement of adult immune competence occurs at approximately 6 years of age, the same time as first permanent molar eruption. The fact that children's immune systems do not become mature until 6 years of age is understandable if we assume that the active immunities provided by breast milk were normally available to the child until about this age. Until the age of 6 years, the child's active immune response (both serum and secretory) can be enhanced by the lymphokines in maternal milk (Hahn-Zoric, Fulconis, Minoli, Moro, Carlsson, Böttiger, Räihä and Hanson, 1990; Pabst and Spady, 1990). Children need these lymphokines, even in small amounts, to augment and prime their own immune responses to stress until they achieve adult levels of immune competence (IgA, IgG, IgM) at the age of 6 years (Doren Fredrickson, personal communication). It may be that eruption of the first permanent molar in nonhuman primates is also isochronous with achievement of adult immune competence, which allows the juvenile to survive *immunologically* without breast milk. This, in turn, would account for weaning at this time.[7]

It is possible that both nutritional and immunological benefits from breastfeeding continue to 6 years of age. Finally, it is possible that the conjunction of weaning, first permanent molar eruption, and achievement of adult immune competence is the result of several different and unrelated genetic factors affecting rates of development in primates.

DISCUSSION

Why is it important that we understand the primate biological pattern on which human beliefs have been overlain? The answer to this question is not merely of academic interest, but has implications for a number of issues facing health professionals and parents in the United States today. For example, recent court cases have involved charges of abuse and neglect leveled against women who nursed their children into toddlerhood. Extended nursing has also been used against mothers in court battles over child custody during divorce proceedings, in which the father has requested custody of a nursing child. Judges in such cases have awarded custody of a nursing toddler to the father, ignoring the intense physical and emotional relationship between the nursing child and its mother, in some cases citing the mother's "failure to wean in a timely manner" as evidence of the mother's unsuitability as a parent. In

one case, custody of a nursing 4 year old was awarded to the father, in part because a psychologist, testifying on the father's behalf as an expert witness, stated "you have to be crazy to nurse that long" (Lawrence, 1989:253–254; for more examples and discussion of the legal aspects of extended breastfeeding see Baldwin, 1993; Lofton and Gotsch, 1983; Suhler, Bornmann and Scott, 1991; Wilson-Clay, 1990). While anthropologists who conduct cross-cultural research on breastfeeding may shake their heads at the opinions expressed in these cases, and while they may understand the American beliefs that underlie these opinions, they can also ask: "Where can one turn for evidence that nursing a 2 year old (or a 4 year old, or even a 6 year old) *is* both normal and natural for humans?" The nonhuman primate comparisons provide the evidence needed.

Additionally, the relationship between a nursing mother and her child's doctor needs to be one of mutual respect and full access to information for both parties. Physicians should be able to provide parents with complete and accurate information about "normal" breastfeeding and weaning practices in *humans*, not just what is "typical" for women in the United States today. Women should be able to feel free to go to their doctor for problems and issues concerning their nursing children without fear of censure or ridicule, or even fear of being turned over to the authorities on charges of child abuse or neglect. Many pediatricians are openly disapproving of mothers who continue to nurse their infants beyond whatever age the doctor has decided—usually on the basis of personal opinion or bias rather than scientific evidence—is appropriate for weaning. When her pediatrician is known for expressing the view that "Any woman who nurses an infant beyond the age of 6 months is doing it for her own sexual pleasure," how can the mother of a nursing toddler turn to him or her for advice on any aspect of infant feeding? How can she go to him or her for a prescription to treat her 3 year old's thrush, which has infected her breasts as well?

Nursing toddlers in the United States are much more common than most people think. There are many women in the United States who nurse their children for 2, 3, 4 years, or even longer (Avery, 1977; Sugarman and Kendall-Tackett, n.d.). But you do not see or hear about them for several reasons. By the time a child is more than 2 years old, she or he is probably only nursing a few times a day, perhaps first thing in the morning and before a nap or going to sleep at night. People outside the family just assume that the child has been weaned. More importantly, because women know that our society is not supportive of nursing toddlers or older children, rather than spend time defending their actions against the disapproval of friends, grandparents, and even total strangers, it is easier to just tell people that "yes, the child has been

weaned." Secretive nursing of this type, sometimes referred to as "closet nursing" or *subrosa* nursing (Avery, 1977; Buckley, 1992; Reamer and Sugarman, 1987; Wrigley and Hutchinson, 1990), is quite common, and mothers and children are very adept at keeping their secret.[8]

Thus, when we do find out that someone is nursing an older child, it seems unusual. Many nursing mothers simply lie to their doctors, and tell them the child has been weaned, thus contributing to the impression among medical professionals that nursing an older child is a rare and unusual behavior.

An additional reason to identify the normal or natural duration of human breastfeeding is to counter the prevailing notion that infants who want or need to nurse for several years are "abnormal," and that mothers who indulge them are simply encouraging dependency. An understanding of our primate heritage should help protect women from misguided charges that they are "infantilizing" their children and preventing their normal development into independent children by prolonging breastfeeding. Overwhelming evidence shows that meeting the dependency needs of children during the first few years of life results in independent, self-sufficient, physically and emotionally healthy children (see Konner, 1976 for a review of this literature). Nevertheless, many developmental psychologists begin from the belief that prolonged nursing is abnormal and unusual, and that women who engage in it must be meeting some need of their own, rather than meeting their infants' needs (Timothy Cavell, personal communication). In this psychological approach, normal human (primate) behavior is made to seem abnormal because it is viewed from the perspective of beliefs that are limited to certain segments of Western, industrialized societies.

Figure 2.2 shows just how "skewed" the pattern of early weaning in the United States is, compared to data from "traditional" societies. The U.S. data come from information presented at a 1993 Ross Laboratories-sponsored seminar on trends in breastfeeding incidence and duration (Ross Labs, 1993). The data for "traditional societies" come from Ford's survey of 64 non-U.S., non-European societies (1964, reprinted from the 1945 edition). The contrasting patterns, U.S. and traditional societies, clearly show that the U.S. pattern of no breastfeeding, or very early weaning, is not "normal" when placed in cross-cultural perspective, just as it is not "normal" when placed in comparative primate perspective. Medical professionals should expand their frame of reference beyond that represented by middle-class Americans if they hope to understand what "normal" human behavior is with respect to breastfeeding and weaning.

Finally, we need to provide empirical evidence to support an alterna-

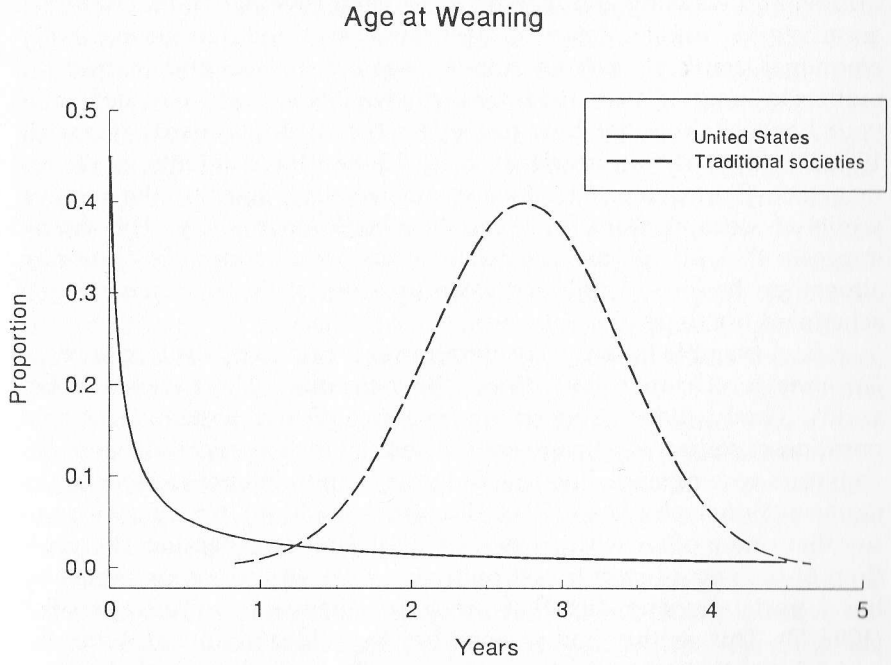

Figure 2.2. A comparison of age at weaning in the United States and in 64 traditional societies.

tive perspective to that offered by scholarly journals and parenting magazines. In 1986, the Jelliffes spoke about the conflict of interest apparent in scholarly publications about breastfeeding:

> It is curiously uncommon for publications of investigations or reviews by those funded by formula companies to be supportive of breastfeeding. Negatively-slanted or 'minimalist' conclusions can, indeed, be predicted by a knowledge of financial support to workshops and/or key contributors. . . . Whatever the results of such studies, the main signals conveyed, especially in summaries, usually emphasize 'difficulties' and/or 'lack of significant differences,' with the over-all inference of 'why bother'? (Jelliffe and Jelliffe, 1986:141).

Most of the time, parenting publications avoid all mention of breastfeeding; this is not surprising in light of the fact that they receive lucrative advertising contracts from the artificial infant formula companies. When they do publish articles about breastfeeding they often "damn with faint praise," by providing inaccurate information about breast-

feeding and weaning and making misleading statements. For example, an article in *Working Mother* in 1992 claims that children get primarily emotional gratification from nursing beyond 1 year, and instructs a mother to simply distract the infant who wants to nurse: "bounce her on your knee or show her how to jiggle a box of dried beans" (Conrad, 1992:48). Similarly, an article on 6- to 12-month-old infants in *Parents* magazine (Bernstein, 1993) focuses on weaning, and on the relative merits of weaning from the breast to a bottle or to a cup. This article suggests that infants are easiest to wean before 6 months, ignoring altogether the idea of child-led weaning. Both of these articles assume scheduled nursings.

A final example from the lay literature is provided by the lead story of *Parenting* for October 1993, titled "Breastfeeding: The basics and beyond" (Grady, 1993). Concerning weaning, Grady writes: "The final question of course, is when to stop. Although the American Academy of Pediatrics recommends breastfeeding for 12 months, *not everyone can or wants to continue that long*" (1993:73, emphasis added). Grady goes on to say that one mother weaned her infant at 4 months because she grew tired of lugging a heavy breast pump to work, and was constrained by her "special nursing diet that precluded many of her usual foods" (1993:73). This mother had weaned her two older infants at 9 months and 2.5 months, respectively, and because "both were perfectly healthy, [she] felt confident that four months was adequate" (1993:73).

The very language used in this article ("that long") implies that 1 year is a long time to nurse an infant, when it is, in cross-cultural and evolutionary perspective, not very long at all. There is no evidence that would support Grady's contention that not everyone can continue that long. Many women around the world routinely lactate for 3 or 4 years after each birth. In addition, there is no need to lug a heavy breast pump to and from work. Manual expression works fine for many working women, or they leave their breast pumps (whether a lightweight manual or heavier electric kind) at work because they have no need for them at home. Also, no special diet is required for the breastfeeding mother, as even very poorly nourished women in third world countries produce the same quantity and quality of milk for their infants as well-nourished women (Jelliffe, Jelliffe and Kersey, 1989; Prentice and Prentice, 1988; Prentice, Prentice and Whitehead, 1981a,b). One has to wonder about the quality of this mother's "usual" diet if many of her usual foods are contraindicated simply because she is nursing an infant.[9]

Finally, the *Parenting* article points out that breastfeeding for 4 months *is* much better nutritionally, immunologically, and emotionally for the infant than not breastfeeding at all. However, a wealth of scientific evidence exists documenting the fact that the benefits of breastfeeding (and

the risks of artificial feeding) continue for as long as the infant nurses (Cunningham, Chapter 9; Cunningham, Jelliffe and Jelliffe, 1991; McKenna and Bernshaw, Chapter 10; Walker, 1993). The children of the mother referred to above may be "perfectly healthy" at the moment, but statistical data suggest that they are at greater risk for allergies (especially food allergies and eczema, see Cunningham, Chapter 9), and upper respiratory and gastrointestinal illnesses, as well as for chronic health problems such as diabetes and multiple sclerosis. As well, one carefully constructed case-control study reports that artificially fed children have a five- to eightfold greater chance of developing lymphoma before the age of 15 years than children breastfed for longer than 6 months (Davis, Savitz and Graubard, 1988). Aside from health concerns, there is now evidence that the longer a child breastfeeds, the higher that child's IQ score and school grades will be in later years, with a dose effect evident even beyond 2 years of nursing (Rogan and Gladen, 1993). This is not to imply that formula-fed infants will grow up to be "stupid," merely that they will not be as intelligent as they would have been had they been breastfed for 2 years or more.[10]

When the normal and natural duration of breastfeeding cannot be agreed upon by pediatricians, law enforcement and child protective services personnel, psychologists, parenting magazines, and even friends, relatives, and mothers themselves, it becomes clear that we need to take a careful look at the data and try to document what human breastfeeding and weaning patterns would look like if they were not modified by beliefs. Understanding the underlying primate blueprint for age at weaning should go far toward educating health care professionals about a reasonable and appropriate age of weaning for humans, however uncommon it may be in the United States to nurse an infant through toddlerhood and beyond.

What, then, *is* the "hominid blueprint" for breastfeeding and weaning behavior? Table 2.3 and Figure 2.3 compile the various ages for a natural weaning time in humans as calculated from comparative nonhuman primate life history data.

The youngest age is that determined by looking at the relationship between birth weight and growth in the infant: a minimum of 2.3 years for boys and 2.5 years for girls in well-nourished, healthy populations. The oldest ages are those determined by looking at the relationship between adult weight and growth in the infant: 7.0 years for boys and 6.0 years for girls in a variety of populations of different adult body sizes. The majority of determinations fall in the 2.5 to 6.0 year range, suggesting that a natural age at weaning for humans would typically fall between 2.5 and 6.0 years of age. The strong isochronous relationship between age and weaning and first permanent molar eruption in the

Table 2.3. Prediction of "Natural" Weaning Age in Humans from Nonhuman Primate Data

Type of data	*Predicted age of weaning*
Some months after age at quadrupling of birth weight (United States, NCHS data, Hamill et al., 1979)	More than 2.3 years for boys, more than 2.5 years for girls
Some months after age at quadrupling of birth weight (Bambara of Mali, Dettwyler, 1985)	Much more than 3 years for boys; more than 3 years for girls
Age at one-third adult weight (Inuit, Jamison 1978)	6.0–7.0 years for boys; 6.0 years for girls
Age at one-third adult weight (United States, NCHS data, Hamill et al., 1979)	7.0 years for boys; 5.75 years for girls
Age at one-third adult weight (Bambara of Mali, Dettwyler, 1991, 1992)	7.0 years for boys; 6.0 years for girls
Age at one-third adult weight (!Kung of Botswana, Truswell and Hansen, 1976)	5.0–6.0 years for boys; 4.0–5.0 years for girls
Formula based on adult female body weight (Inuit, Jamison, 1978)	3.66 years
Formula based on adult female body weight (United States, NCHS data, Hamill et al., 1979)	3.36 years
Formula based on adult female body weight (Bambara of Mali, Dettwyler, 1992)	3.30 years
Formula based on adult female body weight (!Kung of Botswana, Truswell and Hansen, 1976)	2.80 years
In relation to gestation length; minimum of six times gestation length (Lee, Majluf and Gordon, 1991)	4.5 years
Age at eruption of the first permanent molar (Smith, 1991a)	5.5–6.0 years

nonhuman primates suggests that the maturational equivalent of 6.0 years of age may have been the "original" natural age at weaning for early hominids.

By "maturational equivalent," I mean that early hominids may have nursed their infants until approximately the time of eruption of the infant's first permanent molar. While this occurs at an average chronological age of 6.0 years in modern human populations, the work of B. Holly Smith suggests that this degree of physical and physiological maturity may have been reached at an earlier chronological age among the first hominids (Smith 1991b, 1992, and personal communication).

Why is the range of suggested natural weaning ages so broad in

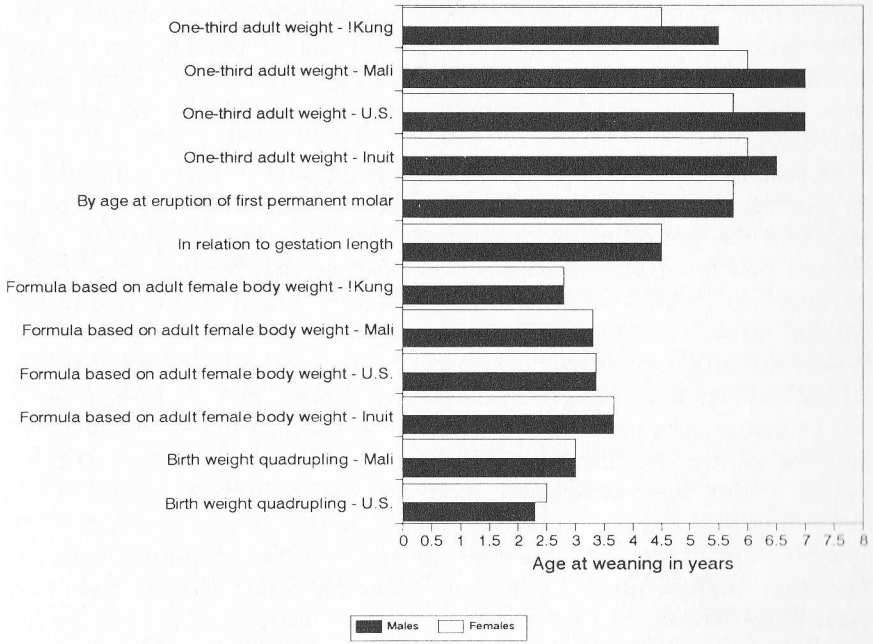

Figure 2.3. Natural age at weaning according to technique used.

humans? Or, to put it another way, why is it the case that the variables—quadrupling of birth weight, attainment of one-third adult weight relationship to adult female body weight, six times the gestation length, and eruption of the first permanent molar—do not fall closer to one another in terms of chronological age of the child? Several factors may account for this relatively large range. First, most primates live their lives in tropical environments. In the tropics, primates face moderate variation in terms of weather, temperature, and food availability from season to season and year to year. In contrast, humans have, relatively late in their evolutionary history, expanded their range out of the tropics to encompass widely varying environmental conditions, with different kinds of dietary resources available, and new diseases with which to cope. Variation in food availability and disease load means variation in growth rates, morbidity, mortality, and fertility. Human populations have had varying success in adapting to these conditions, as well. Flexibility in deciding when to wean may well have been a hallmark of early human cultural adaptation. In some contexts, children could safely be weaned

earlier than 6 years because of abundant, appropriate foods and, perhaps more importantly, relatively low levels of disease stress and/or high levels of medical care. The resulting shorter inter-birth intervals would have given humans a competitive edge in reproductive success.

A second important factor has been the uniquely human cultural trait of modifying food texture and nutritional value through both fire (cooking) and the pounding or grinding of plant products, especially once cereals had been domesticated. It is possible that beginning with the earliest use of fire to modify food, perhaps as much as one-half to one million years ago, human populations were able to circumvent the 6-year nursing imperative by providing alternatives to the adult diet of uncooked vegetation and raw animal products (meat, fish, insects, eggs, etc.) consumed by our foraging ancestors for several million years before the use of fire. Additionally, for those populations that domesticated cereal grains and developed food processing techniques involving pounding or grinding, it may have been possible to even further disengage the age of weaning from the age at first molar eruption. Thus, the common modern human pattern of weaning earlier than 6 years may have ancient roots, related to long-standing cultural modifications of the adult diet, which rendered it suitable for young children. At the same time, sedentary life in densely settled villages increases disease stress on human populations, making the immunological benefits of breast milk even more critical for children.

The ethnographic literature reviewed briefly earlier suggests that prior to the widespread use of artificial infant formulas, children were traditionally nursed for 3 to 4 years. Where children are nursed "for as long as they want," parents usually report self-weaning between 3 and 4 years of age. Thus, three to four years may have been the "natural age at weaning" for populations with a relatively steady food supply that could be safely adapted for young children. The steady eroding away of this resource in just a few generations, under the onslaught of Western values and commercial infant formula companies, has resulted in many children today who are allowed to nurse for only 1 or 2 years, even in so-called "traditional" societies. And many, of course, are never allowed to nurse at all. The costs of these changes in terms of rising morbidity and mortality among children has been somewhat hidden in Western, industrialized countries by the development of modern medicine. But antibiotics and vaccines and modern infant formulas can never replace mother's milk, as we are learning. Mother's milk is more than just a product that confers nutritional and immunological advantages to those children who receive it, and breastfeeding is much more than just a process for the transfer of a mother's milk to her child. Breastfeeding is

an intricate dance between mother and child, during which the child's physical, cognitive, and emotional well-being are nurtured, and through which they flourish. Further, genetic changes cannot keep pace with cultural changes.

It is reasonable to assume that five to seven million years of evolution as hunting and gathering hominids on the East African savannah have resulted in an organism that relies on nursing to provide the context for physical, cognitive, and emotional development. Natural selection has favored those infants with a strong, genetically-coded blueprint that leads them to expect nursing to continue for a number of years after birth, and that results in the urge to suckle remaining strong for this entire period. Lawrence's statement that "beyond a year, weaning is rarely child-initiated until age four," makes perfect sense in this context (Lawrence, 1989:253).

Most societies today may be able to meet a child's nutritional needs with modified adult foods after the age of 3 or 4 years. Modern, industrialized societies can replace some (but not all) of the immunological benefits of breastfeeding with antibiotics and vaccines.[11] But the physical, cognitive, and emotional needs of the young child persist. Just as infant formula can never match mother's milk, so the rubber nipple of a bottle or pacifier can never replace a warm, soft breast, and a cold, hard, crib mattress is a poor substitute for a warm body to sleep with. When the child's instinctive needs for contact and stimulation are not met by breastfeeding, the child may turn to finger- or thumb-sucking, pacifiers, rocking, hair-twisting, or other self-soothing behaviors in an attempt to assuage these needs.[12] Such behaviors, rather than being viewed as adaptations or accomplishments by independent infants, might be viewed instead as the accommodations of infants to an environment where their primary needs are not being adequately met through the multisensorial contact of extended breastfeeding.

This chapter explicitly does not advocate nursing for any specific length of time. As La Leche League International states: "The length of breastfeeding and the pattern of weaning will differ for each mother-child pair. It is appropriate for the breastfeeding relationship to continue until the child outgrows the need" (La Leche League International, 1992).

This chapter *does* advocate that medical professionals and paraprofessionals, family members, friends, acquaintances, and even strangers, recognize that human children, like their nonhuman primate relatives, are *designed to expect* all the benefits of breast milk and breastfeeding for a minimum of 2.5 years. The information that 3 or 4 years of breastfeeding, or even longer, is both normal and appropriate for human infants, should be disseminated to health care professionals and parents alike. It

is to be hoped that people will stop criticizing mothers and suggesting that they need to wean because the child is "too old." Above all, it is to be hoped that people will stop questioning the motives of mothers who nurse their children for several years. It is to be hoped that mothers who follow their own instincts to meet their children's needs—not only their physiological needs for nutrition and immunological protection, but their cognitive and emotional needs for warmth, touching, social contact, and interaction through breastfeeding *as long as the child expresses those needs*—will be encouraged and supported, both by health care professionals and by their families and friends.

SUMMARY

An examination of the relationships between age at weaning and various life-history variables among the nonhuman primates has revealed that, if humans weaned their offspring according to the primate pattern, without regard to beliefs and customs, most children would be weaned somewhere between 2.5 and 7 years of age. The data presented in this chapter reveal that the commonly used pediatric "rules of thumb" suggesting that children should be weaned when they have tripled their birth weight (around 1 year of age) or at the equivalence of their length of gestation (around 9 months of age) are inappropriate. Age at quadrupling of birth weight, and six times the length of gestation, would be more accurate "rules of thumb" to use based on studies of large-bodied nonhuman primates. Substantial evidence is already available, and continues to accumulate, that sharply curtailing the duration of breastfeeding, far below what the human child has evolved to expect, has significant deleterious health consequences for modern humans.

ACKNOWLEDGMENTS

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NOTES

1. "Traditional societies" refer to small-scale societies, usually at the band or tribe level of political organization, which often rely on relatively simple technology (no electricity, no running water, for example). They stand in contrast to modern, Western, industrialized countries.
2. The composition of human milk suggests that human infants are evolved to expect continuous contact with their mothers and "on demand" feeding for the first several years of life (Ben Shaul, 1962; Trevathan, 1987; Wood, Lai, Johnson, Campbell and Maslar, 1985). The iatrogenic problem of "insufficient milk" is often caused by poor lactational management by pediatricians—in particular, infrequent, scheduled feedings and restricted feed duration—who fail to understand the relationships between feed frequency and duration on the one hand, and milk supply and fat content, on the other. See Millard (1990) for an excellent discussion of the cultural history of scheduled breastfeeding.
3. In defense of Lawrence, and the pediatricians who followed her guidelines in recommending weaning at 1 year of age, it should be noted that the apparent link between birth weight tripling and weaning age across all mammals constituted the state-of-the-art in studies of this type for many years. It was an understandable recommendation based on knowledge available at the time. Now, however, we have much more specific and relevant data about primates. Thus, it is time to reevaluate this often repeated, inaccurate characterization of the link between postnatal growth and weaning age.
4. Keep in mind that you cannot extrapolate from data based on population averages to specific individuals. That is, a baby born with a relatively low birth weight of 5 pounds should not necessarily be weaned when she or he reaches 20 pounds, nor should a 10 pound baby necessarily be nursed until she or he weighs 40 pounds. All of the postulated relationships between weaning and quadrupling of birth weight are based on average age at weaning and average birth weight.
5. In addition, this relationship may shed some light on the supposedly purely "cultural" practice of mothers nursing their male infants longer than their female infants, which has been reported from a number of cultures (see McKee, 1984 for citations of this phenomena from Canada, Sweden, Ireland, Ecuador, Brazil, Peru, Guatemala, Taiwan, India, Jordan, Liberia, and Botswana).
6. Once again, in defense of Lawrence, and the pediatricians who followed her guidelines in recommending weaning at 9 month of age, it should be noted that the apparent link between length of gestation and weaning age across all

mammals constituted the state-of-the-art in studies of this type for many years. It was an understandable recommendation based on knowledge available at the time. Now, however, we have much more specific and relevant data about this relationship in primates, and its connection to body size. Thus, it is time to reevaluate this often repeated, inaccurate characterization of the link between length of gestation and weaning age. It should also be noted that Lawrence's example of elephants is also inaccurate, as field studies of elephants have shown lactation to continue for approximately 4 years (more than twice the length of gestation).

7. Identifying and carefully measuring the immunological benefits of breast milk relative to infant formula for children beyond 2 years of age in the United States has been difficult due to both the lower disease risk in the United States—a result of widespread immunization, antibiotics, and good sanitation—and to the lack of women nursing that long who could form the basis of an adequate sample. These difficulties make it impossible currently to state that breastfeeding beyond 2 years of age either *does* or *does not* confer significant immunological benefits to children in general. However, evidence from numerous studies suggests that the longer a child is breastfed, up to the study limits of 24 months, the greater the protection against a variety of illnesses, and the higher the IQ score. There is no reason to suspect that the steady increase in benefits from breastfeeding seen from 0–5 months, 6–11 months, 12–17 months, and 18–24 months, would suddenly stop or reverse the day following the child's second birthday.

8. Reamer and Sugarman (1987:94) write: "This secret nursing is termed 'closet nursing,' and is a protective device for avoiding social criticism while continuing to provide loving nurturing to their growing babies and toddlers. Unfortunately, closet nursing propagates ignorance about long-term breast feeding so that younger mothers, just beginning to nurse, may not realize that experienced long-term breast-feeding mothers are near at hand to give them advice."

9. It is well-known that foods ingested by the mother can affect the breast milk, which then may not agree with the child, leading to fussiness, gas, colic, and even intestinal bleeding. The primary culprit, however, is cows' milk protein, and breastfeeding mothers of sensitive infants are well-advised to omit dairy products from their own diet (see Walker, 1993 for a review of this literature). It has even been suggested that women from families with known cows' milk allergies avoid dairy products during pregnancy. In the case of a baby with sensitivity to cows' milk protein, the worst thing the mother could do is wean the baby onto a cows' milk-based formula. Some children react unfavorably to foods ingested by the mother that produce gas (cabbage, Brussell sprouts, eggplant, etc.), and some children react unfavorably when their mothers consume very spicy foods. Except for these minor dietary adjustments, which are necessary only for a few infants, breastfeeding mothers should be able to eat a wide variety of foods.

10. An important point to remember about relative risk, and reduction of risk, is that some diseases and conditions are very rare. Thus, one might ask "Is it worth changing one's behavior—breastfeeding instead of bottle-feeding—to

reduce the risk of a rare event?" What is abundantly clear from the research comparing the health of breastfed and bottle-fed children is that the reduction in risk for any one disease may be small, and some of the diseases, such as childhood lymphoma, *are* very rare to begin with, but that the accumulated reduction in risk across all the diseases studied to data is substantial. A number of researchers think that the lower risk of many diseases in breastfed infants is due to their stronger immune systems, rather than specific mechanisms of protection for each condition. Thus, lower rates of lymphoma and multiple sclerosis in breastfed infants can probably be attributed to successful defense of the body by a strong immune system. In choosing whether, and for how long, to breastfeed, parents are making decisions that will have long-lasting consequences for their children's health. They need to be fully informed about the risks that may be avoided by breastfeeding, to make informed and responsible decisions. Just as parents today are informed about the risks involved in not using child safety seats, and drinking during pregnancy—dangers unknown a generation ago—parents today need access to information about the risks of infant formula and shortened duration of breastfeeding. No one would suggest that a parent whose child died in a car accident in the 1950s should "feel guilty" for not having used a child safety seat before such seats were invented. Nor should parents feel guilty for having chosen to bottle-feed their children before knowledge of the health consequences has been made widely available.

11. Breastfeeding provides health benefits to children, even first world children, as long as the mother is lactating (Gulick, 1986; Prentice, 1991). Scientific research continues to uncover factors in human breast milk that affect the child's immune system, and that cannot be duplicated in infant formula. Some of these factors may not affect health until the later decades of life. If this is the case, then the next decade should bring more, and more conclusive, evidence of the failure of infant formula to adequately protect children from chronic diseases.

12. Short writes: "Thumb-sucking is almost certainly an abnormal form of behaviour brought about because of inadequate nipple contact. Young monkeys and apes do not suck their thumbs in the wild, but do so if they are artificially reared on the bottle; !Kung babies likewise never suck their thumbs" (Short, 1983:36).

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