

# SECTION

# 1

## **Evidence-Based Nutrition in the Life Cycle; Prenatal to the Adolescent**



# CHAPTER

# 2

## Nutritional Requirements During Pregnancy and Lactation and Normal Infant Nutrition

*Jennifer L. Bueche, PhD, RD, CDN, and Rachelle Lessen, MS, RD, IBCLC*

With Special Sections: Social and Cultural Aspects of Breast-Feeding  
*Yeemay Su Miller, MS, RD, and Virginia L. Marchant-Schnee, BS*

Postpartum Depression and Maternal Nutrition  
*Rachelle Lessen, MS, RD, IBCLC*

### CHAPTER OUTLINE

#### Nutritional Requirements During Pregnancy and Lactation

- Energy Intake
- Carbohydrate
- Protein
- Fat
- Micronutrient Intakes
- Water
- Nutritional Assessment: Pregnancy and Lactation
- Evidence Analysis for Evidence-Based Practice: Pregnancy and Lactation

#### Normal Infant Nutrition

- Growth
  - Adequate Growth in Infancy
  - Development of Growth Chart
- Early Feeding
  - Colic
- Food Safety
  - Safe Handling of Infant Formula
  - Safe Handling of Complementary Foods
- Nutrient Requirements
  - Energy
  - Protein
  - Fatty Acids
  - Iron
  - Zinc
  - Vitamin D

- Supplemental Nutrients
- Vegetarianism
- Complementary Feeding
  - Transitioning from All Milk to Family Foods
  - Feeding Guidelines
  - Complementary Foods and Growth
  - Meal Patterns and Nutrient Intakes
  - Food Trends and Preferences
- Feeding Skills and Neuromuscular Development
  - Reflexes
  - Advanced Motor Skills
  - Chewing Ability
  - Determinants of Food Acceptance
  - Caregiver Behaviors
  - Effect of Feeding Mode in Infancy
  - Feeding Relationship
  - Portion Size

### **Special Section: Social and Cultural Aspects of Breast-Feeding**

- A Brief History of Breast-Feeding
- Current Trends Affecting Breast-Feeding
- Who Breast-Feeds?
- Barriers to Breast-Feeding
- Routine Maternity Care Practices
- Physiologic and Psychological Factors
- Social Support and Acculturation
- Marketing of Breast Milk Substitutes
- Returning to Work
- Legislation: Protecting a Women's Right to Breast-Feed

### **Special Section: Postpartum Depression and Maternal Nutrition**

## **Reader Objectives**

**After studying this chapter and reflecting on the contents, you should be able to**

1. Articulate the nutritional impact of pregnancy and lactation.
2. Compare growth differences between breast-fed and formula-fed infants.
3. Describe the impact of early diet on later development of obesity, diabetes, and food allergies.
4. Discuss adequate intake of key nutrients in the first year of life, including energy, protein, fatty acids, iron, zinc, and vitamin D.
5. Describe caregiver behaviors that can impact normal transitioning from an all-milk infant diet to a diet of family foods.
6. Compare and contrast actual complementary feeding patterns with recommended guidelines.

The physiologic changes that occur during pregnancy and lactation affect nutritional requirements. These nutritional requirements include both macronutrients and micronutrients, which in turn affect the health of both mother and baby. After birth, early childhood is an important time for the development of food preferences and eating patterns. Establishment of lifelong eating habits begins in infancy and is based on a complex integration of physiologic and psychological events, including food preferences, food availability, parental modeling, praise or reward for food consumption, and peer behaviors (Stang, 2006).

## Nutritional Requirements During Pregnancy and Lactation

Jennifer L. Bueche, PhD, RD, CDN

The physiologic changes that occur during pregnancy and lactation affect nutritional requirements. The Dietary Reference Intakes (DRIs) provide the reference standards for recommended nutrient requirements for pregnant and lactating females (see Appendix 2).

### Energy Intake

Increased energy intake is needed during pregnancy and lactation. Increased energy is needed during pregnancy because of an increase in metabolic rate (+15%). Adequate energy intake is required for adequate weight gain during pregnancy to support the growth of the fetus, placenta, and maternal tissues. Energy needs for pregnant females in the first trimester are the same as their nonpregnant counterparts based on the 2002 DRIs. Energy requirements increase between 340 and 360 kcal/day in the second trimester and increase by 112 kcal/day in the third trimester (Institute of Medicine [IOM], Food and Nutrition Board, 2002). Energy requirements during lactation depend on whether the mother is breast-feeding exclusively or feeding a combination of human milk and formula. Energy needs are higher the first 6 months (500 kcal/day) as compared with the second 6 months (400 kcal/day) because the mother produces more milk in the first 6 months. It is important to note that some of the energy required to produce milk comes from the mobilization of maternal body fat (~170 kcal/day); thus the IOM recommends an additional 330 kcal/day above nonpregnant estimated energy requirements.

### Carbohydrate

During pregnancy and lactation carbohydrates should continue to provide the primary energy source (45% to 65% of total kcal). The IOM established DRIs for carbohydrate intake during pregnancy and lactation to provide enough kilocalories in the diet, to prevent ketosis, and to maintain appropriate blood glucose levels during pregnancy (IOM, Food and Nutrition Board, 2002). The estimated average requirement is 160 g/day, and the adequate intake (AI) is 210 g/day.

### Protein

Pregnant and lactating females require an additional 25 g of protein based on the current DRI/Recommended

Daily Allowance (RDA) of 71 g compared with those who are not pregnant. Protein requirements can also be calculated based on 1.1 g/kg/day using prepregnant weight (IOM, Food and Nutrition Board, 2002). The additional protein is required to help form fetal and maternal tissues.

### Fat

Dietary fats are an important contributor to total energy intake. Although there are no DRIs for total fat, AIs have been established for fatty acids. The AIs for linoleic and linolenic acid are 13 and 1.4 g/day, respectively, for pregnant females (IOM, Food and Nutrition Board, 2002). These are important fatty acids because they are used by the body to form other fatty acids: linoleic acid is converted to arachidonic acid (AA) and linolenic acid is converted to docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). AA, DHA, and EPA are critical for fetal growth and development. In addition, DHA is particularly important for brain development and formation of the retina.

During lactation, the maternal diet has an impact on the amount and type of fat in breast milk. In cases of severe energy restriction, body fat is mobilized for energy and breast milk resembles maternal body fat stores. No DRI for lipids exists because energy requirements are highly variable; thus fat should contribute 20% to 35% of total calories (IOM, Food and Nutrition Board, 2002).

### Micronutrient Intakes

The requirements for most micronutrients increase during pregnancy, although there are some, such as vitamins D, E, and K and the mineral calcium, that do not increase at all. Of concern is the association between excessively high intakes of preformed vitamin A consumed during pregnancy and fetal malformations. Pregnant females are cautioned to not exceed the UI of 3,000 µg/day. Surprisingly, calcium requirements do not increase during pregnancy because maternal physiology accommodates the extra needs by increasing absorption and reducing urinary calcium loss. Most females become pregnant with insufficient iron stores to meet the physiologic needs of pregnancy. The DRI/RDA for iron is 27 mg/day because iron is needed to form hemoglobin and for the growth and development of the fetus and placenta. This is a substantial increase when compared with nonpregnant females (DRI/RDA is 18 mg/day). Without supplemental iron maternal anemia develops.

Supplemental iron therapy consists of 60 to 120 mg of ferrous iron in divided doses throughout the day. The consumption of iron supplements in excess of 56 mg per dose is not recommended because excessive iron consumption interferes with zinc absorption and should be avoided (Fairweather-Tait, 1995). The DRI/RDA for folate has been set at 600 µg/day during pregnancy because of the importance of folate in neural tube development. It is recommended that all females of childbearing age consume 400 µg/day of folic acid as a supplement or in fortified foods in addition to consuming folate naturally occurring in foods to achieve red blood cell folate concentrations considered optimal for protection against neural tube defects.

Recommendations for micronutrient intakes during lactation are similar to those during pregnancy except for vitamin C. The requirement for vitamin C increases substantially with lactation (120 mg/day) because a large amount of vitamin C is secreted in milk.

## Water

It is important that pregnant and lactating females take in enough fluid. This is particularly important for females who are lactating because although increased fluid does not increase milk production, a lack of fluid can decrease milk volume.

## Nutritional Assessment: Pregnancy and Lactation

A poor nutritional status before and during pregnancy increases the risk for a premature birth or low birth weight infants. “Low birth weight babies are 40 times more likely to die before 1 year of age compared to normal-weight infants” (Villar et al., 2003). Low birth weight and premature births are the leading causes of infant mortality. It has been theorized that inadequate growth during the prenatal period may have profound long-term effect (Rasmussen, 2000). This is known as the fetal origins hypothesis. The evidence suggests that nutrient inadequacies in the womb may cause permanent changes in the structure and/or function of organs and tissues, predisposing individuals to certain chronic diseases later in life (Barker, 1991).

Adequate weight gain during pregnancy is one of the most important determinants of fetal growth and development. The IOM developed current weight gain guidelines for pregnant females based on maternal prepregnancy body mass index (IOM, 2005).

Excessive weight gain is undesirable as well. Obesity increases the risk of gestational diabetes, pregnancy-induced hypertension, and cesarean section (Brost et al., 1997).

## Evidence Analysis for Evidence-Based Practice: Pregnancy and Lactation

Adequate nutritional intake and an appropriate gestational weight gain are among the most important modifiable contributors to healthful outcomes for both mother and infant (IOM, National Academies of Science, 1990). Nutritional intervention may especially benefit high-risk groups such as pregnant teens, high-risk pregnancies (including multiple births), and those diagnosed with gestational diabetes given the need to individualize nutritional recommendations. There is much evidence in the literature to support the benefits of breast-feeding. Thus it is the position of the American Dietetic Association (2005) that “exclusive breastfeeding provides optimal nutrition and health protection for the first 6 months of life, and breastfeeding with complementary foods for at least 12 months is the ideal feeding pattern for infants.” The new MyPyramid was not designed to provide nutritional recommendations for pregnant and lactating females; however, current nutritional recommendations for pregnant and lactating females are outlined in the 2005 U.S. dietary guidelines for Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2005).

## Normal Infant Nutrition

*Rachelle Lessen, MS, RD, IBCLC*

## Growth

### Adequate Growth in Infancy

In general, if a mother is well nourished and is exclusively breast-feeding, her milk will provide adequate nutrition for her infant to grow at an appropriate rate. Human milk has unique nutritional characteristics, such as a high ratio of whey to casein, a high proportion of nonprotein nitrogen, and fatty acids essential for brain and retinal development. It is not known at what point human milk is no longer sufficient for sustained growth, but it is unlikely that complementary foods are required before 6 months of age. Although it is commonly believed that insufficient calories and

protein in human milk limit growth, it is probably more likely that other factors, such as iron and zinc, affect growth. This applies to infants in both disadvantaged and affluent populations (Dewey, 2001).

Feeding mode has been found to impact weight gain and body composition during the period of exclusive or predominant milk feeding in early infancy. In a prospective cohort study of 40 exclusively breast-fed infants and 36 exclusively formula-fed infants, weight gain was greater in the formula-fed group (Butte, Wong, Hopkinson, Smith, & Ellis, 2000b). Changes in body composition and weight were both age dependent and gender dependent. Daily intakes of energy, protein, fat, and carbohydrates were positively associated with weight gain and fat-free mass from birth through 12 months, but not after that. Formula-fed infants took in greater volumes and consumed significantly more energy, protein, fat, and carbohydrates.

### Development of Growth Charts

The nutritional status of children is assessed by plotting height and weight on **growth charts** to determine adequacy of nutrient intake, particularly calories and protein. The growth charts currently in use by the Centers for Disease Control and Prevention (CDC) have been available since 2000 and are an improvement over the previous charts from 1977 (see Appendix 1). The growth charts for children from birth through 3 years are based on data from the National Health and Nutrition Examination Survey (NHANES III) with supplemental birth data from Wisconsin and Missouri. This national survey data represent the combined size and growth patterns of breast-fed and formula-fed infants in the U.S. general population from 1971 to 1994. It replaces data based on primarily formula-fed infants from 1929 to 1975 from the Fels Longitudinal Study that contained few breast-fed infants (National Center for Health Statistics, 2000). These data do not reflect differences in racial or ethnic groups that could affect growth and include all infants and children in the United States regardless of race and ethnicity. The most important influences on growth potential appear to be economic, nutritional, and environmental (National Center for Health Statistics, 2000).

Current growth charts do not accurately reflect the growth patterns of breast-fed infants (Dewey, 2001). During 1988 to 1994 when NHANES III data were collected, less than 50% of all infants born in the United States were exclusively breast-fed at birth

and only about 10% were exclusively breast-feeding at 6 months (Ryan, Wenjun, & Acosta, 2002). There is considerable evidence to show that growth rates differ for breast-fed and formula-fed infants. Formula-fed infants typically weigh 600 to 650 g more at 12 months than breast-fed infants. Average weight of breast-fed infants is noticeably lower than formula-fed infants from 9 to 12 months, whereas length is not significantly different. Thus breast-fed infants appear leaner and may even be classified as failure to thrive because of a downward trend in percentiles on the growth chart (Dewey, 2001). However, one study found no decrease in weight gain observed in exclusively breast-fed children in the first year of life (Kramer et al., 2002).

The World Health Organization (WHO) conducted a 6-year multicenter international study to develop new growth charts derived from the growth of exclusively or predominantly breast-fed infants based on the assumption that optimal infant growth occurs in infants from healthy populations who are exclusively breast-fed for the first 6 months of life with continued breast-feeding until 2 years of age. The new WHO Child Growth Standards (de Onis, Garza, Onyango, & Borghi, 2007) show how every child in the world should grow when free of disease and when their mothers follow healthy practices such as breast-feeding and not smoking. The standards depict normal human growth under optimal environmental conditions and can be used to assess children everywhere, regardless of ethnicity, socioeconomic status, and type of feeding (de Onis et al., 2007).

## Early Feeding

### Colic

Infantile colic is characterized by paroxysms of uncontrolled crying or fussing in an otherwise healthy and well-nourished infant. The crying and fussing behavior can be described by the rule of threes: It starts at 3 weeks of age, there is more than 3 hours of crying a day for at least 3 days a week, and it lasts for more than 3 weeks. Colic resolves spontaneously without any further sequelae. Some attribute this behavior to psychogenic causes from tension in the maternal–infant bond and to maternal smoking or alcohol consumption, whereas other models focus on possible allergens in breast milk or infant formula as the causative agent (Schach & Haight, 2002).

Colic can be particularly distressing for not only the infant, but for the parents as well. Colic occurs

**Growth charts:** Used to assess nutritional status of children by plotting height and weight and comparing to reference data.

in both breast-fed and formula-fed infants. Breast-feeding is not protective against colic, and it is estimated that at 6 weeks the overall prevalence of colic in all infants is 24% (Clifford, Campbell, Speechley, & Gorodzinsky, 2002). Colic appears earlier and resolves earlier in formula-fed infants. Lucas and St. James-Robert (1998) reported that at 2 weeks 43% of formula-fed infants show signs of intense crying and colic behavior but only 16% of breast-fed infants demonstrated these symptoms. By 6 weeks distressed behavior was seen in 31% of breast-fed infants but only in 12% of formula fed infants.

In searching for a remedy for this stressful condition, attempts to modify the infant's diet may be implemented. Cow's milk protein may contribute to the etiology of colic, and removal of the protein may alleviate the symptoms. Use of a hypoallergenic formula for non-breast-fed infants may be recommended (Canadian Paediatric Society, 2003). Switching to a low lactose formula or a formula with fiber was not found to be helpful in reducing colic symptoms.

A hypoallergenic maternal diet for breast-feeding mothers may reduce colicky symptoms in some infants. For some, removal of all cow's milk from the mother's diet can provide relief for the colicky breast-fed infant. Other common allergens that may produce colicky symptoms in an infant include proteins from peanuts, eggs, soy, wheat, tree nuts, and strawberries. Hill et al. (2005) conducted a randomized controlled trial of breast-feeding infants less than 6 weeks of age with colic. Mothers in the experimental group excluded dairy, soy, wheat, eggs, peanuts, tree nuts, and fish. After 1 week 74% of mothers in the experimental group reported a 25% reduction in cry or fuss behavior versus 37% of the mothers in the control group.

Lust and colleagues (1996) hypothesized that maternal intake of cruciferous vegetables would cause colic symptoms in the breast-fed infant. A mailed questionnaire was used to collect information on maternal diet and colic in infants under 4 months of age. A positive relationship was seen between colic and consumption of cabbage, cauliflower, broccoli, cow's milk, onion, and chocolate. Symptoms were self-reported, and analysis failed to show a dose-response relationship between colic symptoms and frequency of the foods consumed by the mother. Mothers reported that they avoided cruciferous vegetables, milk, dried beans, spicy foods, chocolate, and caffeine either on the advice of a friend or because of a past experience related to the infant's perceived reaction to the food. Clifford et al. (2002)

### Research About Colic

Studies have failed to show a clear link between dietary factors in either breast milk or formula as the cause of infant colic. Evidence suggests that dietary interventions may be helpful for some infants, especially those with a family history of atopic disease and severe colic. Most of the studies on the impact of dietary changes on colic have had a small sample size and were not blinded or controlled. Colic always improves over time, and any intervention is susceptible to a placebo effect affecting the outcome. Speculations as to the origins of colic abound, and treatment options are limited.

found that maternal intake of caffeinated beverages was not associated with colic symptoms.

Rather than transitioning an infant from breast milk to a hypoallergenic formula when symptoms persist, Schach and Haight (2002) reported a unique protocol treatment at the Davis Medical Center at the University of California that called for a maternal elimination diet followed

by the use of Pancrease MT 4 enzymes with all meals and snacks. Pancrease is a digestive enzyme that further breaks down protein in the digestive track before it enters the bloodstream, thereby minimizing the potential for allergens to appear in human milk and eliciting an allergic reaction in the infant. Symptoms of colic, as well as blood in the stool, were reduced after the mothers began the treatment.

## Food Safety

### Safe Handling of Infant Formula

Infant formula should be prepared with careful attention to manufacturer's instructions for use and storage. Bottle-fed infants are at an increased risk for exposure to food-borne pathogens, particularly if the bottles are left at room temperature for several hours. Freshly expressed, but not previously frozen, breast milk contains live white cells that destroy pathogens and can remain at room temperature for up to 8 hours before feeding. All bottles, nipples, and other feeding equipment should be properly cleaned and disinfected between uses.

Powdered infant formula products are not sterile and can be a source of potentially devastating illness and infection in infants. At greatest risk are neonates in the first 28 days of life, premature infants, low birth weight infants, and immunocompromised infants. Intrinsic contamination of powdered infant formula products with *Enterobacter sakazakii* and *Salmonella* has been a cause of significant disease, causing severe developmental sequelae and death (MMWR, 2002). The Infant Formula Act of 1980 (revised 1986) requires formula makers to use "good manufacturing practice" but does not guarantee or require sterility



(Baker, 2002). Formula manufacturers are urged to develop a sterile powdered product for high-risk infants. Even low concentrations of *E. sakazakii* in powdered infant formula can cause serious harm due to the potential for exponential multiplication during preparation and holding at ambient temperatures. Good hygienic practices, such as hand washing, using sanitized containers, and preparing only the

### Nitrates

Infant methemoglobinemia results in cyanosis in infants with few other clinical symptoms and is caused by nitrates in food or water that are converted to methemoglobin-producing nitrites before or after ingestion. The resulting compound, methemoglobin, cannot bind oxygen and results in hypoxemia. Absorbed nitrate that has not been converted to nitrite can be readily excreted in the urine without adverse effects. The greatest risk to infants comes from well water contaminated with nitrates (Greer, Shannon, the Committee of Nutrition, & the Committee on Environmental Health, 2005). It is estimated that 2 million families drink water from private wells that fail to meet federal drinking water standards for nitrate, and 40,000 infants younger than 6 months old live in homes that have nitrate-contaminated water supplies. Breast-fed infants whose mothers consume water with high nitrate nitrogen concentrations are not at increased risk, because nitrate concentration does not increase in human milk.

Nitrates also occur naturally in plants and may be concentrated in foods such as green beans, carrots, squash, spinach, and beets. Some commercially prepared infant foods are voluntarily monitored for nitrate content, and because of exceedingly high levels in spinach, this product is often labeled as not to be used for infants younger than 3 months of age. Concerns for home-prepared foods are unfounded because there is no nutritional indication for introduction of complementary foods before 6 months. The risk of methemoglobinemia decreases with age as the infant's gastric pH approaches lower levels typical of later childhood and fetal hemoglobin, which more readily oxidizes to methemoglobin, is replaced by adult hemoglobin after 3 months.

amount needed for one feeding and using immediately, have been recommended to minimize risk (European Food Safety Authority, 2004). The U.S. Food and Drug Administration (FDA) issued warnings regarding the use of powdered infant formula in neonatal intensive care units. No events have been reported for healthy full-term infants in home settings or involving the use of sterile liquid infant formula products (FDA Talk Paper, 2002).

### Safe Handling of Complementary Foods

Infants are at risk of exposure to food-borne pathogens when complementary foods are not prepared using safe food-handling techniques. Contamination of food with microbes is recognized as the leading cause of diarrheal disease and ill health in infants. A wide range of symptoms, including diarrhea, vomiting, abdominal pain, fever, and jaundice, occurs with potentially severe and life-threatening consequences. Two particular areas of food preparation are of concern because they allow the survival and growth

of pathogens to disease-causing levels. The first is preparation of food several hours before consumption along with storage at ambient temperatures favoring the growth of pathogens and/or toxins. The second concern is insufficient cooling of foods or inadequate reheating to reduce or eliminate pathogens (Motarjemi, 2000). General food safety guidelines for both commercially prepared and homemade infant food should be followed.

## Nutrient Requirements

### Energy

It is difficult to estimate energy requirements for infants and young children. The 1985 Food and Agriculture Organization/WHO/United Nations Organization (FAO/WHO/UNO) recommendations for energy intake were derived from the observed intakes of healthy thriving children. This assumes that the natural ad libitum feeding of infants and toddlers reflects desirable intake. However, the observed energy intake of infants and toddlers may not be optimal and may reflect outside influences such as type of feedings and caregiver behaviors. The FAO/WHO/UNO recommendations for energy were based on data compiled from the literature predating 1940 and up to 1980 and included an extra 5% allowance for presumed underestimation of energy intake (IOM, 2002).

Experts questioned the validity of the 1985 FAO/WHO/UNO recommendations for energy intake, and in 1996 experts concluded that the guidelines were too high. Energy requirements for infants and toddlers based on actual energy expenditure and energy deposition, rather than observed intake, would more accurately reflect true energy needs. Energy requirements of infants and young children need to support a rate of growth and body composition consistent with good health. Satisfactory growth is an indicator that energy needs are being met.

Butte et al. (2000a) used data obtained from doubly labeled water studies on infants aged 3 to 24 months to define energy requirements in the first 2 years of life based on total energy expenditure and energy deposition. They were able to demonstrate that total energy expenditure was greater in older infants than in younger infants, greater for males than for females, and greater for formula-fed infants than for breast-fed infants. After adjusting for body weight and fat-free mass, only feeding mode, not gender or age, influenced total energy expenditure. Breast-fed infants had lower rates of energy deposition in

the first year of life, although differences between breast-fed and formula-fed infants diminished in the second year. The energy cost of growth is important in early infancy when energy deposition contributes significantly to energy requirements. At 3 months of age 22% of energy requirements are utilized for growth. This drops dramatically to 6% at 6 months and even further to 2% to 3% of total energy requirements in late infancy. Estimated energy requirements based on studies of total energy expenditure and energy deposition were 80% of the former recommendations, providing strong evidence that revisions were needed to lower the energy requirements for children in this age group.

The WHO/United Nations Children's Fund (UNICEF) compiled data from 21 studies of children in developing countries to estimate the amount of energy received from breast milk and to determine how much energy would be required from complementary foods to meet their needs for growth. To ensure that children receive sufficient calories, foods must be prepared with an adequate energy density and served an appropriate number of times per day. Both energy density and meal frequency independently affect the child's total energy consumption.

Dewey (2000b) expressed concern that the improper introduction of complementary foods has the potential to adversely affect breast milk intake and breast-feeding duration. Providing excess energy in the form of complementary foods can reduce the intake of breast milk. Breast-fed infants reduce their intake of human milk as non-breast milk foods and fluids are introduced. Although it appears that the timing of breast-feeding in relation to complementary foods (e.g., offering complementary foods before or after breast-feeding) does not seem to affect overall breast milk intake, there is a paucity of information on the effect of the introduction of complementary foods on breast-feeding.

### Protein

It is not difficult to meet the protein needs of infants. Exclusively breast-fed infants receive adequate protein for at least the first 6 months of life. The most recent recommended AI of protein for infants from birth to 6 months is 1.5 g/kg/day and reflects the observed mean intake of infants who are fed mostly human milk (IOM, 2002). This value is calculated from various studies in which the volume of human milk consumed is measured by test weighing, and the average protein content of human milk was determined using values from several studies.

DuPont (2003) reported that total protein in breast milk varies greatly during the course of lactation, providing from less than 2.0 g/kg/day in the first weeks of life to approximately 1.15 g/kg/day at 4 months, less than the AI recommendations of the IOM. Dewey, Cohen, Rivera, Canahuati, and Brown (1996b) reported that protein intake of breast-fed infants decreases from 2.0 g/kg/day at 1 month to 1.0 g/kg/day at 6 months as protein concentration in milk decreases and average breast milk intake increases slightly. According to Dewey et al., estimated daily protein intake of a 6-month-old breast-fed infant is 8.0 to 8.4 g/day, lower than the calculated AI of 9.1 g/day.

Protein content of infant formula is greater than human milk, but no study has shown that the amount of protein in human milk has deleterious effects. Multiple studies have shown that infants fed human milk have improved immune function and fewer illnesses than formula-fed infants. The casein and whey in infant formula are different from those present in human milk; therefore the digestibility, absorption, and functionality of these proteins differ. The IOM (1990) states that digestibility and comparative protein quality need to be considered when determining the amount of protein to be included in infant formula based on various protein sources. Protein requirements for formula-fed infants may be greater due to less efficient utilization and retention of protein than breast-fed infants. Dewey et al. (1996b) found that adding extra protein to 4- to 6-month-old exclusively breast-fed infants did not improve weight or length gain despite an additional 20% protein to their diet, and no differences were found in growth rate based on protein intake.

The amount of protein required for growth is highest in early infancy and decreases over time. At 1 month of age 64% of protein intake is used for growth, decreasing to 24% at 6 to 12 months. Daily increments in body protein gains in male breast-fed infants decreased from 1.0 g/kg/day at 1 month to 0.2 g/kg/day at 6 months. Protein needs for growth in early infancy are influenced by birth weight as well. Infants with higher birth weights generally grow at a slower rate and would require less protein than infants born at a lower birth weight who experience faster rates of weight gain (Dewey, Beaton, Fjeld, Lonnerdal, & Reeds, 1996a). Protein requirements (both total protein and protein per kilogram body weight) for infants older than 6 months are lower than the requirements for younger infants. High protein follow-up formulas are not indicated or necessary for infants consuming a variety of foods (Dewey, 2000a).

Calculations for protein requirements for infants ages 7 through 12 months are based on the relationship between protein intake and nitrogen balance. Studies examining protein losses, requirements for maintenance, and protein deposition were used to derive the DRI/RDA for older infants of 1.5 g/kg/day, which do not differ greatly from the AI for younger infants. Higher protein intake would be indicated for a child requiring catch-up growth or recovery from an infection. Infants older than 6 months may receive a significant portion of their protein needs from complementary foods.

An adequate growth rate has traditionally been used as the determinant for sufficient protein intake. Dewey et al. (1996a) reported that other measures of protein intake, such as immune function and behavioral development, may become compromised long before growth falters. Observed differences in growth rates between infants who are breast-fed and formula-fed raise the question of whether maximal growth rate is synonymous with optimal growth rate. Higher intakes of protein in formula-fed infants have been a cause for concern, because the liver and kidney need to metabolize and excrete the increased levels of plasma amino acids and urea nitrogen, which could have long-term consequences on immature organs.

### Fatty Acids

Both human milk and currently available infant formula contain generous amounts of the essential fatty acids, linoleic and alpha-linolenic acid. Cow's milk contains very little, and infants and toddlers who drink cow's milk often have low levels of these fatty acids. Corn, soybean, or safflower oil can be added to the diet of a child who has been weaned from breast milk or formula to provide these nutrients (Butte et al., 2004).

In addition to the essential fatty acids linoleic and alpha-linolenic acid, there is growing concern that

#### LCPUFA (long chain polyunsaturated fatty acids):

A category of dietary fats important in brain and retinal growth; normally present in human milk, they are now added to infant formula.

infants also need long chain polyunsaturated fatty acids (LCPUFAs) in their diets. These fats, particularly AA and DHA, are vital for neural development and visual acuity. Infants fed formula containing only linoleic and alpha-linolenic acid, the precursors for AA and DHA,

are able to synthesize only a limited amount of long chain fatty acids. When compared with breast-fed infants, formula-fed infants had less mature neurophysiologic maturation and brain function (Khedr, Farghaly, Amry Sel, & Osman, 2004).

These LCPUFAs are concentrated in the phospholipid bilayer of biologically active brain and retinal neural membranes during the periods of rapid brain and retinal growth from the last trimester of pregnancy until 2 years of age. During this critical period of rapid growth and maturation, the quantity and quality of the LCPUFAs may influence the efficiency of nerve cell signaling and have long-lasting effects on brain function. The rationale for adding these LCPUFAs to infant formula is based on the observation that they are present in large quantities in the brains and retinas of breast-fed children and are present in breast milk. In February 2002 term infant formula with added DHA and AA became readily available, and shortly thereafter DHA and AA were added to preterm infant formula. In 1998 an expert panel for the FDA in the United States and a working group for the Canadian authorities did not

#### Research Studies by Formula Companies

A study sponsored by Ross Products Division, Abbott Labs, makers of Similac, Neosure, and Isomil infant formulas, found that the addition of DHA and AA to infant formula increased DHA and AA plasma levels to those commonly seen in breast-fed infants without improvement in measures of visual acuity or other neurodevelopment tests (Auestad et al., 2001). A study sponsored by Mead Johnson Nutritional, makers of Enfamil Lipil, found that when infants received a continuous supply of DHA and AA throughout the first year of life they had improved visual acuity at 1 year of age (Morale et al., 2005). Compared with women in other countries where greater intakes of fish are consumed, the DHA levels in the milk of mothers from the United States are much lower and do not meet the WHO recommendations.

recommend the addition of LCPUFAs to infant formula because of the uncertainties related to product safety and efficacy (Koo, 2003). Maternal plasma and human milk DHA levels as well as the infant's plasma levels can be increased by adding DHA to the maternal diet at levels of 200 mg/day or greater. However, studies have not shown marked improvement in infant outcome related to visual function and neurodevelopment in breast-fed infants whose mothers received 200 mg/day DHA supplementation (Jensen et al., 2005).

A comparison of the multitude of studies on LCPUFA supplementation and visual acuity and neurodevelopmental outcomes in infants is hindered by the fact that many of the neurodevelopment tests were never designed to test normal healthy infants and lack predictive ability for long-term neurodevelopment outcomes. Although DHA and AA supplementation no doubt raises plasma levels in both infants and breast-feeding mothers, it remains highly controversial whether or not there is any functional benefit in visual acuity or neurodevelopment. The

safety of these additives is an additional concern, although there have been few reported adverse events. The oils used for the supplementation are new food products from Martek Biosciences and have been approved by the FDA as “Generally Recognized as Safe” and are approved for use in infant formula and baby food.

DHA is an oil derived from microalgae, and AA is an oil derived from soil fungi. An imbalance of omega-3 to omega-6 fatty acids could have biological effects such as prolonged bleeding time and diminished growth, and close monitoring of infants consuming infant formula with added LCPUFAs through scientific studies is indicated and indeed required by the FDA. Although families will embrace a new product promising to deliver a formula that is closer to human milk and is good for the brain and eyes, the cost of these products is a burden on the family budget and on public funding for nutrition programs. Justification of increased costs of up to 25% may prove difficult without substantial scientific evidence of improved clinical outcomes in vision and intelligence.

## Iron

**Iron deficiency anemia:** The most common childhood deficiency resulting in motor and cognitive developmental deficits.

Iron deficiency anemia is the most common childhood nutritional deficiency worldwide, with consequences of delays in motor and cognitive development caused by irreversible brain injury. Developmental deficits occur when iron deficiency becomes severe and chronic enough to result in anemia. Although iron supplementation increases iron stores, poor developmental outcomes may persist with lower scores on mental and motor tests and functional impairment in school-aged children. A high prevalence of nutritional iron deficiency anemia was first noted in the United States in infants in the 1930s and has decreased dramatically since the 1960s when it was acknowledged as

a public health problem. Interventions, including an increase in breast-feeding, the start of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in 1972, and education of physicians and the public, resulted in a dramatic decrease in iron deficiency anemia across all socioeconomic groups in the United States. The intervention was so successful that in the 1980s it was sug-

**WIC:** The Special Supplemental Nutrition Program for Women, Infants, and Children that serves to safeguard the health of low-income women, infants, and children up to age 5 who are at nutritional risk by providing nutritious foods to supplement diets, information on healthy eating, and referrals to health care.

gested that routine screening of all infants be replaced by selective screening of high risk patients.

It now appears that the prevalence of iron deficiency anemia is increasing in 1- to 3-year-olds (Kazal, 2002). Data from the 2001 Pediatric Nutrition Surveillance System indicated that 16.6% of 6- to 11-month-old infants and 15.3% of 12- to 17-month old children were anemic. The subjects in this national sample were largely from low-income populations, where 82% were enrolled in WIC (Altucher, Rasmussen, Barden, & Habicht, 2005). It is not unusual for children ages 1 to 3 years to have low intakes of iron. Most 12-month-olds receive 100% of the daily requirement for iron, but this declines to less than recommended intake by 18 months, likely due to cessation of breast-feeding and switching from iron-fortified infant formula to cow's milk and reduced intake of iron-fortified cereals (Kazal, 2002). Juice intake can decrease a child's appetite for other more nutritional solid foods, further contributing to iron deficiency.

Healthy, normal birth weight, full-term infants receive adequate iron from human milk for approximately the first 6 to 9 months of life. Reserves at birth are a critical factor for anemia. Total body iron is fairly stable in infants from birth through age 4 months as stored iron is gradually used to support growth. Between 4 and 12 months there is a significant increase in iron requirements as body size increases. These needs cannot be met through the iron available in human milk. The concentration of iron in human milk is 0.2 to 0.4 mg/L and remains stable throughout lactation. Although the absolute amount of iron in human milk is low, efficiency of iron absorption from human milk is quite high, at about 50%. Once iron stores are depleted, iron-related physiologic functions may become compromised with both cognitive and motor deficits even in the absence of anemia. After age 2 years when growth velocity decreases, iron stores start to accumulate and the risk for deficiency decreases (American Academy of Pediatrics [AAP], 2004).

The risk for anemia is much greater in low birth weight infants. In a study of low birth weight infants born in Honduras, infants with birth weights less than 3,000 g were at risk for anemia at 6 months even when iron-fortified complementary foods were introduced between ages 4 and 6 months (Dewey, Pearson, & Brown, 1998). It is recommended that low birth weight breast-fed infants receive iron drops beginning at ages 2 to 3 months.

Fomon (2001) stated that infants who are exclusively or predominantly breast-fed are at risk of

becoming iron deficient by 8 to 9 months of age. Whereas Fomon recommended beginning iron supplementation of breast-fed infants at an early age to prevent depletion of body stores, the AAP notes that iron deficiency is rare in breast-fed infants due to increased absorption and the absence of microscopic blood loss in the intestinal tract that may occur with whole cow's milk. Supplementation of healthy term breast-fed infants with iron to prevent deficiency is controversial. Unnecessary supplementation can increase the prevalence of gastrointestinal infection, sepsis, and cancer because iron is essential for the growth of microorganisms and malignant cells. Gastrointestinal effects such as nausea, vomiting, constipation, and abdominal pain have been reported by individuals on iron supplementation. Routine iron supplementation of breast-fed infants with normal hemoglobin levels resulted in increased diarrhea and poor linear growth, possibly due to the pro-oxidant effect of iron on the intestinal mucosa. Reduction in zinc absorption leading to poor growth can occur from excessive iron intake (Dewey et al., 2002). Ermis and coworkers (2002) found that supplementation of breast-fed infants from ages 5 to 9 months with iron at a dose of 2 mg/kg every other day prevented iron deficiency and iron deficiency anemia. Every-other-day dosing improved compliance and reduced unpleasant side effects.

Domellof, Lonnerdal, Abrams, and Hernall (2002) found that regulation of iron absorption in breast-fed infants undergoes developmental changes from ages 6 to 9 months that enhances the ability of the infant to adapt to a low iron diet. Unlike iron absorption in adults that increases in states of iron depletion, iron absorption in infants was found to be directly related to the dietary intake rather than to iron status. Iron status as measured by serum ferritin was improved in infants given iron supplementation, but there was a significant inverse relationship between dietary iron provided and absorption of iron from human milk. Unsupplemented infants absorbed 37% of the iron in human milk compared with only 17% absorption in breast-fed infants supplemented with 1 mg/kg/day. Supplemental iron drops had a greater effect on decreasing iron absorption from human milk than iron in complementary foods. Domellof et al. concluded that breast-feeding with the addition of complementary foods containing adequate iron likely provides sufficient iron for some, but not all, healthy 9-month-old infants, possibly due to up-regulation of iron in response to low dietary intake, thus avoiding iron deficiency.

Iron absorption from foods varies greatly from less than 1% to 50% of available iron. About 4% of the iron in fortified infant formula is absorbed versus 50% of the iron in human milk. The AAP estimates that for infants consuming iron-fortified formula there is an 8% risk for iron deficiency and less than 1% risk for iron deficiency anemia. Infants drinking cow's milk have a 30% to 40% risk of iron deficiency by ages 9 to 12 months. Exclusively breast-fed infants have a 20% risk of iron deficiency by 9 to 12 months of age. Formula-fed infants should not be switched to whole cow's milk until after 1 year of age, and there is no medical indication for low iron formulas. The AAP has recommended that the manufacture of low iron formulas be discontinued because there is no scientific evidence to support the claim that iron-fortified formulas increase gastrointestinal distress in infants.

The main sources of iron from complementary foods in the infant diet are iron-fortified cereal and meats. Absorption of iron from infant cereal is only about 4%. The form of iron used in dry infant cereals is an insoluble iron salt or metallic iron powder that is used to reduce oxidative rancidity, and these forms have low bioavailability. Meat is a much better source of iron because the iron is in the heme form, with an absorption efficiency of 10% to 20%. Non-heme iron from plant foods and fortified products is less well absorbed. Plant-based foods have a high phytic acid, polyphenol, and/or dietary fiber content that can inhibit absorption of micronutrients. Ascorbic acid counteracts the effects of phytate on iron absorption by preventing it from binding with available iron.

Estimates for absorption of iron depend on the amount of animal or fish protein in a meal relative to plant-based foods. Consumption of meat, fish, or poultry enhances the absorption of non-heme iron from plant-based foods. Vitamin C in the form of fresh fruits such as cantaloupe, kiwi, or strawberries or vegetables such as broccoli and kale consumed at the same time as non-heme iron enhances absorption. Tea, bran, and milk inhibit non-heme iron absorption. Heme iron is absorbed in the intestines intact and is not affected by inhibitors of non-heme iron.

Engelmann and colleagues (1996) studied the effect of meat intake on hemoglobin levels in breast-fed infants. When healthy 8-month-old partially breast-fed infants were fed a high meat intake of 27 g/day for 2 months, they had only minimal decreases in hemoglobin of 0.6 g/L compared with a

similar group of breast-fed infants with a low meat intake of 10 g/day who had decreases in hemoglobin of 4.9 g/L. The group with the low meat intake had overall greater intakes of iron (3.4 versus 3.1 mg/day) but lower intakes of iron from meat (0.1 versus 0.4 mg/day), suggesting that animal muscle protein has an iron absorption enhancing effect and can minimize decreases in hemoglobin that are typically observed from ages 8 to 10 months in breast-fed infants.

Heath, Tuttle, Simons, Cleghorn, & Parnell (2002) found that 9- to 18-month-old New Zealand breast-fed infants experienced low rates of iron deficiency anemia of 7% even while their intake of breast milk and infant formula declined. Their intake of highly bioavailable iron in the form of meat, poultry, and fish increased from 0 g/day at 9 months to 21 g/day at 12 months and 32 g/day at 18 months. Their intake of vitamin C was also high, at 52 to 96 mg/day, likely further enhancing iron absorption.

Kattelman and coworkers (2001) found that the age of introduction of complementary foods to formula-fed infants did not affect iron status parameters. Infants introduced to complementary foods early, at 3 to 4 months of age, had greater iron intakes at age 6 months but no difference in hemoglobin levels at ages 12, 24, or 36 months than infants with later introduction to complementary foods at age 6 months. These infants were all formula fed and received at least the RDA for iron for the first 6 months of life.

## Zinc

The AI for zinc for infants from birth to age 6 months reflects the usual zinc intake of infants fed exclusively human milk. Human milk alone is inadequate to

meet infants' needs for zinc after 6 months of age (IOM, 2001). **Zinc deficiency** is prevalent in undernourished children and is linked to reduced activity and play with subsequent poor developmental outcomes.

Zinc deficiency is associated with poor growth as well as diarrheal disease. It is estimated that 12- to 24-month-olds only meet 50% to 60% of the DRI/RDA for zinc (Krebs, 2000). Meeks Gardner et al. (2005) found that when poor undernourished Jamaican children ages 9 to 30 months were supplemented with 10 mg zinc daily and also participated in a weekly program to improve mother-child interactions, the developmental quotient and hand and eye coordination improved. Diarrheal morbidity was

reduced, but there were no improvements in the children's growth.

Zinc concentration in human milk is low, but bioavailability is high. Neonatal stores are likely sufficient to maintain zinc homeostasis until 6 months of age. The young infant has a relatively high zinc requirement to support the rapid growth of early infancy. Zinc concentration in human milk decreases throughout lactation, but as the infant's growth rate declines with increasing age so does the requirement for zinc (Lawrence, 1999). The concentration of zinc in human milk decreases rapidly from 4 mg/L at 2 weeks to 2 mg/L at 2 months and to 1.2 mg/L at 6 months (Krebs, Reidinger, Robertson, & Hambridge, 1994). Despite an increased intake in volume over the first 6 months, this steep decline in zinc concentration in human milk results in a decline in zinc intake. Zinc concentration in human milk of well-nourished mothers is resistant to changes in the maternal diet. Although zinc supplementation is associated with improved growth, exclusively breast-fed infants grow well without additional zinc. Dewey et al. (1998) found that when breast-fed children received complementary foods fortified with zinc to double their average zinc intake there was no significant increase in weight or length.

Zinc absorption is greater from a diet high in animal protein, and the best source of zinc is red meat. Plant-based foods containing phytic acid bind with zinc in the intestines and reduce absorption. Vegetarians who rely on a plant-based diet may need to increase their zinc intake by 50% due to decreased bioavailability of zinc from phytic acid. Complementary foods based on unrefined cereals and legumes have a high phytate-to-zinc ratio and can compromise zinc status, whereas rice has a lower phytate-to-zinc ratio (Gibson & Holtz, 2000). Offering infants complementary foods of animal origin such as red meat and fish improves zinc intake and bioavailability. Supplementation with a combination of micronutrients can lead to problems of interaction and limitations of absorption. A zinc supplement given in water interferes with absorption of iron but not when both are added to food (Rossander-Hulten, Brune, Sandstrom, Lonnerdal, & Hallberg, 1991).

## Vitamin D

**Rickets** was almost universally seen in African-American infants living in the northern United States at the turn of 20th century. With the dis-

**Zinc deficiency:** Prevalent in undernourished children and associated with poor growth, poor developmental outcomes, and diarrheal disease.

**Rickets:** Vitamin D deficiency resulting in growth deficits, developmental delay, failure to thrive, short stature, tetany, seizures, and skeletal deformities.

covery of vitamin D and a public health campaign to fortify infant foods and supplement breast-fed infants with cod liver oil, rickets were nearly eradicated (Rajakumar & Thomas, 2005). Once again, nutritional rickets is a public health concern. Breast-fed infants are at risk for vitamin D deficiency due to limited amounts of vitamin D in breast milk and the current trend to limit sun exposure (Fomon, 2001). Vitamin D deficiency rickets can cause significant morbidity, including delays in growth and motor development, failure to thrive, short stature, tetany, seizures, and skeletal deformities. A review of published reports from 1986 to 2001 found 166 cases of rickets in children in North Carolina, Texas, Georgia, and the mid-Atlantic region (Weisberg, Scablon, Li, & Cogswell, 2004). Most cases (83%) were African-American, and 96% were breast-fed. Only 5% of the breast-fed infants received vitamin D supplementation, and most were weaned from the breast to a diet low in vitamin D and calcium.

Dark-skinned infants who are exclusively breast-fed are at particular risk. From 1990 to 1999 in North Carolina 30 cases of nutritional rickets were seen in African-American children who were breast-feeding without supplemental vitamin D, even though infants living in sunny southern states were believed to be at low risk (Kreiter et al., 2000). Vitamin D deficiency rickets is common in infants in Pakistan, Saudi Arabia, and the United Arab Emirates where breast-feeding women have limited sun exposure and a diet low in vitamin D. Infants are not routinely supplemented with vitamin D while breast-feeding, and many mothers avoid consumption of fortified dairy products. Despite abundant sunshine only rural women who spent more time working outdoors had adequate serum levels of vitamin D (Dawodu, Adarwal, Hossain, Kochiyil, & Zayed, 2003).

Guidelines from the AAP, based on recommendations of the National Academy of Sciences, state that all infants, including those exclusively breast-fed, require a minimum intake of 200 IU of vitamin D per day beginning the first 2 months of life to prevent vitamin D deficiency rickets (Gartner, Greer, & the Section on Breastfeeding and Committee on Nutrition, 2003). Universal supplementation of all breast-fed infants is controversial and not endorsed by all practitioners (Henderson, 2005). Implicit in this recommendation is that human milk is inferior and does not meet all the infant's nutritional requirements, reducing the mother's confidence in her choice to breast-feed her infant. Concerns for oral

supplementation of the breast-fed infant include aspiration and possible changes in the pH and flora of the gut, altering absorption of other nutrients and affecting rates of infection. The only infant vitamin D supplements readily available either contain other vitamins not required by healthy full-term infants or are available in highly concentrated forms that increase the risk of overdose.

Vitamin D synthesis occurs in the skin from exposure to ultraviolet B light from sunlight. Dietary sources include fish liver oils, fatty fish, and foods fortified with vitamin D, particularly cow's milk, infant formula, and breakfast cereals. Sunlight exposure may not be sufficient at higher latitudes, during winter months, or with sunscreen use. Individuals with dark skin pigmentation have limited vitamin D synthesis with sunlight exposure. Human milk typically contains 25 IU/L of vitamin D, not enough to meet the recommended requirement. Infant formula has at least 400 IU/L; therefore an infant consuming more than 500 mL/day of infant formula receives the recommended 200 IU/day.

Maternal vitamin D status has a direct effect on the vitamin D content in human milk. Traditionally, sunlight exposure provided adequate vitamin D for both mothers and breast-feeding infants. For instance, in light-skinned individuals 10 to 15 minutes of total body peak sunlight exposure endogenously produces and releases into circulation 20,000 IU of vitamin D. The daily recommended intake for vitamin D for lactating women is 400 IU, an amount unlikely to provide for optimal vitamin D levels in human milk. Wagner and colleagues (2006) found that by supplementing lactating mothers with 6,400 IU/day of vitamin D they were able to increase maternal vitamin D levels sufficiently to increase the amount of vitamin D in human milk from 82 to 873 IU/L and to significantly improve circulating vitamin D in both the mother and the breast-fed infant.

### Supplemental Nutrients

Human milk continues to provide many nutrients in the second half of the first year of life during the period of **complementary feeding**. Human milk intake of infants ages 9 to 11 months meets the estimated needs for vitamin C, folate, vitamin B<sub>12</sub>, selenium, and iodine. After 6 months complementary foods are needed to provide 12% of vitamin A; 25% to 50% of copper; 50% to 75% thiamin, niacin, and

**Complementary feeding:** The period that begins with the introduction of the first nonmilk food and ends with the cessation of breast or formula feeding.

manganese; and up to 98% of iron and zinc (Gibson & Holtz, 2000).

Despite the fact that most young children receive adequate vitamins and minerals from their diet, many families supplement their child's diet with additional vitamins and minerals. Eichenberger Gilmore, Hong, Broffitt, & Levy (2005) studied trends in children under age 2 years in Iowa and found that by 24 months 31.7% used some type of supplement. In the first 6 months of life 3.5% to 6.3% of non-breast-fed infants received supplements compared with 18.3% to 29.2% of breast-fed infants. After 6 months of age use of multiple vitamin supplement and multiple vitamin with minerals increased with age. Diet alone provided AI of most vitamins and minerals, and with additional supplementation intake of vitamin A exceeded the recommended upper limit. Hypervitaminosis A is a concern because reports associate excessive vitamin A intake with decreased bone mineral density and increased risk of fracture. The long-term adverse effects of high intakes of vitamin A during early life are not clear.

Milner and coworkers (2004) reported that early use of multivitamins increased the risk of developing food allergies and asthma. There was an association between infant multivitamin supplementation within the first 6 months of life and an increased risk of developing asthma by 3 years of age among black children. In addition, multivitamin supplementation in the first 6 months of life was associated with increased risk for food allergies by 3 years of age in both formula-fed and breast-fed infants. Early infancy may be a sensitive time for exposure to exogenous stimuli that influence the differentiation of naive T cells into either proinflammatory or anti-inflammatory cells. Vitamins may be a potent stimulus for the differentiation of T cells that promote allergic response when encountering specific antigens. Recommendations for routine vitamin supplementation, including vitamin D supplementation for breast-fed infants, may need reevaluation in light of these findings.

Fortified foods provide a significant portion of nutrient needs, reflecting a limited intake of nutritious foods such as fruits and vegetables (Fox, Reidy, Novak, & Ziegler, 2006c). As infants move into the toddler stage, a decrease in naturally occurring vitamin A from vegetables is replaced by vitamin A from cereals and supplements. At the same time, two of three of the leading sources of vitamin C are fortified juices and fortified sweetened beverages rather than fruits and vegetables. Consumption of a wide

variety of foods to meet nutrient needs, rather than reliance on fortified foods and supplements, is optimal. There is potential for excess intake and toxicity when vitamin A, zinc, and folate are consumed through fortified foods and supplements.

### **Vegetarianism**

A vegetarian diet during infancy and childhood can be adequate in all essential nutrients, with normal growth and nutritional status expected unless the diet is severely restricted. A breast-fed infant of a well-nourished vegetarian mother receives adequate nutrition, particularly if the mother pays close attention to her own intake of iron, vitamin B<sub>12</sub>, and vitamin D. Women who consume three or more servings of dairy products receive sufficient vitamins D and B<sub>12</sub> from their diet. Women following a vegan diet need to supplement with foods fortified with vitamin B<sub>12</sub> such as nutritional yeast or soy milk. Vegan infants who are not breast-fed need to receive soy infant formula until 1 year of age. Soy milk, rice milk, or homemade formulas do not provide adequate nutrition for infants less than 1 year old and should not be used to replace breast milk or commercial infant formula (American Dietetic Association, 2003).

A variety of protein-rich vegetarian foods is available for the older infant and toddler, including tofu, legumes, soy or dairy yogurt and cheese, eggs, and cottage cheese. These foods can be easily pureed or mashed for increased acceptance when the child is first introduced to complementary foods. Later, soft cooked beans, bean spreads, or nut butters on toast, chunks of tofu, or cheese and soy burgers can be offered as finger foods. Fat is an important source of energy and should not be restricted in children under 2 years of age. Vegan infants need a supplementary source of vitamin B<sub>12</sub> when they are weaned from breast milk or infant formula. Read more about vegetarianism in Chapter 7.

## **Complementary Feeding**

### **Transitioning from All Milk to Family Foods**

Complementary feeding is defined as the period extending from the first introduction of nonmilk feeds to the cessation of breast or formula feeding (Weaver, 2000). Any food that provides energy and displaces breast milk is considered a complementary food. A gradual progression from an exclusive milk diet to a variety of complementary foods allows the infant's gastrointestinal function to accommodate new types



of foods, including starch, sucrose, and fiber. In many other mammals there are abrupt and well-defined changes to the intestinal mucosa and enzyme activity as weaning occurs. However, in humans these changes are less obvious and more gradual. Human milk contains many bioactive substances, including digestive enzymes such as bile salt-stimulated lipase, amylase, and protease, that may be involved in the digestion of complementary foods.

The timing of complementary feeding varies according to cultural practices and the personal beliefs of the mother as well as guidance she receives from her pediatrician. In some instances pediatricians may suggest adding cereal to the infant's diet before age 4 months when a mother is concerned about the baby's sleeping patterns or growth. Child nutrition experts agree that there is no reason to introduce complementary foods before 4 months of age. At least 60 countries have policies in place to introduce complementary foods after 6 months of age. Earlier introduction of complementary foods can affect immune function and immunotolerance, development of chronic disease, and risk of atopy.

At birth the gut of a full term infant may be anatomically and functionally mature, but subtle immaturities in luminal digestion, mucosal absorption, and protective function could predispose the infant to gastrointestinal and systemic disease during the first 6 months of life. It is not known exactly when the period of immature immune function ends and when it is safe to feed foreign proteins. Early introduction can cause protein-induced enteropathies, leading to mucosal inflammation, villous atrophy, diarrhea, and failure to thrive (Muraro et al., 2004).

The question of when the normal term infant is developmentally ready to discontinue **exclusive breast-feeding** and begin the intake of solid and semisolid complementary foods is an important one. There probably is not a single optimal age for introduction of complementary foods but rather optimal ages that are determined by factors such as infant birth weight, maternal nutrition while breast-feeding, and environmental conditions.

### Feeding Guidelines

From 1979 until 2001 the WHO recommended that normal full-term infants be exclusively breast-fed for 4 to 6 months. Later, it was found that discontinuing exclusive breast-feeding before 6 months increased infant morbidity and mortality, and the WHO rec-

ommendations were revised to encourage exclusive breast-feeding for 6 months. Early introduction of complementary foods and exposure to pathogens in food could result in symptomatic infection and illness in the infant and reduced sucking at the breast, followed by a decrease in the amount of milk and immune substances consumed as well as decreased maternal milk production from reduced demand. Exclusive breast-feeding for 6 months results in greater immunologic protection and limits exposure to pathogens at an early age when the immune system is immature. Energy and nutrients that are valuable for normal growth and development can be used for their intended purpose rather than diverted for immunologic function.

Malnutrition is the leading cause of death in children under 1 year of age worldwide. Inappropriate feeding practices include early cessation of exclusive breast-feeding, introducing complementary foods too early or too late, and providing nutritionally inadequate or unsafe foods. Malnourished children who survive are frequently sick and may suffer life-long consequences. Overweight and obesity are increasing at alarming rates throughout the world and are associated with poor feeding practices that often begin in early childhood. Global strategies for infant and young child feeding can impact social and economic development.

The WHO feeding guidelines (World Health Organization [WHO], 2003) are for generally healthy breast-fed infants. These guidelines target primarily low income countries where most children are breast-fed and safe low-cost alternatives to breast milk are not readily available. No information is included for feeding premature infants or children with infections or other acute or chronic diseases that could affect nutritional status. No information is provided on feeding non-breast-fed infants. An important goal of the WHO is to improve complementary feeding practices in terms of timeliness, quality, quantity, and safety to ensure adequate global nutrition. It is difficult to make recommendations regarding the optimal age for introduction of complementary foods. Ideally, the appropriate time to introduce complementary foods and the optimal duration of breast-feeding consider infant outcomes, such as growth, behavioral development, micronutrient status, the risks of infection, allergy, and impaired intestinal function, as well as those of the mother, such as general health and nutritional status and return to fertility.

The AAP states that there is no evidence for harm when safe, nutritious, complementary foods are

#### Exclusive breast-feeding:

Infant receiving only breast milk and no other foods or drinks for the first 6 months.

introduced after 4 months when the infant is developmentally ready. The AAP Section on Breastfeeding (2005) recommends that complementary foods rich in iron be introduced gradually around 6 months of age, but due to the unique needs of individual infants the need to introduce complementary foods could occur as early as 4 months or as late as 8 months of age. Exclusive breast-feeding in the first 6 months is defined by the AAP as consumption of human milk with no supplementation of any type (no water, no juice, no nonhuman milk, and no foods) except for vitamins, minerals, and medications. During the first 6 months water, juice, or other liquids are unnecessary, even in hot climates, and can introduce contaminants or allergens. Exclusive breast-feeding provides protection from many acute and chronic diseases. Breast-feeding is also more likely to continue for at least the first year of life when infants are exclusively breast-fed for the first 6 months. For optimal health benefits breast-feeding should continue for 12 months or longer. The recommendations of the WHO are to breast-feed for at least 2 years, and the AAP states that there is no upper limit to the duration of breast-feeding and no evidence of psychological or developmental harm from breast-feeding into the third year of life or longer (AAP, Section on Breastfeeding, 2005). Indeed, in late infancy breast milk provides significant amounts of energy and micronutrients and is a key source of PUFAs crucial for brain development and neurologic function (Villalpando, 2000).

A partnership of the Agricultural Research Service (ARS) at the U.S. Department of Agriculture-Children's Nutrition Research Center at the Baylor College of Medicine in Houston, Texas and the American Dietetic Association, funded by Gerber Food Products Company, developed the "Start Healthy Feeding Guidelines for Children Ages 0–24 Months." The expert panel realized that guidance was needed to help parents through the transition period from an all-milk diet to the first introduction of solids foods by adding variety and texture throughout the weaning process and to establish healthy eating patterns. These new guidelines are an effort to address the growing problem of childhood obesity and inappropriate food choices at an early age. They are intended to complement and expand on already existing guidelines from the AAP, CDC, and other expert groups. These evidence-based guidelines answer the important questions "when, what, and how" complementary foods should be introduced (Butte et al., 2004). Where scientific evidence was limited or unavailable, expert opinion was referenced. For instance,

there is only limited evidence to suggest any order for introduction of textures, and expert opinion suggests a general progression based on the child's readiness for and acceptance of different food textures.

### **Complementary Foods and Growth**

Introducing complementary foods to the exclusively breast-fed infant before 6 months does not increase total calorie intake or improve growth. A breast-fed infant who receives complementary foods at 4 months decreases his or her intake of human milk to maintain the same level of calories. Complementary foods displace human milk, and the infant receives fewer immune factors and is at greater risk for infection. No significant improvement in weight or length was observed by Dewey (2001) in infants up to 12 months of age when they received complementary foods at 4 months compared with infants who received exclusive human milk until 6 months.

Despite recommendations to exclusively breast-feed for the first 6 months of life, this practice may be uncommon. Carruth, Skinner, Houck, & Moran (2000) found that in a study of 94 mothers, 60 added solid food by 4 months and 8 were feeding cereal in a bottle. The median age for introduction of cereal was 4 months and for juice 4½ months. Thirteen mothers introduced cereal, juice, or fruit as early as 2 months. In looking at the growth of the children who had early solids, there was no association between the age of introduction of complementary foods and change in weight or length from 2 to 8 months or from 12 to 24 months. These results were similar to the WHO data (WHO Working Group, 2002) showing only minor differences in growth among infants receiving complementary foods at different ages. The WHO data was based on a unique longitudinal seven-country study of predominantly breast-fed infants. They found little evidence of risk or benefit related to growth based on timing of introduction or types or frequency of complementary foods in healthy infants living in environments without major economic restraints and with low rates of illness.

The amount of energy and nutrients needed from complementary foods depends on the amount of breast milk or formula the infant is consuming. Although it is possible for an infant to receive adequate nutrition for the first year solely from iron-fortified formula, all infants need complementary foods for exposure to novel tastes and textures and to develop appropriate feeding skills. A variety of flavors and foods is important in the first 2 years of life and may increase the likelihood that children will try new foods.

### Learning Point

Breast-feeding exposes the infant to a variety of flavors from the very beginning through mother's milk. Repeated exposures to a new food may be necessary before it is accepted.

### Meal Patterns and Nutrient Intakes

During infancy and early childhood, lifelong patterns of eating are formed that can influence later eating habits and overall health. As the child makes the transition from an all-milk diet to sharing foods from the family table, meeting nutritional guidelines may become more problematic for families. Families strive to follow nutrition recommendations to provide the best for their children, particularly in the year after birth when the infant is eating mostly jarred baby foods. As the infant matures and begins to incorporate more of the family foods into his or her diet, less than optimal nutrition becomes evident. Transitioning from baby food to table food has been associated with a decreased intake of vitamin A, iron, and folate at meals as baby food fruits, vegetables, and meats are not replaced with equivalent table foods.

Children imitate what others around them are eating, and if no one else eats fruits or vegetables, the young child will quickly abandon these foods. When other family members drink sweetened carbonated beverages and eat high calorie low nutrient dense foods, such as French fries, donuts, and potato chips, the young child will happily join in. As rates of obesity, excess weight, and type 2 diabetes are increasing in children, it is evident that the influence of early diet needs to be addressed. At a surprisingly young age many infants and toddlers do not receive a variety of fruits and vegetables and instead are consuming high calorie, high fat, salty snacks and sweetened drinks. It is the parent's responsibility to offer nutritious foods to infants and toddlers. Although a preference for sweet foods is innate, repeated exposure at an early age and observing other family members eating these foods increases the likelihood that young children will develop preference for these foods. The disappearance of the family meal and the increase in the number of meals eaten outside the home and from fast food establishments has concerned experts as the prevalence of snacking and the quantity and quality of foods consumed by children and adolescents in recent years has changed.

### Learning Point

Food-related behaviors are established early in life, and how and what an infant or toddler eats in the first years of life can influence later food choices.

### Food Trends and Preferences

The Feeding Infants and Toddlers Study (FITS) was a cross-sectional telephone study using a national random sample of 3,022 infants and toddlers between 4 and 24 months of age and a subsample of 703 two-day dietary recalls. The sample size was sufficiently large to categorize data by age groups: 4 to 6 months, 7 to 11 months, and 12 to 24 months. Conducted in 2002, it consisted of up to three telephone interviews to collect data on growth, development, and feeding patterns. The study had a large sample size and was representative of ethnicity of the general population. It also included a large proportion of breast-fed infants. The FITS survey collected data on food choices and their nutritional impact, feeding practices and patterns, and infant and toddler growth and developmental milestones (Devaney et al., 2004a). The study was sponsored by Gerber Products Company and provided in-depth nutritional information about feeding behaviors of infants and toddlers and compared intakes with the newly developed DRIs (see Appendix 2).

Some new trends were noted in infant nutrition. The unhealthy practice of early introduction of unmodified cow's milk before 6 months of age has been nearly eradicated, but the fact that some infants under 24 months of age drank little or no milk in a day is concerning. Overall, the FITS study found that most infants and toddlers in the United States were receiving adequate nutrition without getting excessive amounts of nutrients. Even infants whose motor skills lagged or those who were described by parents as picky eaters were receiving adequate nutrients. In fact, the data suggested that many children were being overfed (Dwyer, Sutor, & Hendricks, 2004).

Energy intake reported by parents was often greater than those recommended using the new DRI standard for energy, called the estimated energy requirement. The mean energy intake exceeded the estimated energy requirement by 10% for infants ages 4 to 6 months, by 23% for infants ages 7 to 12 months, and by 31% for ages 12 to 24 months (Devaney, Ziegler, Pac, Karwe, & Barr, 2004b). For infants under 6 months of age, the largest discrepancies were for those receiving complementary foods in addition to breast milk or formula. The FITS infants and toddlers consumed more energy than recommended on average for all age groups. Over-reporting of food intake by caregivers is possible because parents may

**FITS:** The Feeding Infants and Toddlers Study conducted on a large random sample of infants and toddlers to collect data on food choices and feeding practices and their impact on growth and development.

perceive the amount of food consumed reflects their success as providers. Parents may also have difficulty accurately assessing food intake because of spillage and a discrepancy between foods offered and foods consumed. However, with 10% of 2- to 5-year-old children considered overweight, it is plausible that overfeeding is occurring in infants and toddlers. Early exposures to fruits and vegetables or to foods high in energy, sugar, and fat at this critical time period can influence food preferences and dietary habits later in life.

Complementary foods continue to be introduced at ages earlier than recommended by experts, and 29% of all infants were introduced to infant cereals or pureed foods before 4 months of age (Briefel, Reidy, Karwe, & Devaney, 2004a). There was no significant difference in the mean age of introduction of complementary foods or cow's milk according to income level or ethnicity or in children ever breast-fed compared with those never breast-fed. The contribution of commercial baby foods and beverages to energy consumption peaks at ages 7 to 8 months and declines as table food intake increases (Briefel, Reidy, Karwe, Jankowski, & Hendricks, 2004b).

The FITS study revealed disturbing trends regarding the food consumption of infants and toddlers. Early food preferences can predict future eating behaviors, and an alarming percentage of young children have already developed suboptimal food consumption patterns. Not surprisingly, food consumption patterns in infants and toddlers reflect the typical eating patterns of older children and adults, such as diets lacking in fruits and vegetables with high intakes of readily available low nutrient snacks and beverages. Daily consumption of fruits and vegetables are the cornerstone of a healthy diet, and a wide variety is encouraged. Many infants and toddlers do not meet the Five a Day for Better Health program's recommendation for fruits and vegetables. Fruit was not consumed daily by more than 25% of infants and toddlers (Skinner, Ziegler, Pac, & Devaney, 2004a). About 50% do not have fruit for breakfast or lunch, and 60% do not have fruit at dinner. Fruit was even more uncommon for snacks. Similar patterns of vegetable consumption were observed, with 50% not having a vegetable at lunch, and 30% not having a vegetable with dinner. Less than 5% had vegetables for breakfast or snacks (Skinner et al., 2004a). Among infants aged 9 to 11 months old, 27% consumed no vegetables in a day, and French fries were among the most commonly eaten vegetable

in all age groups above 9 months (Fox, Pac, Devaney, & Jankowski, 2004). Fewer than 10% of infants and toddlers consumed dark leafy vegetables at any age. Intake of deep yellow vegetables decreased as infants transitioned from commercial baby food to table food. Commercial baby food was the main source of fruits and vegetables until 9 months of age when children were offered a greater percentage of cooked vegetables and fresh fruits. Bananas were the most commonly consumed fruit, followed by apples, and few children received citrus, melon, or berries.

Establishment of healthy patterns of beverage consumption including milk with meals is important for adequate calcium intake during the years of active bone growth in childhood and adolescents. Water is a better choice for quenching thirst than sweetened juice drinks or carbonated beverages. The FITS study found that colas, fruit-flavored carbonated drinks, and carbonated mineral water were consumed by an increasing percentage of children from ages 4 through 24 months. Substitution of fruit drinks or carbonated beverages for milk at lunch, dinner, and snacks was evident after 15 months (Skinner, Ziegler, & Ponza, 2004b). Fruit juice is not a necessary component of the diet of infants and toddlers and, if used at all, should be introduced after 6 months of age and limited to 8 ounces per day (Kleinman, 2000a). Adverse gastrointestinal reactions to pear or apple juice are possible because of poor absorption of fructose and sorbitol (Fomon, 2001). Offering juice in a bottle after teeth have erupted can increase the risk of dental caries and should be avoided.

According to the AAP, limited amounts of 100% juice amounting to 4 to 6 ounces per day can be offered after 6 months of age, yet Skinner et al. (2004b) found from the FITS study that 22% of infants were introduced to juice earlier. Juice consumption increases dramatically with age. Ten percent of toddlers ages 15 to 24 months consume more than 14 ounces of juice per day. Fruit drinks are also popular, and 5% of toddlers consume more than 16 ounces of fruit drinks a day. The AAP does not provide recommendations for limitations on fruit drinks or carbonated beverages but states that they are not equivalent to 100% juice and should not be considered a fruit serving. Most fruit juices and fruit drinks contain added vitamin C and provide 20% to 30% of the daily vitamin C requirements, but apple juice, the most commonly consumed juice, contains little vitamin A and folate, nutrients commonly obtained from fruits and vegetables. Overfeeding

juice and juice drinks can displace more nutritious beverage options such as milk and water and can be associated with excessive calorie intake and risk of obesity in older children.

Desserts and sweets are introduced at a surprisingly early age, with 10% of 4- to 6-month-olds already consuming a dessert, sweet, or sweetened beverage daily. These numbers increased dramatically after age 6 months, when nearly half were consuming one or more foods in this category. Younger infants consume commercial baby food desserts or cookies marketed specifically for infants, but after age 9 months children are offered many of the foods that other family members eat, such as cakes, cookies, doughnuts, ice cream, candy, fruit-flavored drinks, and salty snacks, foods that are low in important nutrients but high in fat and calories. Parents should offer age-appropriate finger foods such as soft fresh fruits, diced canned fruit, well-cooked vegetables, and easily dissolvable fortified grains such as unsweetened ready-to-eat cereals.

There are no controlled studies addressing the practical aspects of introducing foods for the first time. Although feeding guidelines for parents abound, there is no evidence for a benefit of introducing one particular food first or at any particular rate. The AAP suggests that when complementary food introduction is initiated after 6 months of age, the order of the specific food introduction is not critical. Mixing cereal with breast milk may enhance acceptance of solid foods by breast-fed infants. Foods commonly consumed by infants at 1 year of age include cereals and fruits. FITS data showed that infant cereal was the most common source of grains in young infants, but even by ages 7 to 8 months many infants were consuming ready-to-eat cereals, crackers, pretzels, rice cakes, breads, and rolls (Fox et al., 2004). After 9 to 11 months, the number of infants receiving infant cereal declined. This was replaced by other noninfant ready-to-eat and cooked cereals, including presweetened cereals. Many presweetened cereals are comparable in vitamins and minerals with unsweetened ready-to-eat cereals but their use in this age group may lead to preference for sweetened foods.

Infants rarely consume meat. Krebs (2000) suggested that meat intake for breast-fed infants at 6 months would adequately support both iron and zinc requirements in this age group. Introduction of red meat is desirable by ages 5 to 6 months because of the high bioavailability of iron (Fomon, 2001). Offering plain single meats promotes the goals of com-

plementary feeding, which is to gradually increase the variety of flavors and textures in the diet. The formula-fed infant is less reliant on complementary foods for iron and zinc. The addition of cereal to complement the intake of protein and energy from formula is considered adequate (Wharton, 2000). In the FITS study few infants were receiving any type of meat, and often the meat appeared in commercially prepared baby food dinners. Fewer than 5% of infants in any age group received plain baby food meats. After 9 to 11 months of age non-baby food meats were offered, with chicken or turkey the most common, followed by beef and hot dogs, sausages, and cold cuts. By 12 months of age less nutritious high-fat deli meats were the second most commonly consumed source of meat. Pork, ham, fish, shellfish, and beans were consumed by only a small number of infants and toddlers on a regular basis. Popular nonmeat protein sources include cheese, eggs, and yogurt (Skinner et al., 2004a). Peanut butter, seeds, and nuts were rarely offered before 1 year of age, and only about 10% of toddlers consumed any peanut butter daily.

Cow's milk and cow's milk products make a significant contribution to nutritional intake during the period of complementary feeding. If breast-feeding continues into the second year of life and the diet contains a reasonable amount of animal protein in the form of meat, fish, poultry, or eggs, most infants thrive without the addition of dairy products to their diet (Michaelsen, 2000).

In the FITS study nearly all children under 24 months of age consumed some form of milk daily. The average duration of breast-feeding was 5½ months (Briefel et al., 2004a). Exclusive breast-feeding was uncommon, and more than half of 4- to 6-month-old infants currently breast-feeding also received infant formula daily. At 6 to 11 months the percentage of breast-fed infants receiving infant formula increased to 70%. Overall, 9 of 10 infants who were ever breast-fed also had received infant formula.

Infant formula was consumed by 82% of 7- to 8-month-olds and decreased as cow's milk was introduced. Over 90% of infant formula consumed was iron fortified, and about 10% consumed soy-based formula. At ages 9 to 11 months 33% had received cow's milk and 20% were receiving cow's milk daily, increasing the potential for iron deficiency. Cow's milk has an undesirably high renal solute load compared with infant formula and is a significant concern for children at risk of dehydration. Iron in cow's milk is low and poorly absorbed, and feeding

non-heat-treated cow's milk can cause microscopic gastrointestinal bleeding in infants, resulting in loss of iron and anemia. Cow's milk is low in essential fatty acids, zinc, vitamin C, and niacin and is high in saturated fats. Recommendations to delay cow's milk introduction until 12 months of age are mainly focused on prevention of iron deficiency anemia (Michaelsen, 2000).

## Feeding Skills and Neuromuscular Development

### Reflexes

A normal progression of sucking and feeding reflexes is necessary for the child to advance from a milk-only diet to consumption of foods from the family diet. Swallowing is present in early fetal life at the end of the first trimester. The fetus has ample opportunities to practice by swallowing amniotic fluid even before the development of the **sucking reflex**,

**Sucking reflex:** Strong reflex present in the newborn elicited by stroking the infant's lips, cheeks, or inside the mouth.

**Gag reflex:** Reflex stimulated by contact with the tongue that gradually diminishes over the first 6 months.

**Rooting reflex:** Reflex present from birth to age 3 months that assists the infant to locate the breast and nipple by turning the head side to side and opening the mouth wide when the mouth is stroked.

which appears by the middle of the second trimester. The sucking reflex is quite strong in the newborn and can be easily elicited by stroking the infant's lips, cheeks, or inside the mouth. By about 3 months of age sucking becomes less automatic and more voluntary. The **gag reflex** is present in the third trimester and is stimulated by contact of the posterior two-thirds of the tongue. This reflex gradually diminishes to one-fourth of the posterior tongue by 6 months of age. The **rooting reflex**, which assists

the infant to locate the breast and nipple by turning the head side to side and opening the mouth wide when the skin surrounding the mouth is stroked, disappears by 3 months of age.

### Advanced Motor Skills

Infants need new oral motor skills to transition from a full liquid milk-based diet to a more solid diet of complementary foods. Disappearance of the rooting and sucking reflexes and the accompanying changes in anatomy help prepare the infant for this transition. Phasic biting, resulting in the rhythmic opening and closing of the jaw when the gums are stimulated, disappears between 3 and 4 months of age. Between 6 and 9 months it becomes possible for the infant to receive a bolus of food without reflexively pushing it out of the mouth. By 12 months of

age rotary chewing is well established, along with sustained controlled biting that permits the infant to consume a variety of foods (Kleinman, 2000c).

During the first 2 years of life there is increasing head and torso control that permits a child to achieve developmental milestones required for proper self-feeding abilities. Finger coordination to permit self finger feeding usually is adequate by 6 to 7 months of age. The infant must be able to sufficiently stabilize the head and balance the trunk before he or she can sit without support and use arm and hand movements for self-feeding. Carruth and colleagues (2004) found that one-third of 4- to 6-month-old infants and 99% of 9- to 11-month-olds can sit alone without support. Stability of the trunk is crucial in the process of progressing to complementary foods, and by 6 months most infants have achieved greater strength in the trunk, shoulder, and neck muscles. There is a wide range of ages when feeding skills emerge, and it is crucial that caregivers allow ample opportunities for appropriate exploratory activities. Offering the child a variety of nutritious foods and allowing them to self-feed when they have sufficiently developed this skill is appropriate and will not jeopardize adequate nutrient intake.

Beginning at 6 months most infants are ready for pureed, mashed, and semisolid foods. By 7 months soft foods that can be pressed down by the infant's tongue can be introduced, and at 9 months the infant can handle foods that can be compressed by the gums. Teeth are not necessary for chewing of soft lumpy foods. The ability to handle advanced textures increases day by day, and children require multiple opportunities to practice new feeding skills. By 8 months they can progress to finger foods they can pick up and feed themselves. By 12 months of age most children can transition to the same diet as the rest of the family, keeping in mind the need for calorically and nutrient-dense foods because of the smaller portion size. Infants possessing self-feeding skills are reported to have higher energy and nutrient intakes (Carruth et al., 2004). Foods that are a choking risk that can lodge in the trachea, such as grapes, nuts, hard raw vegetables and fruits, and popcorn, should be avoided. Introduction to a cup usually occurs after 6 months, and by 12 months most infants are drinking from a "sippy cup."

### Chewing Ability

Advances in gross motor skills parallel advances in dentition as the first primary teeth erupt at 7 to 8 months and continue throughout the first 2 years,

with approximately 15 teeth by 19 to 24 months of age. Carruth et al. (2004) found the ability to consume foods that required chewing increases with age. Nutrient intakes of energy, fat, protein, vitamin B<sub>6</sub>, vitamin B<sub>12</sub>, folate, zinc, thiamin, niacin, and magnesium were greater for infants under 1 year of age who were able to eat foods that required chewing. Individual differences in the age of eruption of teeth can influence the ability to chew certain foods, especially meat and fibrous vegetables.

Feeding difficulties, particularly difficulty with chewing tough or fibrous foods, in Japanese children are thought to be caused by inappropriate transition from a milk-based diet to a diet of family foods. Sakashita and coworkers (2004) found that at 2 years of age many preschool children swallowed without chewing or were unable to chew and swallow certain foods and that many kindergarten children did not chew properly, retained food in the side of their mouth, or frequently spit food out (Sakashita et al., 2004). A transitional diet containing very soft and pureed foods for an extended period has been suspected of preventing children from developing proper masticatory system and chewing and swallowing ability. Leafy vegetables were usually offered early as a weaning food but were not well accepted because the fiber makes it difficult to chew. Meats were often introduced later than recommended, possibly due to parental concerns related to food allergies (Sakashita, Inoue, & Tatsuki, 2003). In Japan foods were specially cooked and fed to children from a spoon, inhibiting the proper development of the masticatory system and mature chewing and swallowing behavior.

### **Determinants of Food Acceptance**

Sakashita et al. (2004) found that acceptance of new foods was greatest in children who were offered food prepared from the family table and was lowest in children fed jarred baby food. Offering infants foods prepared from the family table promotes feeding progress by giving the infant an opportunity to experience a variety of food textures from an early age. Infants first offered lumpy solid foods between ages 6 and 9 months had fewer feeding difficulties and improved acceptance than infants not introduced to these foods until after age 10 months. Observing other family members eating at the family table and having the opportunity to try new foods is also an important component of transitioning an infant to family foods. Sakashita et al. (2004) found that first-born children experience more feeding difficulties

than second- or third-born children. This may be a result of limited opportunities to observe other family members eating and to learn feeding behavior from older siblings.

The number of accepted foods increases rapidly from 6 months to 1 year and continues to increase throughout the first 2 years. Foods requiring significant chewing before swallowing, such as leafy vegetables and sliced meat, may be poorly accepted. Processed sliced deli meats are often more readily accepted when offered. Because chewing ability affects ability to swallow and therefore food acceptance, breast-fed infants who have more opportunity to develop the masticatory system have a higher rate of food acceptance than bottle-fed infants. Exposure to food flavors through mother's milk also prepares the infant for a variety of flavors. Breast-feeding seems to facilitate increased acceptance of different foods due to the greater variation in breast milk flavors compared with infant formula.

Other causes of food refusal include dislike of the taste or smell and an unfamiliar appearance. Often, a child's food preference reflects those of other family members. Early food experiences can be imprinted on the memory, and when children refuse to eat vegetables at an early age, these food preferences may remain throughout the childhood and adolescent years with significant health consequences. Child-feeding practices contribute to the development of food intake controls and energy balance and can affect childhood obesity. Obese individuals tend to prefer fatty foods to fruits and vegetables and dislike tough or fibrous texture. Exposure to fruits and vegetables in infancy and early childhood should be encouraged to reduce risk factors for obesity and obesity-related diseases.

### **Caregiver Behaviors**

Although early childhood malnutrition can be attributable to poverty and lack of resources, family and caregiver characteristics, such as education and household management or coping skills of the mother, can determine normal growth and development. Lack of knowledge regarding appropriate foods and feeding practices can contribute to malnutrition to a greater degree than lack of food. Not only is providing the appropriate combination of complementary foods to meet the child's nutritional needs important, feeding practices such as frequency of feeds and feeding style need to be considered. Caregiving behaviors that have been identified as promoting normal growth and development are (1) active

or interactive feeding, (2) selecting foods appropriate to the child's motor skills and taste preferences, (3) feeding in response to the child's hunger cues, (4) feeding in a nondistracting safe environment, and (5) talking and playing with the child in the context of the meal. This type of responsive parenting has been described as sensitive and supportive caregiving associated with good growth and development. Feeding interactions should include the caregiver observing the infant's intake and non-verbal cues and responding accordingly (Pelto, 2000). If children refuse many foods, parents should be encouraged to be creative and experiment with different food combinations, tastes, and textures. Parents should be taught to encourage children to eat, but never to force, because this can lead to aversion to food and behavioral problems.

### **Effect of Feeding Mode in Infancy**

In early infancy parents choose whether the child will be breast-fed or bottle fed and whether human milk or formula will be consumed. They may also control the timing of the feedings and the volume consumed, although this is less likely when the infant is breast-fed. When a mother breast-feeds and her infant's sucking slows or stops, the mother assumes the child is satisfied and is finished eating. The amount of milk consumed is primarily under the infant's control. Breast-fed infants are able to adjust the amount of milk consumed to maintain a constant energy intake. Formula-feeding mothers may rely on visual cues of formula remaining in the bottle and encourage the infant to continue feeding after he or she has exhibited signs of satiety.

Taveras et al. (2004) found that the longer a mother breast-fed, the less likely she was to restrict her child's intake at 1 year. Compared with mothers who formula fed, mothers who exclusively breast-fed for 6 months were less likely to restrict their child's intake. Breast-feeding for at least 12 months was associated with lower levels of controlling feedings and resulted in improved intake by toddlers (Orlet Fisher, Birch, Smiciklas-Wright, & Picciano, 2000). Breast-feeding may protect against obesity by allowing the infant to naturally regulate energy intake based on hunger cues and by preventing parents from overriding these cues by controlling the feeding. Mothers who breast-feed may be more responsive to their infants' signals regarding the timing and volume of feedings.

### **Feeding Relationship**

As the child transitions to a variety of family foods, the need to be independent and autonomous will

be evident in the feeding relationship as the child assumes more control of his or her eating. The feeding relationship reflects the overall parent-child relationship, and feeding struggles may be indicative of other difficulties involving parent-child interactions. Feeding is a major area of frequent daily exchanges between the parent and the child, reflecting the characteristics of both the parent and the child that can either support or hinder the child's development. Feeding involves more than providing the correct mix of calories and vitamins to ensure adequate nutrition. The feeding relationship itself is crucial for the child's growth and development (Slaughter & Bryant, 2004). Feeding is a blend of nutrition, parenting, and human development and provides an opportunity for parents to be present and to provide love, support, and attention that can affect the child's physical, social, and emotional health.

As infants progress from a milk-based diet to sharing family foods, they develop unique likes and dislikes regarding the foods they are offered and will communicate these preferences to their parents. How the parents respond to this assertiveness can impact the child's developing sense of self and autonomy. The ability to refuse food and have this be accepted by the parents is paramount to future interactions between the child and the parents and provides a base for all future social interactions. It is important for the child's development to be able to say "no" and still be unconditionally loved and supported. If the parent withholds love from the child or forces or pressures the child to eat, the child feels helpless and abandoned. Furthermore, the child learns that he or she does not have the ability to say "no" and be respected, which can have far-reaching effects. By allowing a child to refuse to eat a certain food or to not eat at all because he or she is not hungry, parents are giving the child permission to express his or her needs without fear of repercussions.

High levels of maternal control over when and what children eat are associated with increased adiposity and an increased desire to consume restricted foods. Maternal restrictive feeding practices have been found to increase the child's preference for the restricted food and to promote overeating when the restricted foods are available and are counterproductive in preventing obesity (Birch, Orlet Fisher, & Krahnstoever Davison, 2003). In place of restricting desirable foods, parents should be taught skills that help children learn how to consume appropriate portion sizes, to like healthy foods, and to recognize hunger and satiety cues to determine when and how much to eat.



## Portion Size

Children demonstrate an innate ability for self-regulation of energy intake. They can compensate for changes in energy density by adjusting the quantity of food they consume. Parents and caregivers po-

tentially interfere with this natural hunger-driven mechanism by coercing children to eat when they are not hungry or by directing them to “finish their plate” or to “take one more bite” when they have demonstrated signs of satiety. Over-restriction of intake to prevent

overeating in infants and toddlers can have negative consequences by preventing the natural development of feeding self-regulation. **Table 2.1** indicates food types and corresponding development infants usually demonstrate; some variances should be expected.

The presence of self-regulation of dietary intake in infants and toddlers was confirmed by analysis of the relationship between portion size, number of eating occasions, number of unique foods, and energy density (Fox, Devaney, Reidy, Razafindrakoto, & Ziegler, 2006a). Children who ate less often during the day consumed larger portions, and children who ate more often ate smaller portions. For infants, energy density was negatively associated with portion size. As the energy density increased, portion size decreased, and as energy density decreased, portion size increased. The number of different foods consumed by 6- to 11-month-olds was also positively associated with portion size, indicating that infants with a more varied diet consume larger portions.

Children under 2 years of age typically eat seven times a day, although the number of meals and snacks reported ranges from 3 to 15. It is appropriate for infants and

**TABLE**

**2.1** Infant Feeding by Age and Development

Age	Development	What to Feed
Birth to 6 mo	Baby can suck and swallow. Baby should be held for feeding.	Breast milk is best. Use formula if not breast-feeding. No water or juice.
6–8 mo	Baby can sit with support and control head movement. Spoon feeding begins.  <i>No honey entire first year.</i>	Breast-fed infants: begin pureed meats first and then eggs, pureed fruits and vegetables, and infant cereal. Formula-fed infants: begin infant cereals and then pureed fruits, vegetables, and meats and eggs. Wait 3–5 days between new foods. Watch for signs of food allergies such as rash, vomiting, or diarrhea.
7–9 mo	Baby can chew, grasp, and hold items. Finger feeding begins. Introduce a cup with water, juice, breast milk, or formula.	Try well-cooked carrots, sliced bananas, unsweetened dry cereals, graham crackers, soft cheeses, pancake bits, and well-cooked pasta.
9–12 mo	Baby can eat with a spoon and will feed self more often. Expect baby to eat with hands and make a mess.	Offer new tastes and textures such as plain yogurt, cottage cheese, tofu, and refried beans. Offer soft foods from the family meal. Limit juice to 4 oz/day. Offer fewer pureed foods and more foods from the family meal. Always try to eat together as a family. Parents should set a good example by eating fruits and vegetables. Avoid dangerous foods that are a choking hazard: raw vegetables, nuts, seeds, whole grapes or cherry tomatoes, hot dogs, popcorn, and spoonfuls of peanut butter.
1 year and beyond	Encourage self-feeding. Continue breast-feeding. Wean from bottle. Begin offering whole cow's milk in cup. No low-fat or skim milk until 2 years of age.	Infant should eat three meals and two to three snacks each day. Feeding should be a happy time for the entire family. Let infant decide when enough is enough. Never force infant to eat or drink. No sweetened drinks or soda. Avoid sweets. Offer fruit for dessert.

toddlers to consume many small meals and snacks because of their small stomachs and high energy demands. Snacks often provide about 25% of toddler's

energy intake (Skinner et al., 2004a). The breakfast, lunch, dinner, and snacks pattern emerges at ages 7 to 8 months and is well established by 9 to 11 months.

### Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)

Food supplements have been available for more than 30 years for low-income women, infants, and children under 5 years of age through WIC of the U.S. Department of Agriculture. Pregnancy, infancy, and early childhood are critical periods of rapid growth and development. Nutritional insult during this time can have far-reaching consequences on cognitive and emotional health and can adversely impact health outcomes. Millions of families have benefited from the WIC program, and it has successfully improved the nutrient intakes of its participants, particularly by reducing the prevalence of iron deficiency anemia and improving physical, emotional, and cognitive development. Almost half of all infants and one-fourth of children ages 1 to 4 years old participate in the WIC program. Mothers of infants and toddlers participating in WIC are more likely to be teenagers, Hispanic, or black and less likely to have completed high school, to be married, or to be employed than nonparticipants (Ponza, Devaney, Ziegler, Reidy, & Squatrito, 2004).

Promoting breast-feeding as the norm for infant feeding is a major goal of the WIC program to ensure successful breast-feeding initiation and continuation of breast-feeding throughout the first year of life. Despite evidence that infants participating in WIC have improved dietary outcomes when compared with nonparticipating low-income infants, such as higher intakes of iron, zinc, and vitamin C, and improved compliance with recommendations not to feed cow's milk in the first 6 months, there is concern that WIC participation leads to less breast-feeding. Historically, WIC infants lag behind the national rates of breast-feeding for the general population, but encouraging trends have been seen since the early 1990s. Breast-feeding initiation rates for WIC infants increased from 34% in 1990 to 59% in 2002 (National WIC Association, 2004). WIC helps low-income at-risk families overcome barriers to breast-feeding by educating women and their families about the benefits of breast-feeding, training WIC staff and peer counselors, providing appropriate food packages, and providing support throughout the postpartum period. However, some critics view the provision of free infant formula as a deterrent to breast-feeding.

In the FITS study more than two-thirds of WIC infants had ever breast-fed, but by ages 4 to 6 months 95% had received infant formula. WIC infants were less likely than nonparticipants to have ever breast-fed, and only 21% were still breast-feeding at 4 to 6 months compared with 48% of nonparticipants. By 7 to 11 months of age almost one-fifth of WIC infants received cow's milk (Ponza et al., 2004). WIC infants and toddlers were more likely to consume sweets, desserts, and sweetened beverages than nonparticipants, and they consumed less baby food fruit, non-baby food fruit, fresh fruit, or canned fruit but consumed more 100% juice than nonparticipants. Overall, the diets of infants and children participating in WIC are nutritionally adequate, and the mean usual intake of calcium, vitamin A, iron, vitamin C, and protein, the nutrients targeted by the WIC program, exceeded recommended intakes. Reported energy intakes are higher for WIC participants than nonparticipants, and this should be addressed in light of the risk of obesity. Fruits

and vegetables should be emphasized, and use of juice and low nutrient sweetened drinks should be avoided or minimized.

In early 2004 the IOM reviewed WIC's supplemental food package and made revisions based on dietary guidelines for infants and young children and nutrition concerns from WIC staff and participants (IOM, 2005). The new package attempts to reduce the prevalence of inadequate and excessive nutrient intakes, encourages consumption of fruits and vegetables, and emphasizes whole grains and lower saturated fat. The food packages are designed to be attractive for breast-feeding mothers and infants and to provide incentives for breast-feeding, especially full breast-feeding. Infants whose mothers intend to breast-feed will not routinely receive formula during the first month of life. After the first month partially breast-fed infants receive 12 to 14 ounces of formula per day. The previous food package provided 26 ounces of formula per day to all infants whether they were breast-fed or not. Exclusively formula-fed infants will continue to receive appropriate amounts of infant formula for the first year of life.

Women who are providing at least half of the infant's feedings as breast milk will receive an expanded food package from 1 month through 11 months after delivery that includes vitamin C-rich juice, fresh or canned fruits and vegetables, low-fat milk, whole-grain cereal, whole-grain bread, eggs, beans, and peanut butter. Fully breast-feeding women receive an additional 30 ounces of canned tuna or salmon, two dozen eggs, and 1 pound of cheese per month.

New WIC recommendations have changed the age of introduction of complementary feedings from 4 months to 6 months, and the amount of formula offered is decreased accordingly as more complementary foods are offered. Juice has been removed from all infant food packages and replaced with baby fruits and vegetables. The package for fully breast-fed infants older than 6 months includes 2½ ounces per day of baby food meats, 8 ounces a day of fruits and vegetables, and iron-fortified cereal. For partially breast-fed infants the revised package offers 10 ounces of infant formula a day along with 4 ounces of fruits and vegetables and iron-fortified infant cereal. Formula-fed infants older than 6 months receive 20 ounces a day of formula compared with 26 ounces a day in the previous package, and the 3 ounces a day of juice has been changed to 4 ounces a day of baby fruits and vegetables. Families receive cash-value vouchers to purchase fresh fruits and vegetables for older children and pregnant and lactating women, and if fresh produce is not available, choices of canned, dried, or frozen fruits or vegetables are permitted. Whole-grain options such as ready-to-eat cereals, whole-wheat bread, brown rice, corn tortillas, oatmeal, and barley will be offered to children ages 1 to 4 years. Children ages 1 to 2 years will receive 2 cups per day of whole milk, and women and children over age 2 years will only receive milk or yogurt that is less than 2% milk fat. Pregnant and lactating mothers will also have the option of choosing enriched soy products as a substitute for dairy milk. The nutrition messages here are clear. The emphasis is on establishing healthier eating habits during the very first year of life.

## Effect of Early Diet on Health Outcomes

It is well known that a relationship exists between many chronic diseases and nutrition. It has been postulated that the diet during infancy and early childhood can impact the progression of chronic diseases that develop later in life, such as cancer, obesity, diabetes, hypertension, allergy, and osteoporosis. Whereas Kleinman (2000b) reported that little evidence exists to support the claim that early eating behaviors and patterns or consumption of specific nutrients can influence the development of some chronic illnesses in adulthood, studies have examined the link between obesity, allergies, and diabetes and diet early in life.

### OBESITY

Increasing trends in childhood obesity, with its associated comorbidities and the likelihood of persistence of obesity into adulthood, compelled researchers to investigate preventive strategies. Treatment of childhood obesity is costly and rarely effective. Childhood obesity is associated not only with adult obesity, but also with adverse health outcomes in adulthood independent of weight status. One of the critical periods of attainment of excess weight is in infancy. A study by Stettler et al. (2005) found that in formula-fed infants, weight gain in the first week of life may be a critical determinant for the development of obesity in later life. Formula feeding is associated with a more rapid increase in weight gain in early infancy and an increased risk for obesity in childhood and adolescence.

An earlier multicenter cohort study by Stettler, Zemel, Kumanyika, & Stallings (2002) demonstrated that a pattern of rapid weight gain during the first 4 months of life was associated with an increased risk of overweight status at 7 years, independent of birth weight and weight at 1 year. For each 100 g of weight gain increase per month, the risk of overweight status at 7 years was increased by 30%. There was a clear association between the rate of early weight gain and childhood overweight status. The greatest proportional weight gain in postnatal life occurs during the time when birth weight is doubled by 4 to 6 months, and this may correspond with a critical period for energy balance regulation mechanisms.

Martorell and colleagues (2001) reviewed and critiqued the literature to determine whether nutrition in early life predisposes individuals to be overweight later in life. They looked at three plausible hypotheses: (1) overnutrition increases the risk of later excess weight; (2) undernutrition, at the other extreme, also is a risk for excess weight; and (3) optimal nutrition during infancy represented by breast-feeding is protective of future obesity. They found the link between undernutrition in infancy and later obesity contradictory and inconsistent. Intrauterine overnutrition, high birth weight, and gestational diabetes were found to be associated with later obesity. Breast-feeding was found to have an enduring influence on the development of subsequent obesity.

According to the AAP (2003), the extent and duration of breast-feeding is associated with a reduction in obesity risk later in life, possibly due to physiologic factors in human milk as well as the feeding and parenting patterns associated with breast-feeding. Increasing initiation and duration of breast-feeding may provide a low-cost readily available strategy to help prevent childhood and adolescent obesity (Dietz, 2001).

Owen, Martin, Whincup, Davey Smith, and Cook (2005) published a quantitative review of the effects of infant feeding on the risk of obesity later in life. Initial breast-feeding protected against obesity later in life, and the association was stronger with prolonged breast-feeding. The consistency of the association they found with increasing age suggested a protective effect of early breast-feeding that was independent of dietary and physical activity patterns later in life. Confounding by maternal factors such as social class and obesity, both of which are associated with childhood obesity and a tendency to formula feed, was a limitation of the observational studies.

Hediger and colleagues (2001) found a reduced risk of obesity for ever breast-fed 3- to 5-year-olds compared with those never breast-fed, but found a much stronger association with maternal obesity. Kries et al. (1999) studied 9,357 German children at the time they entered school at ages 5 and 6 years. They found a remarkably consistent, protective, and dose-dependent effect of breast-feeding on excess weight and obesity. This cross-sectional study found that obesity was reduced by 35% when

children were breast-fed for 3 to 5 months. This protective effect was not attributable to social class or life-style factors and remained significant after adjusting for potential confounding factors. Gillman et al. (2001) found that adolescents who were mostly or only fed breast milk in the first 6 months of life were at a 22% lower risk of being overweight than adolescents who were only formula fed. They found an estimated 8% reduction in the risk of adolescent obesity for every 3 months of breast-feeding.

Bergmann et al. (2003) found that maternal obesity, bottle-feeding, maternal smoking during pregnancy, and low socioeconomic status were risk factors for becoming overweight and adiposity at age 6 years in a longitudinal study of German children from birth. At age 3 months body mass index and triceps skin-fold thickness were already significantly higher in the children who were formula fed. Children who were formula-fed continued to have a higher prevalence of excess weight and obesity, and the findings remained stable after adjusting for maternal weight, maternal smoking, and socioeconomic status.

Questions regarding the optimal duration of exclusive breast-feeding or whether combining breast-feeding with formula supplementation may weaken the preventive influence of breast-feeding need to be addressed. Gillman et al. (2001) found that infants who received more breast milk than formula in the first 6 months of life had a lower risk of obesity in older childhood and adolescence than children who received mostly or only formula. In a retrospective cohort study Bogen and coworkers (2004) found that in a population of low-income families breast-feeding was associated with a reduced risk of obesity at age 4 years only among whites whose mothers did not smoke in pregnancy and only when breast-feeding continued for at least 16 weeks without formula or at least 26 weeks with formula.

Several explanations are offered for the protective effect of breast-feeding against obesity. Breast milk production is stimulated by the infant's sucking, and it is unlikely that rapid weight gain in an exclusively breast-fed infant is a result of overfeeding. A breast-fed infant establishes a point of satiety based on internal physiologic cues rather than on external social cues. Children can naturally regulate their energy intake, but parents' behavior can override the child's appetite signals. It is possible that during bottle feeding parents exhibit more control of the feeding and prevent self-regulation by the child. Parents who do not recognize the child's hunger and satiety cues may contribute to the risk of later obesity. Overfeeding in infancy may increase adipose number and fat content at a critical time period and prevent development of lifelong patterns of healthy appetite regulation that would protect against the risk of obesity.

Metabolic consequences of ingesting human milk may help regulate appetite and food consumption. Leptin, a hormone that regulates food intake and energy metabolism, is present in human milk. In a study by Savino, Costamagna, Prino, Oggero, & Silvestro (2002) serum leptin levels were higher in breast-fed infants than in formula-fed infants. Breast-feeding may help to program the infant against later energy imbalance (Gillman et al., 2001). Owen et al. (2005) suggested that breast-feeding affects intake of calories and protein, insulin secretion, and modulation of fat deposition and adipocyte development. A higher protein to nitrogen content of infant formula might induce a metabolic response of increased insulin production in formula-fed infants, leading to excessive weight gain. Protective mechanisms of breast-feeding are difficult to identify because many of the same factors associated with obesity, such as race, ethnicity, maternal education, social status, and maternal obesity, are also associated with the initiation and duration of breast-feeding or the decision to formula feed. The effects of breast-feeding on the later development of obesity can be sustained and persist into adulthood either through learned behavior or perhaps through a more complex programming mechanism. Read more about childhood obesity in Chapter 7.

### ALLERGIES

Most food allergies are acquired in the first year or two of life. Sensitization often occurs with the first exposure to an antigen. The prevalence of food allergy peaks at 6% to 8% at 1 year of age and then gradually

decreases to 1% to 2% in later childhood. Foods that account for most allergic reactions in children are cow's milk protein, eggs, peanuts, soy, tree nuts, fish, and wheat. Symptoms manifest as urticaria, angioedema, anaphylaxis, atopic dermatitis, respiratory symptoms, or gastrointestinal disorders. Food allergies can be classified as (1) IgE mediated, with symptoms such as angioedema, urticaria, wheezing, rhinitis, vomiting, eczema, and anaphylaxis reactions; (2) mixed gastrointestinal syndromes involving both IgE- and T-cell mediated components, such as eosinophilic esophagitis; or (3) non-IgE-mediated allergies, such as protein-induced enterocolitis. Public health strategies for primary prevention of food allergies are necessary, but results of studies to determine the etiology of food allergies are conflicting. Breast-feeding is presumed to be protective, but study results vary and the size of the effect is controversial.

Early introduction of foreign proteins, including cow's milk, wheat, soy, rice, eggs, fish, and chicken, could induce a T-cell-mediated immune reaction of the intestinal mucosa associated with inflammation, villous atrophy, diarrhea, and failure to thrive (Schmitz, 2000). The earlier these foods are introduced to the infant, the greater the risk of developing enteropathy. These enteropathies are linked to the immaturity of the gut's immune system, leading to sensitization rather than to tolerance when exposed to foreign proteins. It is unknown precisely when the gut has matured sufficiently to accept foreign protein, although it is unlikely to occur in the first few months of life. Infants with dietary-induced proctocolitis, a non-IgE-mediated allergy, appear healthy but have visible specks or streaks of blood in their stool. Blood loss is minimal, and anemia is rare. This type of allergy is not usually associated with vomiting, diarrhea, or growth failure and is often caused by sensitivity to cow's milk or soy protein, often through the maternal diet while breast-feeding (Sicherer, 2003).

Atopic dermatitis is a chronic skin condition often seen in young children and is often the first sign of allergic sensitization in infants. The pathophysiology remains unclear, but it is increased in families with a history of atopic disorders, suggesting a genetic component. In infancy, atopic dermatitis is closely related to both IgE- and non-IgE-mediated food hypersensitivities that occur in formula-fed and breast-fed infants. Intact food allergens, particularly from cow's milk, eggs, and peanuts, may be secreted in small quantities by the mammary gland epithelium, causing a reaction with the mucosal immune system in the infant's intestinal lumen (Heine, Hill, & Hosking, 2004).

Use of soy or hypoallergenic infant formula as primary prevention of milk allergy is controversial, and the AAP Committee on Nutrition (2000) has established guidelines for the use of hypoallergenic infant formulas. The actual prevalence of milk protein allergy in infancy is only 2% to 3%. Because of the increased costs of using a hypoallergenic formula, their use should be limited to infants with well-defined clinical symptoms. Infants with cow's milk allergies should not be fed milk from goats, sheep, or other animals because of the likelihood of allergic reaction to other mammalian milk. Soy milk is often used as a substitute for cow's milk infant formula and may be well tolerated. Soy formula feeding is not recommended for primary prevention of allergies in high-risk infants. Infants with IgE-mediated cow's milk allergies may have better tolerance to soy than infants with non-IgE-mediated symptoms. Eight percent to 14% of infants with IgE-mediated cow's milk allergies have adverse reactions to soy, although anaphylaxis is rare. A higher prevalence of concomitant reactions (25% to 60%) is seen when soy is fed to infants with non-IgE-mediated cow's milk allergies; therefore soy is not recommended as a substitute for infants with proctocolitis and enterocolitis reactions. For these children an extensively hydrolyzed protein formula or a free amino-acid-based infant formula should be used. Benefits should be seen within 2 to 4 weeks, and the formula should be continued until the infant is at least 1 year of age.

A family history of allergy, defined as both parents or one parent and one sibling with allergic disease, is the strongest predictor of allergic disease in children. In high-risk infants up to 6% of exclusively breast-fed infants developed food-specific IgE allergies with symptoms occurring with the first reported direct food exposure. How-

ever, in the general population food allergy in exclusively breast-fed infants ranges from 0.04% to 0.5% (Zeiger, 2003).

Bottle feeding and early exposure to potential food allergens are risk factors for atopic disease. Studies suggest that combined maternal avoidance of food allergens while breast-feeding and infant avoidance of allergens for at least the first 6 months may reduce eczema and food allergy in early childhood (Zeiger, 2003). Data supporting a protective effect on respiratory allergy and asthma in later childhood are less compelling. Exclusive, rather than partial, breast-feeding for at least 4 months appears to have a significant impact on the occurrence of atopic dermatitis, allergic rhinitis, and respiratory symptoms (Kill, Wickman, Lilja, Nordvall, & Pershagen, 2002). High-risk infants should be breast-fed throughout the first year of life or longer or, alternately, fed with a hypoallergenic formula. Breast milk contains immunomodulating properties to regulate the immune system and also contains milk-specific IgA to bind cow's milk allergens and prevent allergies.

Food antigens have been detected in the milk of mothers after consumption of allergenic foods such as cow's milk, eggs, wheat, and peanuts, and the concentrations are sufficient to trigger reactions in allergic children (Zeiger, 2003). Concentrations of antigens in human milk depend on the amount consumed by the mother and appear in human milk 1 to 6 hours after ingestion. Peanut protein may be quickly cleared from the milk within 3 hours after ingestion. Secretion of antigens into human milk is variable. In a study by Vadas and coworkers (2001), only 48% of lactating women secreted peanut protein in their milk after ingestion of peanuts. Similarly, approximately two-thirds of women secrete cow's milk and egg protein into their milk after ingestion.

Characteristics of women who secrete food antigens into their milk have not been accounted for, making it difficult to determine preventive strategies. One study from Finland found that a maternal diet high in saturated fat and low in vitamin C while breast-feeding was associated with an increased risk of atopic sensitization in the infant (Joppu, Kalliomaki, & Isolauri, 2000). Allergic disease has also been linked to a maternal diet with a high ratio of omega-6 to omega-3 fatty acids, typical of Western diets containing processed and fried foods (Koletzko, 2000). Fish oil supplementation to provide omega-3 fatty acids during pregnancy and to infants older than 6 months has been shown to reduce the severity of atopic disease (Upham & Holt, 2005).

Gut microflora may play a role in immunomodulation in infants, reducing the risk of early atopic disease. Probiotics have successfully been used to reduce atopic eczema in high risk children by having mothers take *Lactobacillus GG* (*GG* refers to a healthy strain) 2 to 4 weeks before delivery and 6 months postnatally while breast-feeding (Kalliomaki et al., 2001).

The AAP provides guidelines for introduction of complementary foods for primary prevention of food allergy in high-risk children. They recommend avoiding cow's milk protein until 12 months, eggs until 24 months, and peanut, tree nut, and fish until 3 years. The AAP advises lactating mothers of high-risk infants to eliminate peanuts and tree nuts and to consider eliminating eggs, cow's milk, and fish while breast-feeding. Because of incomplete scientific data to support this, the European committees have decided on more general feeding recommendations, suggesting adding a limited number of foods with low allergenicity when starting solid foods, and they do not recommend modifications of the maternal diet while breast-feeding (Zeiger, 2003). There are no well-designed studies that demonstrate a clear benefit of avoiding potentially allergenic foods in the first year of life as a preventive measure against the development of atopic disease.

A study of British children recruited at birth for a population-based prospective birth cohort study to explore whether late introduction of solids is protective against the development of asthma, eczema, and atopy found, contrary to feeding guidelines, that late introduction of eggs after 8 months was associated with an increase in preschool wheezing, atopy, and eczema at age 5½ years and that the introduction of milk after 6 months was associated with an increase in eczema. The authors concluded that their study of 642 children did not support feeding recommendations to delay introduction of solid foods to protect against the development of asthma and allergy (Zutavern et al., 2004).

**Allergic disease:** Sensitization to allergens manifested by urticaria, angioedema, anaphylaxis, atopic dermatitis, respiratory symptoms, or gastrointestinal disorder.

The prevalence of peanut allergy is increasing and the cause is elusive as there are few known risk factors. Data from the Avon Longitudinal Study of Parents and Children were collected prospectively from early pregnancy throughout childhood to investigate possible causes of peanut allergy. Researchers found a positive association with consumption of soy infant formula (Fox et al., 2003). In the total cohort of 13,971 children, 8.3% consumed soy milk or soy formula in the first 2 years, compared with 24.5% of those with peanut allergy and 34.8% of those with a positive peanut challenge. They also found that creams containing peanut oil applied to the infant's skin to treat rashes during the first 6 months of life increased the risk of peanut allergies. No association was found with the mother's diet during pregnancy or lactation. Peanut-specific IgE was not detectable in the cord blood, indicating that sensitization had not occurred in utero, and mothers of children with peanut allergy did not eat more peanuts during breast-feeding than mothers in the control group.

There is no way to predict when a child will outgrow a food allergy, but 75% to 90% of milk-allergic children can tolerate cow's milk by 4 years of age. Some infants lose their milk allergy in as little as a few months, whereas others may remain symptomatic for as long as 8 to 10 years (Wood, 2003). Many also become tolerant to egg, soy, and wheat, although fish, tree nut, and peanut allergies may persist throughout the lifetime (Nowak-Wegrzyn, 2003). Other foods that may cause allergic reactions in infants and young children include berries, tomatoes, citrus, and apples. Children with non-IgE-mediated cow's milk allergy often outgrow their allergies by 5 years of age without the development of additional allergic complications. Children with IgE-mediated allergies often have persistent allergic symptoms at 8 years of age. They also more frequently have asthma, rhinoconjunctivitis, atopic eczema, and sensitization to other allergens and are at increased risk for sensitization to in-

halant allergens (Saarinen, Pelkonen, Makela, & Savilahti, 2005). Read more about food allergies in Chapter 7.

### DIABETES AND CELIAC DISEASE

Two studies by Norris et al. (2005a, 2005b) looked at the association between the development of type 1 diabetes and celiac disease and early introduction of gluten-containing foods. The Diabetes Autoimmunity Study in the Young is a prospective study of triggers for diabetes and celiac disease in genetically predisposed children with a parent or sibling with type 1 diabetes or celiac disease. The timing of introduction of gluten-containing cereals was found to be associated with the risk of developing diabetes or celiac disease in children at increased risk for the disease. Children initially exposed to wheat, barley, or rye between birth and 3 months or later than 7 months were at increased risk of developing diabetes and celiac disease than children first exposed to cereal between 4 and 6 months.

In Sweden, where the prevalence of celiac disease is 1% to 2% of Swedish children, introducing gluten-containing foods at 4 to 6 months is recommended during the time of exclusive breast-feeding. Enacted in 1996, this policy was a change from previous recommendations to introduce gluten after 6 months. New evidence showed that the risk of childhood celiac disease could be reduced with concurrent breast-feeding during the time that gluten is introduced into the infant's diet. Despite public health programs to inform families of the recommendations, a survey in 2004 showed that only 45% were compliant with the recommendation to introduce gluten earlier than 6 months while breast-feeding. As many as 45% continued to avoid gluten until after 6 months and another 10% introduced gluten without breast-feeding (Odijk, Hulthen, Ahlstedt, & Borres, 2004). Read more about celiac disease and diabetes in Chapters 7 and 8, respectively.

## Issues to Debate

1. Discuss the nutritional impact of pregnancy and lactation on teens.
2. Should more be done to promote breast-feeding?
3. Should there be more food labeling because of the prospect of infant food allergies?
4. What are some of the cultural aspects that affect the transitioning from an all-milk infant diet to a diet of family foods?

### Normal Infant Nutrition Case Study

Caleb was born by standard vaginal delivery to a healthy 30-year-old mother. Caleb's mother decided while she was pregnant to exclusively breast-feed him for the first 6 months of life because she was familiar with the advantages associated with exclusive breast-feeding, such as reduction of illness and allergies, enhanced intelligence, convenience of feedings, and cost savings. Caleb weighed 7 pounds at birth (25% percentile) and gained weight appropriately for the first 6 months of life. At his 6-month checkup he weighed 18 pounds and was at the 50th to 75% percentile for weight.

Caleb's mother chose to introduce pureed foods she prepared herself when Caleb was 6 months old. At this time he exhibited an interest in what his parents were eating and had developed good head and neck control. She

prepared sweet potatoes, carrots, squash, and peas and pureed them in a food processor until they were a smooth consistency. She froze them in single serving portions in an ice cube tray. She introduced one food at a time and waited 3 to 5 days between foods while observing Caleb for signs of food allergy. Gradually, she added more foods to his diet, including chicken, turkey, beef, cereal, pears, peaches, and bananas. When Caleb was 7 months old he was offered a sippy cup with water at meals.

Caleb was developing fine motor control and was able to grasp foods and attempt self-feeding. His mother offered him small pieces of toast, Cheerios, cut-up fresh melon, soft-cooked carrots, French toast, and pieces of cheese and turkey. He also began to eat cottage cheese and yogurt and a greater variety of foods from the family meal. Caleb continued to breast-feed, but the number of feedings per day began to decrease as he increased his intake of complementary foods. Caleb was breast-fed without any supplemental formula until he was 13 months old, when he was offered whole cow's milk by cup. By 1 year of age he had gradually transitioned from an all-milk diet in the first 6 months to a mixed diet of breast milk and pureed foods and finally to a diet of family foods including a variety of fruits and vegetables, grains, meats, and dairy.

What did Caleb's mother do correctly?

## References

### Pregnancy and Lactation

- American Dietetic Association. (2005). Position of the American Dietetic Association: Promoting and supporting breastfeeding. *Journal of the American Dietetic Association*, 105, 810–818.
- Barker, D. J. (1991). The foetal and infant origins of inequalities in health in Britain. *Journal of Public Health Medicine*, 13, 64–68.
- Brost, B. C., Goldenberg, R. L., Mercer, B. M., Iams, J. D., Meis, P. J., Moawad, A. H., et al. (1997). The Preterm Prediction Study: Association of cesarean delivery with increases in maternal weight and body mass index. *American Journal of Obstetrics and Gynecology*, 179, 333.
- Fairweather-Tait, S. J. (1995). Iron–zinc and calcium–iron interactions in relation to zinc and iron absorption. *Proceedings of the Nutrition Society*, 54, 465.
- Institute of Medicine (IOM), National Academies of Science. (1990). *Nutrition During Pregnancy*. Washington, DC: National Academy Press.
- Institute of Medicine (IOM), Food and Nutrition Board. (2002). *Dietary Reference Intakes for Energy and the Macronutrients, Carbohydrate, Fiber, Fat, and Fatty Acids*. Washington, DC: National Academy Press.
- Rasmussen, K. M. (2000). The “fetal origins” hypothesis: Challenges and opportunities for maternal and child nutrition. *Annual Review of Nutrition*, 21, 73–95.
- U.S. Department of Agriculture and U.S. Department of Health and Human Services. (2005). *Nutrition and Your Health: Dietary Guidelines for Americans* (6th ed.). Washington DC: U.S. Government Printing Office.
- Villar, J., Meriardi, M., Gulmezoglu, A. M., Abalos, E., Carroli, G., Kulier, R., et al. (2003). Characteristics of randomized controlled trials included in systematic review of nutritional interventions reporting maternal morbidity, mortality, preterm delivery, intrauterine growth restriction and small for gestational age and birth weight outcomes. *Journal of Nutrition*, 133, 1632S–1639S.

### Infant Nutrition

- Altucher, K., Rasmussen, K., Barden, E., & Habicht, J. (2005). Predictors of improvement in hemoglobin concentration among toddlers enrolled in the Massachusetts WIC program. *Journal of the American Dietetic Association*, 105, 709–715.
- American Academy of Pediatrics (AAP). (2004). *Pediatric Nutrition Handbook* (5th ed.). Elk Grove Village, IL: American Academy of Pediatrics.
- American Academy of Pediatrics (AAP), Committee on Nutrition. (2000). Hypoallergenic infant formulas. *Pediatrics*, 106, 346–349.
- American Academy of Pediatrics (AAP), Committee on Nutrition. (2003). Prevention of pediatric overweight and obesity. *Pediatrics*, 112, 424–430.

- American Academy of Pediatrics (AAP), Section on Breastfeeding. (2005). Breastfeeding and the use of human milk. *Pediatrics*, 115, 496–506.
- American Dietetic Association. (2003). Position of the American Dietetic Association and Dietitians of Canada: Vegetarian diets. *Journal of the American Dietetic Association*, 103, 748–765.
- Auestad, N., Halter, R., Hall, R., Blatter, M., Bogle, M., Burks, W., et al. (2001). Growth and development in term infants fed long-chain polyunsaturated fatty acids: A double-masked, randomized, parallel, prospective, multivariate study. *Pediatrics*, 108, 372–381.
- Baker, R. D. (2002). Infant formula safety. *Pediatrics*, 110, 833–835.
- Bergmann, K. E., Bergmann, R. L., Kries, R. von, Böhm, O., Richter, R., Dudenhausen, J. W., et al. (2003). Early determinants of childhood overweight and adiposity in a birth cohort study: Role of breast-feeding. *International Journal of Obesity*, 27, 162–172.
- Birch, L., Orlet Fisher, J., & Krahnstoever Davison, K. (2003). Learning to overeat: Maternal use of restrictive feeding practices promotes girls' eating in the absence of hunger. *American Journal of Clinical Nutrition*, 78, 215–220.
- Bogen, D. L., Hanusa, B. H., & Whitaker, R. C. (2004). The effect of breast-feeding with and without formula use on the risk of obesity at 4 years of age. *Obesity Research*, 12, 1527–1535.
- Briefel, R., Reidy, K., Karwe, V., & Devaney, B. (2004a). Feeding Infants and Toddlers Study: Improvements needed in meeting infant feeding recommendations. *Journal of the American Dietetic Association*, 104, S31–S37.
- Briefel, R., Reidy, K., Karwe, V., Jankowski, L., & Hendricks, K. (2004b). Toddlers' transition to table foods: Impact on nutrient intakes and food patterns. *Journal of the American Dietetic Association*, 104, S38–S44.
- Butte, N., Cobb, K., Dwyer, J., Graney, L., Heird, W., & Rickard, K. (2004). The Start Healthy Feeding Guidelines for infants and toddlers. *Journal of the American Dietetic Association*, 104, 442–454.
- Butte, N., Wong, W., Hopkinson, J., Heinz, C., Mehta, N., & Smith, E. O. (2000a). Energy requirements derived from total energy expenditure and energy deposition during the first 2 y of life. *American Journal of Clinical Nutrition*, 72, 1558–1569.
- Butte, N., Wong, W., Hopkinson, J., Smith, E. O., & Ellis, K. (2000b). Infant feeding mode affects early growth and body composition. *Pediatrics*, 106, 1355–1366.
- Canadian Paediatric Society. (2003). Dietary manipulations for infantile colic. *Paediatrics & Child Health*, 8, 449–452.
- Carruth, B. R., Skinner, J., Houck, K., & Moran, J. D. (2000). Addition of supplementary foods and infant growth. *Journal of the American College of Nutrition*, 19, 405–412.
- Carruth, B. R., Ziegler, P., Gordon, A., & Hendricks, K. (2004). Developmental milestones and self-feeding behaviors in infants and toddlers. *Journal of the American Dietetic Association*, 104, S51–S56.

- Centers for Disease Control Enterobacter sakazakii* infections associated with the use of powdered infant formula—Tennessee, 2001. *Morbidity and Mortality Weekly Report*, 51, 297–300.
- Clifford, T., Campbell, K., Speechley, K., & Gorodzinsky, F. (2002). Infant colic: Empirical evidence of the absence of an association with source of early infant nutrition. *Archives of Pediatric and Adolescent Medicine*, 156, 1123–1128.
- Dawodu, A., Adarwal, M., Hossain, M., Kochiyil, J., & Zayed, R. (2003). Hypovitaminosis D and vitamin D deficiency in exclusively breastfeeding infants and their mothers in summer: A justification for vitamin D supplementation of breastfeeding infants. *Journal of Pediatrics*, 142, 169–173.
- de Onis, G., Garza, C., Onyango, A. W., & Borghi, E. (2007). Comparison of the WHO Child Growth Standards and the CDC 2000 Growth Charts. *Journal of Nutrition*, 137, 144–148.
- Devaney, B., Kalb, L., Briefel, R., Zavitsky-Novak, T., Clusen, N., & Ziegler, P. (2004a). Feeding Infants and Toddlers Study: Overview of the study design. *Journal of the American Dietetic Association*, 104, S8–S13.
- Devaney, B., Ziegler, P., Pac, S., Karwe, V., & Barr, S. (2004b). Nutrient intakes of infants and toddlers. *Journal of the American Dietetic Association*, 104, S14–S21.
- Dewey, K. G. (2000a). Protein and amino acids. *Pediatrics*, 106, 1292.
- Dewey, K. G. (2000b). Complementary feeding and breastfeeding. *Pediatrics*, 106, 1301–1302.
- Dewey, K. G. (2001). Nutrition, growth, and complementary feeding of the breastfed infant. *Pediatric Clinics of North America*, 48, 87–104.
- Dewey, K. G., Beaton, G., Fjeld, C., Lonnerdal, B., & Reeds, P. (1996a). Protein requirements of infants and children. *European Journal of Clinical Nutrition*, 50, S119–S150.
- Dewey, K. G., Cohen, R. J., Rivera, L. L., Canahuati, J., & Brown, K. H. (1996b). Do exclusively breast-fed infants require extra protein? *Pediatric Research*, 39, 303–307.
- Dewey, K. G., Domellof, M., Cohen, R., Rivera, L. L., Hernell, O., & Lonnerdal, B. (2002). Iron supplementation affects growth and morbidity of breast-fed infants: Results of a randomized trial in Sweden and Honduras. *Journal of Nutrition*, 132, 3249–3255.
- Dewey, K. G., Peerson, J. M., & Brown, K. H. (1998). Effects of age of introduction of complementary foods on iron status of breastfed infants in Honduras. *American Journal of Clinical Nutrition*, 67, 878–884.
- Dietz, W. H. (2001). Breastfeeding may help prevent childhood overweight. *Journal of the American Medical Association*, 285, 2506–2507.
- Domellof, M., Lonnerdal, B., Abrams, S., & Hernell, O. (2002). Iron absorption in breast-fed infants: Effects of age, iron status, iron supplements, and complementary foods. *American Journal of Clinical Nutrition*, 76, 198–204.
- DuPont, C. (2003). Protein requirements during the first year of life. *American Journal of Clinical Nutrition*, 77(Suppl.), 1544S–1549S.
- Dwyer, J., Sutor, C., & Hendricks, K. (2004). FITS: New insights and lessons learned. *Journal of the American Dietetic Association*, 104, S5–S7.
- Eichenberger Gilmore, J., Hong, L., Broffitt, B., & Levy, S. (2005). Longitudinal patterns of vitamin and mineral supplement use in young white children. *Journal of the American Dietetic Association*, 105, 763–772.
- Engelmann, M. D. M., Sandstrom, B., & Michaelsen, K. (1996). Meat intake and iron status in late infancy: An intervention study. *Journal of Pediatric Gastroenterology and Nutrition*, 26, 26–33.
- Ermis, B., Demirel, F., Demircan, N., & Gurel, A. (2002). Effects of three different iron supplementations in term healthy infants after 5 months of life. *Journal of Tropical Pediatrics*, 48, 280–284.
- European Food Safety Authority. (2004). EFSA Panel advises on how to avoid microbiological risks in infant formulae—at home and in hospital. Retrieved January 8, 2005, from [http://www.efsa.eu.int/press\\_room/press\\_release/696/pr\\_biohaz03\\_microrisk\\_en1.pdf](http://www.efsa.eu.int/press_room/press_release/696/pr_biohaz03_microrisk_en1.pdf)
- FDA Talk Paper. (2002). FDA warns about possible *Enterobacter sakazakii* infections in hospitalized newborns fed powdered infant formulas. Retrieved January 7, 2005, from <http://www.cfsan.fda.gov/~lrd/tpinf.html>
- Fomon, S. (2001). Feeding normal infants: Rationale for recommendations. *Journal of the American Dietetic Association*, 101, 1002–1005.
- Fox, M. K., Devaney, B., Reidy, K., Razafindrakoto, C., & Ziegler, P. (2006a). Relationship between portion size and energy intake among infants and toddlers: Evidence of self-regulation. *Journal of the American Dietetic Association*, 106, S77–S83.
- Fox, M. K., Pac, S., Devaney, B., & Jankowski, L. (2004). Feeding infants and toddlers study: What foods are infants and toddlers eating? *Journal of the American Dietetic Association*, 104, S22–S30.
- Fox, M. K., Reidy, K., Karwe, V., & Ziegler, P. (2006b). Average portions of foods commonly eaten by infants and toddlers in the United States. *Journal of the American Dietetic Association*, 106, S66–S76.
- Fox, M. K., Reidy, K., Novak, T., & Ziegler, P. (2006c). Sources of energy and nutrients in the diets of infants and toddlers. *Journal of the American Dietetic Association*, 106, S28–S42.
- Gartner, L., Greer, F., and the Section on Breastfeeding and Committee on Nutrition. (2003). Prevention of rickets and vitamin D deficiency: New guidelines for vitamin D intake. *Pediatrics*, 111, 908–910.
- Gibson, R., & Holtz, C. (2000). The adequacy of micronutrients in complementary foods. *Pediatrics*, 106, 1298–1300.
- Gillman, M. W., Rifas-Shiman, S. L., Camargo, C. A., Berkey, C. S., Frazier, A. L., Rockett, H. R. H., et al. (2001). Risk of overweight among adolescents who were breastfed as infants. *Journal of the American Medical Association*, 285, 2461–2467.

- Greer, F., Shannon, M., the Committee of Nutrition, & the Committee on Environmental Health. (2005). Infant methemoglobinemia: The role of dietary nitrate in food and water. *Pediatrics*, *116*, 784–786.
- Heath, A. M., Tuttle, C. R., Simons, M. S. L., Cleghorn, C., & Parnell, W. (2002). Longitudinal study of diet and iron deficiency anaemia in infants during the first two years of life. *Asia Pacific Journal of Clinical Nutrition*, *11*, 251–257.
- Hediger, M., Overpeck, M., Kuczmarski, R., & Ruan, W. J. (2001). Association between infant breastfeeding and overweight in young children. *Journal of the American Medical Association*, *285*, 2453–2460.
- Heine, R., Hill, D., & Hosking, C. (2004). Primary prevention of atopic dermatitis in breastfed infants: What is the evidence? *Journal of Pediatrics*, *44*, 564–567.
- Henderson, A. (2005). Vitamin D and the breastfed infant. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *34*, 367–372.
- Hill, D., Roy, N., Heine, R., Hosking, C., Francis, D., Brown, J., et al. (2005). Effect of a low-allergen maternal diet on colic among breastfed infants: A randomized, controlled trial. *Pediatrics*, *116*, e709–e715.
- Institute of Medicine (IOM). (2001). *Dietary Reference Intake for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. Washington, DC: National Academy Press.
- Institute of Medicine (IOM). (2002). *Dietary Reference Intake for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Part I*. Prepublication copy. Washington, DC: National Academy Press.
- Institute of Medicine (IOM). (2005). Report brief. WIC Food Packages: Time for a Change. Retrieved October 4, 2007, from [www.iom.edu/report.asp?id=26667](http://www.iom.edu/report.asp?id=26667)
- Jensen, C., Voigt, R., Prager, T., Zou, Y., Fraley, J. K., Rozelle, J., et al. (2005). Effects of maternal docosahexaenoic acid intake on visual function and neurodevelopment in breastfed term infants. *American Journal of Clinical Nutrition*, *8*, 125–132.
- Joppu, U., Kalliomaki, M., & Isolauri, E. (2000). Maternal diet rich in saturated fat during breastfeeding is associated with atopic sensitization of the infant. *European Journal of Clinical Nutrition*, *54*, 702–705.
- Kalliomaki, M., Salminen, S., Avilommi, H., Kero, P., Koskinene, P., & Isolauri, E. (2001). Probiotics in primary prevention of atopic disease; a randomised placebo-controlled trial. *Lancet*, *357*, 1076–1079.
- Kattelman, K. K., Ho, M., & Specker, B. L. (2001). Effect of timing of introduction of complementary foods on iron and zinc status of formula fed infants at 12, 24, and 36 months of age. *Journal of the American Dietetic Association*, *101*, 443–447.
- Kazal, L. (2002). Prevention of iron deficiency in infants and toddlers. *American Family Physician*, *66*, 1217–1224.
- Khedr, E. M., Farghaly, W. M., Amry Sel, D., & Osman, A. A. (2004). Neural maturation of breastfed and formula-fed infants. *Acta Paediatrica*, *93*, 734–738.
- Kill, I., Wickman, M., Lilja, G., Nordvall, S. L., & Pershagen, G. (2002). Breast feeding and allergic diseases in infants—a prospective birth cohort study. *Archives of Diseases in Children*, *87*, 478–481.
- Kleinman, R. (2000a). American Academy of Pediatrics recommendations for complementary feeding. *Pediatrics*, *106*, 1274.
- Kleinman, R. (2000b). Complementary feeding and later health. *Pediatrics*, *106*, 1287–1288.
- Kleinman, R. (2000c). Complementary feeding and neuromuscular development. *Pediatrics*, *106*, 1279.
- Koletzko, B. (2000). Complementary foods and the development of food allergy. *Pediatrics*, *106*, 1285.
- Koo, W. (2003). Efficacy and safety of docosahexaenoic acid and arachidonic acid addition to infant formulas: Can one buy better vision and intelligence? *Journal of the American College of Nutrition*, *22*, 101–107.
- Kramer, M., Guo, T., Platt, R., Shapiro, S., Collet, J. P., Chlamers, B., et al. (2002). Breastfeeding and infant growth: Biology or bias? *Pediatrics*, *110*, 343–347.
- Krebs, N. (2000). Dietary zinc and iron sources, physical growth and cognitive development of breastfed infants. *Journal of Nutrition*, *130*, 358S–360S.
- Krebs, N. F., Reidinger, C. J., Robertson, A. D., & Hambridge, K. M. (1994). Growth and intakes of energy and zinc in infants fed human milk. *Journal of Pediatrics*, *124*, 32–39.
- Kreiter, S., Schwartz, R., Kirkman, H., Charlton, P., Calikoglu, A., & Davenport, M. (2000). Nutritional rickets in African-American breast-fed infants. *Journal of Pediatric*, *137*, 153–157.
- Kries, R. von, Koletzko, B., Sauerwald, T., Mutius, E. von, Barnert, K., Grunert, V., et al. (1999). Breast feeding and obesity: Cross sectional study. *British Medical Journal*, *319*, 147–150.
- Lack, G., Fox, D., Northstone, K., & Golding, J. (2003). Factors associated with the development of peanut allergy in childhood. *New England Journal of Medicine*, *348*, 977–985.
- Lawrence, R. (1999). *Breastfeeding: A Guide for the Medical Profession* (5th ed.). St. Louis: Mosby.
- Lucas, A., & St. James-Robert, I. (1998). Crying, fussing and colic behavior in breast and bottle-fed infants. *Early Human Development*, *53*, 9–18.
- Lust, K., Brown, J., & Thomas, W. (1996). Maternal intake of cruciferous vegetables and other foods and colic symptoms in exclusively breastfed infants. *Journal of the American Dietetic Association*, *96*, 47–48.
- Martorell, R., Stein, A. D., & Schroeder, D. G. (2001). Early nutrition and later adiposity. *Journal of Nutrition*, *131*, 874S–880S.
- Meeks Gardner, J. M., Powell, C. A., Baker-Henningham, H., Walker, S. P., Cole, T. J., & Grantham-McGregor, S. M.



- (2005). Zinc supplementation and psychosocial stimulation: Effects on the development of undernourished Jamaican children. *American Journal of Clinical Nutrition*, 2005, 82, 399–405.
- Michaelsen, K. F. (2000). Cow's milk in complementary feeding. *Pediatrics*, 106, 1302–1303.
- Milner, J., Stein, D., McCarter, R., & Moon, R. (2004). Early infant multivitamin supplementation is associated with increased risk for food allergy and asthma. *Pediatrics*, 114, 27–32.
- Morale, S., Hoffman, D., Castañeda, Y., Wheaton, D., Burns, R., & Birch, E. (2005). Duration of long-chain polyunsaturated fatty acids availability in the diet and visual acuity. *Early Human Development*, 81, 197–203.
- Motarjemi, Y. (2000). Research priorities on safety of complementary feeding. *Pediatrics*, 106, 1304–1305.
- Muraro, A., Dreborg, S., Halken, S., Høst, A., Niggemann, B., Aalberse, R., et al. (2004). Dietary prevention of allergic diseases in infants and small children. Part III. Critical review of published peer-reviewed observational and interventional studies and final recommendations. *Pediatric Allergy and Immunology*, 15, 291–307.
- National Center for Health Statistics. (2000). Vital and health statistics of the Centers for Disease Control and Prevention. *Advance Data*, 314.
- National WIC Association Position Paper. (2004). *Breast-feeding Promotion and Support in the WIC Program*. Washington, DC: Author.
- Norris, J., Barriga, K., Hoffenber, E., Taki, I., Miao, D., Haas, J., et al. (2005a). Risk of celiac disease autoimmunity and timing of gluten introduction in the diet of infants at increased risk of disease. *Journal of the American Medical Association*, 293, 2343–2351.
- Norris, J., Barriga, K., Klingensmith, G., Hoffman, M., Eisenbarth, G., Erlich, H., et al. (2005b). Timing of initial cereal exposure in infancy and risk of islet autoimmunity. *Journal of the American Medical Association*, 290, 1713–1720.
- Nowak-Węgrzyn, A. (2003). Future approaches to food allergy. *Pediatrics*, 111, 1672–1680.
- Odijk, J. van, Hulthen, L., Ahlstedt, S., & Borres, M. P. (2004). Introduction of food during the infant's first year: A study with emphasis on introduction of gluten and of egg, fish, and peanut in allergy-risk families. *Acta Paediatrica*, 93, 464–470.
- Orlet Fisher, J., Birch, L., Smiciklas-Wright, H., & Picciano, M. F. (2000). Breast-feeding through the first year predicts maternal control in feeding and subsequent toddler energy intakes. *Journal of the American Dietetic Association*, 100, 641–646.
- Owen, C. G., Martin, R. M., Whincup, P. H., Davey Smith, G., & Cook, D. G. (2005). Effect of infant feeding on the risk of obesity across the life course: A quantitative review of the published evidence. *Pediatrics*, 115, 1367–1377.
- Pelto, G. (2000). Improving complementary feeding practices and responsive parenting as a primary component of interventions to prevent malnutrition in infancy and early childhood. *Pediatrics*, 106, 1300–1301.
- Ponza, M., Devaney, B., Ziegler, P., Reidy, K., & Squatrito, C. (2004). Nutrient intakes and food choices of infants and toddlers participating in WIC. *Journal of the American Dietetic Association*, 104, S71–S79.
- Rajakumar, K., & Thomas, S. (2005). Reemerging nutritional rickets: A historical perspective. *Archives of Pediatric and Adolescent Medicine*, 159, 335–341.
- Rossander-Hulten, L., Brune, M., Sandstrom, B., Lonnerdal, B., & Hallberg, L. (1991). Comparative inhibition of iron absorption by manganese and zinc in humans. *American Journal of Clinical Nutrition*, 54, 152–156.
- Ryan, A. S., Wenjun, Z., & Acosta, A. (2002). Breastfeeding continues to increase into the new millennium. *Pediatrics*, 110, 1103–1109.
- Saarinen, K. M., Pelkonen, A. S., Makela, M. G., & Savilahti, E. (2005). Clinical course and prognosis of cow's milk allergy are dependent on milk-specific IgE status. *Journal of Allergy and Clinical Immunology*, 116, 869–875.
- Sakashita, R., Inoue, N., & Kamegai, T. (2004). From milk to solids: A reference standard for the transitional eating process in infants and preschool children in Japan. *European Journal of Clinical Nutrition*, 58, 643–653.
- Sakashita, R., Inoue, N., & Tatsuki, T. (2003). Selection of reference foods for a scale of standards for use in assessing the transitional process from milk to solid foods in infants and pre-school children. *European Journal of Clinical Nutrition*, 57, 803–809.
- Savino, F., Costamagna, M., Prino, A., Oggero, R., & Silvestro, L. (2002). Leptin levels in breast-fed and formula-fed infants. *Acta Paediatrica*, 91, 897–902.
- Schach, B., & Haight, M. (2002). Colic and food allergy in the breastfed infant: Is it possible for an exclusively breastfed infant to suffer from food allergy? *Journal of Human Lactation*, 18, 50–52.
- Schmitz, J. (2000). Complementary feeding and enteropathies. *Pediatrics*, 106, 1286.
- Sicherer, S. (2003). Clinical aspects of gastrointestinal food allergy in childhood. *Pediatrics*, 111, 1609–1616.
- Skinner, J., Ziegler, P., Pac, S., & Devaney, B. (2004a). Meal and snack patterns of infants and toddlers. *Journal of the American Dietetic Association*, 104, S65–S70.
- Skinner, J., Ziegler, P., & Ponza, M. (2004b). Transitions in infants' and toddlers' beverage patterns. *Journal of the American Dietetic Association*, 104, S45–S50.
- Slaughter, C., & Bryant, A. H. (2004). Hungry for love: The feeding relationship in the psychological development of young children. *Permanente Journal*, 8, 23–29.
- Stang, J. (2006). Improving the eating patterns of infants and toddlers. *Journal of the American Dietetic Association*, 106, S7–S9.
- Stettler, N., Stallings, V. A., Troxel, A., Zhou, J., Schinnar, R., Nelson, S. E., et al. (2005). Weight gain in the first week of life and overweight in adulthood. *Circulation*, 111, 1897–1903.

- Stettler, N., Zemel, B. S., Kumanyika, S., & Stallings, V. A. (2002). Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics*, *109*, 194–199.
- Taveras, E., Scanlon, K., Birch, L., Rifas-Shiman, S., Rich-Edwards, J., & Gillman, M. (2004). Association of breastfeeding with maternal control of infant feeding at age 1 year. *Pediatrics*, *114*, e577–e583.
- Upham, J., & Holt, P. (2005). Environment and development of atopy. *Current Opinion in Allergy and Clinical Immunology*, *5*, 167–172.
- Vadas, P., Wai, Y., Burks, W., & Perelman, B. (2001). Detection of peanut allergens in breast milk of lactating women. *Journal of the American Medical Association*, *285*, 1746–1748.
- Villalpando, S. (2000). Feeding mode, infections, and anthropometric status in early childhood. *Pediatrics*, *106*, 1282–1283.
- Wagner, C. L., Hulsey, T. C., Fanning, D., Ebeling, M., & Hollis, B. W. (2006). High-dose vitamin D3 supplementation in a cohort of breastfeeding mothers and their infants; a 6-month follow-up pilot study. *Breastfeeding Medicine*, *1*, 59–70.
- Weaver, L. (2000). Gastrointestinal digestive and absorptive function. *Pediatrics*, *106*, 1280–1281.
- Weisberg, P., Scablon, K., Li, R., & Cogswell, M. (2004). Nutritional rickets among children in the United States: Review of cases reported between 1986 and 2003. *American Journal of Clinical Nutrition*, *80*(Suppl.), 1697S–16705S.
- Wharton, B. (2000). Patterns of complementary feeding (weaning) in countries of the European Union: Topics for research. *Pediatrics*, *106*, 1273–1274.
- WHO Working Group on the Growth Reference Protocol and the WHO Task Force on Methods for the Natural Regulation of Fertility. (2002). Growth of healthy infants and the timing, type and frequency of complementary foods. *American Journal of Clinical Nutrition*, *76*, 620–627.
- World Health Organization (WHO). (2003). *Global Strategy for Infant and Young Child Feeding* [pamphlet]. Geneva: Author.
- Wood, R. A. (2003). The natural history of food allergy. *Pediatrics*, *111*, 1631–1637.
- Zeiger, R. (2003). Food allergen avoidance in the prevention of food allergy in infants and children. *Pediatrics*, *111*, 1662–1671.
- Zutavern, A., Mutius, E. von, Harris, J., Mills, P., Moffatt, S., White, C., et al. (2004). The introduction of solids in relation to asthma and eczema. *Archives of Diseases in Children*, *89*, 303–308.

## Special Section: Social and Cultural Aspects of Breast-Feeding

Yeemay Su Miller, M.S., R.D. and Virginia L. Marchant

*“It’s like making a choice between a car that runs perfectly and is free, or a lower quality car that’s expensive . . . seems like a no-brainer to me.”*

Statement from a man regarding the decision to breast-feed or formula feed a baby

### A Brief History of Breast-Feeding

Deciding whether or not to breast-feed and for how long is not as simple as deciding what car to buy. Many complex social and cultural factors play interrelated roles in a woman’s decision to breast-feed. Until the mid-18th century, aristocrat families, and later the urban middle class, employed wet nurses to feed their infants as the social norm until the age of weaning, usually at 2 years of age. The ability to hire a wet nurse was regarded as a status symbol, and the mothers who hired wet nurses could then carry out upper class social obligations and civic duties. One could draw parallels between these women and today’s mothers who choose to bottle feed, free from being the only one who can perform the frequent and sometimes taxing task of feeding their infants. In an ironic twist of modern times, breast-feeding rates are higher among more educated and higher-income older mothers, whereas less educated lower-income mothers are more likely to bottle feed their infants (CDC, 2004).

### Current Trends Affecting Breast-Feeding

Throughout history men have dictated the significance of the female breast, from sacred and life giving to a sensual erotic object. Not until the later half of the 20th century did women begin to repossess their breasts, with increasing numbers of women seeking breast augmentation surgeries, which place second only to liposuction for the most common cosmetic surgery. Sociologist Barbara Behrmann notes in her book, *The Breast-Feeding Café* (2005), “Women in the U.S. nurse [their babies] in a culture in which our breasts are used to sell everything from cars to beer; in which deep cleavage dominates the checkout aisle...and in which the number of women who artificially enhance their breasts has increased 533% from 1992 to 2002.”

Surveys conducted by the American Society of Plastic Surgeons in 2001 reveal that 206,354 women underwent breast augmentation (i.e., breast implants) in the United States. The actual risk of impeding

future breast-feeding varies, depending on the type of procedure, the skill and techniques of the surgeon, and physiology of the individual woman’s breasts. Some women who receive breast implants may have the ability to do some breast-feeding as long as the surgery is done skillfully with proper technique (Hefter, Lindholm, & Elvenes, 2003).

Reduction mammoplasty (breast reduction surgery) procedures have tripled from 47,874 performed in 1997 to 126,614 in 2002 (Plastic Surgery Information Service, n.d.). Unfortunately, women who undergo this particular surgery are likely unable to breast-feed exclusively or successfully for very long (Souto, Giugliani, Giugliani, & Schneider, 2003). The research of Souto et al. with a cohort of Brazilian women who had undergone reduction mammoplasty revealed that most of them expressed a strong wish and intention to breast-feed and were told over-optimistically by their surgeons that lactation would be preserved. However, the women who had undergone reduction mammoplasty were not as successful with any or exclusive breast-feeding when compared with control subjects. These women expressed that they would have undergone the surgery even if told lactation may not be preserved (Souto et al., 2003).

### Who Breast-Feeds?

Thirty percent of all women who give birth in the United States choose not to breast-feed at all, according to the most recent CDC National Immunization Survey. Although slightly more than 70% of women do initiate breast-feeding at birth or soon thereafter, significantly fewer women continue to breast-feed their infants to 6 months, with 14% exclusively breast-feeding and 36% partially breast-feeding. Only 18% of women breast-feed their infants to 1 year of age, the duration recommended by the AAP (CDC, 2004). These rates fall short of the U.S. Department of Health and Human Services’ *Healthy People 2010* public health initiative, which sets a national goal of 75% of all women breast-feeding their

infants starting at birth or in the early postpartum period, 50% continuing to breast-feed at 6 months, and 25% at 1 year (U.S. Department of Health and Human Services and CDC, n.d.).

Women who choose to initiate breast-feeding at the highest rates tend to be white, over 25 years of age, college educated, and of middle to high socioeconomic status (CDC, 2004). Although the breast-feeding rates for Hispanic or Latino women in the United States closely match or even exceed those of their white peers, the greatest disparity from the national overall rate occurs among African-American women, 50% of whom breast-feed at birth, with only 23% continuing to breast-feed to 6 months, and less than 10% to 1 year (CDC, 2004). Worldwide, the WHO (2005) estimates that only 35% of infants are breast-fed to 4 months of age.

A report by the CDC showed that children were more likely to have ever been breast-fed if they were ineligible for or did not receive WIC assistance (CDC Report, 2004). Another study showed that women who participated in the WIC program were significantly less likely to breast-feed to 6 months of age and that this factor was stronger than other demographic characteristics (Ryan & Zhou, 2006). Research also showed that overweight and obese mothers are less likely to breast-feed and for shorter duration than mothers of normal weight and body mass index (Kugyelka, Rasmussen, & Frongillo, 2004; Rasmussen & Kjolhede, 2004; Lovelady, 2005).

Breast-feeding rates also vary widely by region and state, with the lowest initiation rates (ranging from less than 55% to 64%) in the southern and mid-western states and the highest (75% or greater) in 14 western states, including Alaska, Idaho, Oregon, Washington, Utah, and California. At 6 months of life the percentage of breast-fed infants drops to below 30% in the south and below 40% in most other states, with a handful of western states maintaining 50% or better. The percentage of infants still breast-fed at 1 year dips below 20% in most states and into the single digits in at least five southern states, most notably Alabama, Mississippi, and Louisiana (CDC, 2004).

### Barriers to Breast-Feeding

It is important to educate new mothers, their partners, family members, and healthcare professionals. The HHS Blueprint for Action on Breastfeeding (U.S. Department of Health and Human Services, 2000) lists the importance of educating the father or mother's partner, other family members, and healthcare pro-

viders, who all can greatly influence a woman's decision to breast-feed (Freed, Fraley, & Schanler, 1992; Ekulona, 1996). Within the U.S. medical system all healthcare providers, including obstetricians, pediatricians, and nurses, need more education on the physiology of lactation and the mechanics of breast-feeding to best support their breast-feeding patients. Yet the breadth of knowledge on these topics taught by most medical schools is likely limited. Providers inadvertently sabotage a mother's efforts to exclusively breast-feed by recommending supplementation with formula when he or she fail to recognize that breast-fed infants gain weight differently from formula-fed peers or recommend complete weaning when a mother reports a lactation problem rather than a referring her to a qualified lactation consultant. National surveys reveal that health care professionals who are educated on how best to support lactation in their patients play an important role in influencing the mother's decision to breast-feed and for longer duration (Lu, Lange, Slusser, Hamilton, & Halfon, 2001).

When the method a mother chooses to feed her baby can be viewed as a life-style decision, it can be determined by the mother's and other family members' attitudes and beliefs about breast-feeding as well as healthcare professionals' views, employment, stress levels, and amount of social support (Donath, Amir, & ALSPAC Study Team, 2003). A mother's perception of the father's attitude or preferences on how the baby should be fed is one top determinant of the mother's decision to initiate bottle feeding over breast-feeding (Freed et al., 1992; Arora, McJunkin, Wehrer, & Kuhn, 2000). Studies have also reported that the maternal grandmother's attitude also influences the type of feeding method by the mother and positively correlates with longer duration of breast-feeding if she supports her daughter's decision to breast-feed (Donath et al., 2003; Swanson & Power, 2005). The perceived influence of other people's views (subjective norms), including the views of the women's partners, other family members, and healthcare providers, is an important predictor of infant feeding behavior (Swanson & Power, 2005). Therefore promoting breast-feeding as a positive norm and as the ideal method to feed an infant within a mother's broad social context increases initiation and continuation of breast-feeding.

### Routine Maternity Care Practices

Research has identified specific hospital nursery and maternity ward practices that interfere with breast-

feeding, especially in the critical first week. Separating the mother and newborn without medical necessity can prevent the establishment of breast-feeding during the first hour of life when newborns are most alert. Introducing pacifiers and bottles to newborns too early often causes “nipple confusion,” because the method of sucking artificial replacements is completely different from the type of suck needed to extract milk from a breast. As a result, an infant may suck improperly or inadequately at the breast.

Supplementation with formula or “sugar water” and pacifier use can also depress the infant’s instinct to breast-feed frequently, which helps establish the mother’s milk supply. The most recent research correlates early pacifier use with a significant decline in exclusive breast-feeding. In addition, “across all types of breastfeeding (exclusive, full, and overall), the most significant predictor of duration was the receipt of supplemental feedings while in the hospital” (Howard et al., 2003).

The WHO outlines a number of maternity care practices for the birthplace, whether it is hospital, clinic, or birth center, that facilitate and support breast-feeding; if these practices are fully implemented, the hospital earns the designation of “baby-friendly.” Currently, fewer than 50 hospitals and maternity care facilities in the United States have earned the “baby-friendly” designation (Shealy, Li, Benton-Davis, & Grummer-Strawn, 2005). A recently published study of baby-friendly hospitals and birth centers in the United States showed that women who gave birth in a baby-friendly setting initiated breast-feeding and exclusively breast-fed their infants in the early postpartum period at significantly higher rates than state, regional, and national rates, and these rates were consistently elevated in a variety of settings (Merewood, Mehta, Chamberlain, Philipp, & Bauchner, 2005).

In addition to the UNICEF and WHO Baby Friendly Hospital Initiative, the U.S. Department of Health and Human Services and the CDC advocate that every facility providing maternity services and care for newborn infants should

- Have a written breast-feeding policy that is routinely communicated to all healthcare staff
  - Train all healthcare staff in skills necessary to implement this policy
  - Inform all pregnant women about the benefits and management of breast-feeding
  - Help mothers initiate breast-feeding within a half-hour of birth
- Show mothers how to breast-feed and how to maintain lactation even if they should be separated from their infants
  - Give newborn infants no food or drink other than breast milk, unless *medically* indicated and under no circumstances provide breast milk substitutes, feeding bottles, or pacifiers free of charge or at low cost
  - Practice rooming-in (allow mothers and infants to remain together) 24 hours a day
  - Encourage breast-feeding on demand
  - Give no artificial teats or pacifiers to breast-feeding infants
  - Foster the establishment of breast-feeding support groups and refer mothers to them on discharge from the hospital or clinic

### Physiologic and Psychological Factors

One of the most common reasons reported by women who introduce formula to their babies and thereby begin to decrease breast-feeding is “lack of confidence in the sufficiency of their breast milk” (Donath et al., 2003; Swanson & Power, 2005), which is a self-efficacy issue. Confidence in one’s body to nourish an infant adequately from the breast is not necessarily a physiologic issue of adequate production or supply of milk. Unlike bottle feeding, in which one can actually see how many ounces an infant is drinking, other measures, such as the number of wet diapers per day and proper weight gain over time, determine the adequacy of a breast-fed infant’s intake. Increasing a mother’s self-efficacy and confidence with breast-feeding appears to be important in helping women breast-feed successfully and for longer duration (Mitra, Khoury, Hinton, & Carothers, 2004; Kools, Thijs, & de Vries, 2005; Noel-Weiss, Bassett, & Cragg, 2006). Therefore helping women combat their lack of self-confidence, providing reassurance, and reinforcing that the more she breast-feeds the more milk she will produce assist mothers in their breast-feeding goals.

Breast-feeding can be painful initially for many women even when done correctly (i.e., correct positioning and hold of the infant, proper latch-on). Flat or inverted nipples, scar tissue, bacterial or yeast infection, changes in hormone levels, plugged ducts, an infant with a vigorous suck, or other underlying causes may not be immediately diagnosed, leading a mother to believe that breast-feeding will always cause pain and to wean her infant prematurely. However, often these problems can be addressed by knowl-

edgeable healthcare professionals or may even resolve themselves within a few weeks. A study of breast-feeding discontinuation reported that 14% of women who initiated breast-feeding discontinued between the first and third week because of breast pain or soreness, whereas only 4% discontinued between the fourth and sixth week, and none after the seventh week (Taveras et al., 2003).

In addition, women with more symptoms of maternal depression had greater odds of discontinuing breast-feeding by 12 weeks. A woman's predelivery perception of breast-feeding and the strength of her intention to breast-feed also determine whether or not she will initiate breast-feeding and continue to do so "through the vulnerable post delivery period when women may experience the most discomfort" (Ahluwalia, Morrow, & Hsia, 2005). Healthcare providers interested in promoting breast-feeding should provide women with the tools and support to overcome potential difficulties, including pain and soreness.

### Social Support and Acculturation

In some industrialized societies, but not all, breast-feeding has been intertwined with sexuality, making it difficult for some people to separate the two distinctly different functions of the breast. Some ignore the biological role of the breast as a mammary gland to produce milk ideally suited for the nutritional needs of a human child. Other individuals misconstrue breast-feeding in public as a form of indecent exposure. As author Gabrielle Palmer states in *The Politics of Breastfeeding*, "The very reason it [breast-feeding] is frowned upon in public is that breasts are perceived exclusively as objects of sexual attention (1988, p. 119)."

To increase the proportion of women who breast-feed and continue exclusively for at least 6 months, the U.S. Department of Health and Human Services in conjunction with the Ad Council launched the first-ever nationwide breast-feeding awareness campaign in 2004. Rather than just promoting the benefits of breast-feeding, the campaign featured television, radio, and print ads that emphasized the risks of not breast-feeding and its impact on infant and child health. The 2005 postsurvey results revealed that awareness of messages about breast-feeding rose from 28% to 38% and significantly more women surveyed had breast-fed a child in the 2004/2005 study (73%) than in the 2004 study (63%). In regard to breast-feeding in public, 42% of respondents surveyed in

2005 reported being somewhat comfortable or very comfortable with breast-feeding their infant in public, a 3% increase from the 2004 study, whereas 48% of women surveyed in 2005 reported being somewhat uncomfortable or very uncomfortable with breast-feeding their infant in a public place, which is a 1% increase from 2004 survey results. Clearly, much more needs to be done to enable women to feel more comfortable with breast-feeding in public and to make it a social norm.

Not only is American society often unsupportive of breast-feeding women, it can be outright hostile to women who breast-feed in public. Women from various regions of the country and different walks of life have reported incidents of discrimination and harassment while breast-feeding their children in public places such as restaurants, public pools, shopping malls, and supermarkets. Many times these stories appear in the local media, accompanied by editorials or letters to the editor, and some even make it into the national news. These media controversies and the public debate over public breast-feeding lead many women to view breast-feeding negatively when deciding on how to feed their infants.

The same factors that influence whether a mother initiates breast-feeding, as previously mentioned, also determine the *duration* of breast-feeding. Based on the AAP recommendation that a mother breast-feed her infant for at least 12 months, breast-feeding beyond this age has been reported in U.S. literature as "extended breastfeeding." However, the average age of weaning throughout the world, historically and currently, falls between ages 2 and 4 years (Stuart-Macadam & Dettwyler, 1995).

In addition, an analysis of data from NHANES indicates that the more highly acculturated a Hispanic woman becomes in the United States, the less likely she will breast-feed. Conversely, the less acculturated a Hispanic woman is in the United States, the more likely she will breast-feed in keeping with the rate of her country of origin (Gibson, 2005).

### Marketing of Breast Milk Substitutes

Expectant mothers are heavily influenced by the plethora of advertisements in parenting magazines, marketing materials in their doctors' offices, coupons for free or steeply discounted breast milk substitutes (formula) that arrive in the mail, and the free samples distributed by the hospital where they give birth. Research suggests that this advertising during pregnancy seriously undermines a future breast-feeding

relationship (Howard, Howard, Lawrence, Andresen, & DeBlieck, 2000). Formula companies also target their marketing to women who remain undecided or intend to just “give breast-feeding a try.” This deluge of marketing material affects the feeding decisions of mothers to such an extent that the manufacture and sale of breast milk substitutes has grown into an 8 billion dollar industry.

Nearly all hospitals distribute discharge packs or “gift bags” provided by major pharmaceutical companies that contain cans or bottles of formula, with marketing materials including coupons for more formula and sometimes packaged with “breast-feeding success” brochures or books on infant care. Research has shown that the distribution of the bags reduces the number of women who exclusively breast-feed for any length of time (Donnelly, Snowden, Renfrew, & Woolridge, 2004).

To curtail the inappropriate marketing of formula that interferes with lactation, the WHO set forth an International Code of Marketing of Breast Milk Substitutes in 1981 (WHO/UNICEF, 1981), which the United States also adopted in 1994. The main goal of the WHO Code is “to contribute to the provision of safe and adequate nutrition for infants, by the protection and promotion of breast-feeding and by the proper use of breast milk substitutes, when these are necessary, on the basis of adequate information and through appropriate marketing and distribution” (WHO/UNICEF, 1981). The Code specifically prohibits

- Advertising of breast milk substitutes
- Distributing free samples of breast milk substitutes to mothers
- Promoting breast milk substitutes through healthcare facilities
- Using company-appointed “nurses” to “advise” mothers on bottle feeding
- Giving gifts or personal samples to health workers
- Placing words or pictures idealizing artificial feeding, including pictures of infants, on the labels of the products
- Promoting unsuitable products for infants, such as sweetened condensed milk

In addition, the Code states that

- Information to health workers should be scientific and factual
- All information on artificial feeding, including the labels, should explain the benefits of breast-

feeding and the costs and hazards associated with artificial feeding

- All products should be of high quality and take into account the climatic and storage conditions of the country where they are used

### Returning to Work

The most recent available statistics from the U.S. Department of Labor (2004) show that 57% of female employees are women with infants and children under the age of 3, and they are the fastest growing segment of today’s labor force. At least 50% of women who are employed when they become pregnant return to the labor force by the time their child reaches 3 months of age. Research indicates that the timing of the mother’s resumption of employment is a key factor that influences the duration of exclusive breast-feeding, and workplace policies and practices, particularly maternity/parental leave provisions, have considerable potential to positively influence breast-feeding practices (Galtry, 2003). Because there is a positive association between length of maternity leave and duration of breast-feeding, some contend that a country’s breast-feeding rates are influenced by and reflected in its maternity leave programs (U.S. Department of Labor, 1996). In Norway and Sweden, which have the highest breast-feeding rates in the world, women are entitled to 12 months and 18 months, respectively, of job-protected maternity and child care leave and compensation at 80% to 100% of normal earnings (Organization for Economic Cooperation and Development, 2001). A 1997 report of the International Labor Organization found that for most industrialized countries, 75% to 100% of pay is guaranteed for up to 16 weeks of maternity leave. In stark contrast, the United States mandates only up to a 12-week maternity leave with no entitled pay and has relatively low breast-feeding rates in comparison with other industrialized countries. In addition, a 2000 report to the U.S. Congress on family and medical leave policies found that 77% of those surveyed who were eligible for Family Medical Leave did not take it, stating they could not afford to do so (Waldfogel, 2001).

The earlier a mother returns to work, the more likely her duration of breast-feeding will decrease (Piper & Parks, 1996; Visness & Kennedy, 1997; Vogel, Hutchison, & Mitchell, 1999), and the odds of a woman being able to continue breast-feeding

after returning to work increase when her work hours are part-time as opposed to full-time. “Improved maternity leave provisions and more flexible working conditions may help women to remain at home with their infants longer and/or to combine successfully breastfeeding with employment outside the home (Scott, Binns, Oddy, & Graham, 2006).” Fortunately, more and more states are either encouraging or mandating that employers accommodate breast-feeding mothers when they return to work:

After initiating lactation programs, many employers have seen positive results in the workplace, such as lower absenteeism, high productivity, high company loyalty, high employee morale, and lower healthcare costs. Because an ill child is a frequent cause of absenteeism among employed mothers and fathers, worksite programs that aim to improve child health may also bring about a reduction in absenteeism. Mothers with a formula-fed child are more prone to miss work because formula-fed children have been found to be ill three times more often than breast-fed children (Oregon Department of Health Services, n.d.).

The HHS Blueprint for Action in Breastfeeding (U.S. Department of Health and Human Services, 2000) lists specific aspects of worksite programs that support the continuation of breast-feeding once mothers return to the workplace:

- Prenatal lactation education specifically tailored to working women
- Corporate policies providing information to all employees on the benefits of breast-feeding and services to support breast-feeding women
- Education for personnel about why their breast-feeding coworkers need their support
- Adequate breaks, flexible work hours, job sharing, and part-time work
- Private “mother’s rooms” for expressing milk in a secure, sanitary, and relaxing environment
- Access to hospital-grade autocycling breast pumps at the workplace
- Small refrigerators for the safe storage of breast milk
- Subsidization or purchase of individually owned portable breast pumps for employees
- Access to a lactation professional on-site or by phone to give breast-feeding education, counsel-

ing, and support during pregnancy, after delivery, and when the mother returns to work

- Coordination with on-site or near-site child care programs so that the infant can be breast-fed during the day
- Support groups for working mothers with children

### Legislation: Protecting a Woman’s Right to Breast-Feed

Florida and New York enacted the first state laws concerning breast-feeding in 1993 and 1994, and since then many state legislatures have added breast-feeding to their general statutes as a matter of public health policy. This legislation ranges from the protection of a mother’s right to breast-feed in public, to requirements that an employer should accommodate a nursing mother’s need to express her milk, to exemptions from jury duty for nursing mothers. The past 5 years have shown an upward trend in comprehensive breast-feeding legislation on the state level that addresses public breast-feeding, workplace issues, and exemption from jury duty. According to La Leche League International (n.d.), which tracks breast-feeding legislation, during the 2005–2006 legislative session 13 states considered bills to protect the right of nursing mothers to breast-feed their children wherever they have the legal right to be.

The provisions of breast-feeding laws can vary widely, as can their interpretations. Currently, 36 states clearly protect a woman’s right to breast-feed in public, whereas 20 other states merely exempt nursing mothers from indecent exposure laws. At least eight states have legislation specifically maintaining that a woman may breast-feed wherever she is authorized to be, “irrespective of whether or not the nipple of the mother’s breast is covered during or incidental to the breast-feeding.”

Legislation that addresses discrimination against nursing mothers in the workplace can also vary. Six states require employers to provide adequate and sanitary facilities for mothers to express and safely store their milk during their lunch or break time. Other states permit but do not require employers to accommodate nursing mothers or designate a workplace as “mother friendly” by providing a flexible work schedule, a private location with an electrical outlet (other than a restroom), a sink with clean running water, and a hygienic refrigerator in the workplace.



## References

### Social and Cultural Aspects of Breast-Feeding

- Ahluwalia, I. B., Morrow, B., & Hsia, J. (2005). Why do women stop breastfeeding? Findings from the pregnancy risk assessment and monitoring system. *Pediatrics*, *116*, 1408–1412.
- American Academy of Pediatrics. (2005). Breastfeeding and the Use of Human Milk Policy Statement. Breastfeeding and the use of human milk, section on breastfeeding. *Pediatrics*, *115*, 496–506.
- Arora, S., McLunkin, C., Wehrer, J., & Kuhn, P. (2000). Major factors influencing breastfeeding rates: Mother's perception of father's attitude and milk supply. *Pediatrics*, *106*, E67.
- Baby Milk Action. (n.d.). Cambridge, England: Center for Breastfeeding Information, Schaumburg, IL. Retrieved May 20, 2006, from <http://www.babymilkaction.org>
- Behrmann, B. (2005). *The Breastfeeding Café*. Ann Arbor, MI: University of Michigan Press.
- Bulk-Bunschoten, A. M., van Bodegom, S., Reerink, J. D., Pasker-de Jong, P. C., & de Groot, C. J. (2001). Reluctance to continue breastfeeding in The Netherlands. *Acta Paediatrica*, *90*, 1047–1053.
- Celi, A. C., Rich-Edwards, J. W., Richardson, M. K., Kleinman, K. P., & Gillman, M. W. (2005). Immigration, race/ethnicity, and social and economic factors as predictors of breastfeeding initiation. *Archives of Pediatrics & Adolescent Medicine*, *159*, 255–260.
- Centers for Disease Control and Prevention. (2005). Breastfeeding: Data and statistics. Breastfeeding practices—Results from the 2004 National Immunization Study. Retrieved October 4, 2007, from [http://www.cdc.gov/breastfeeding/data/NIS\\_data/data\\_2004.htm](http://www.cdc.gov/breastfeeding/data/NIS_data/data_2004.htm)
- Connecticut General Assembly, Office of Legislative Research. Retrieved May 30, 2006, from <http://www.cga.ct.gov/ps99/rpt/olr/99-r-0760.doc>
- Donath, S. M., Amir, L. H., & ALSPAC Study Team. (2003). Relationship between prenatal infant feeding intention and initiation and duration of breastfeeding: A cohort study. *Acta Paediatrica*, *92*, 352–356.
- Donnelly, A., Snowden, H. M., Renfew, M. J., & Woolridge, M. W. (2004). Commercial hospital discharge packs for breastfeeding women (Cochrane review). *The Cochrane Library*, Issue 2.
- Ekulona, E. (1996). Family health: Taking responsibility/making the difference. *Healthy Start Father's Journal*, 1–18.
- Freed, G. I., Fraley, J. K., & Schanler, R. J. (1992). Attitudes of expectant fathers regarding breastfeeding. *Pediatrics*, *90*, 224–227.
- Galtry, J. (2003). The impact on breastfeeding of labour market policy and practice in Ireland, Sweden, and the USA. *Social Science and Medicine*, *57*, 167–177.
- Gibson-Davis, C. M., & Brooks-Gunn, J. (2006). Couples' immigration status and ethnicity as determinants of breastfeeding. *American Journal of Public Health*, *96*, 641–646.
- Giles, F. (2003). *Fresh Milk: The Secret Lives of Breasts*. New York: Simon and Schuster.
- Giovannini, M., Riva, E., Banderali, G., Scaglioni, S., Veehof, S. H., Sala, M., et al. (2004). Feeding practices of infants through the first year of life in Italy. *Acta Paediatrica*, *93*, 492–497.
- Haynes, S. G. (2005). National Breastfeeding Awareness Campaign Results. U.S. Department of Health and Human Services Office on Women's Health (OWH).
- Heath, A. L., Tuttle, C. R., Simons, M. S., Cleghorn, C. L., and Parnell, W. R. (2002). A longitudinal study of breastfeeding and weaning practices during the first year of life in Dunedin, New Zealand. *Journal of the American Dietetic Association*, *102*, 937–943.
- Hefter, W., Lindholm, P., & Elvenes, O. P. (2003). Lactation and breast-feeding ability following lateral pedicle mammoplasty. *British Journal of Plastic Surgery*, *56*, 746–751.
- Howard, C. R., Howard, F. M., Lanphear, B., Eberly, S., deBlicke, E. A., Oakes, D., et al. (2003). Randomized clinical trial of pacifier use and bottle-feeding or cupfeeding and their effect on breastfeeding. *Pediatrics*, *111*, 511–518.
- Howard, C. R., Howard, F., Lawrence, R., Andresen, E., & DeBlicke, E. (2000). Office prenatal formula advertising and its effects on breastfeeding patterns. *Obstetrics and Gynecology*, *95*, 296–303.
- Hurst, N. (2003). Breastfeeding after breast augmentation. *Journal of Human Lactation*, *19*, 7–8.
- International Labour Organization. (1998). Retrieved May 31, 2006, from <http://www.ilo.org/public/english/bureau/inf/pr/1998/7.htm>
- Johnson, J. O., & Downs, B. (2005). Maternity leave and employment patterns of first time mothers. Current population reports. Retrieved June 5, 2006, from <http://www.census.gov/prod/2005pubs/p70-103.pdf>
- Kools, E. J., Thijs, C., & de Vries, H. (2005). The behavioral determinants of breast-feeding in The Netherlands: Predictors for the initiation of breast-feeding. *Health Education Behaviors*, *32*, 809–824.
- Kronborg, H., & Vaeth, M. (2004). The influence of psychosocial factors on the duration of breastfeeding. *Scandinavian Journal of Public Health*, *32*, 210–206.
- Kugyelka, J. G., Rasmussen, K. M., & Frongillo, E. A. (2004). Maternal obesity is negatively associated with breastfeeding success among Hispanic but not Black women. *Journal of Nutrition*, *134*, 1746–1753.
- Le Leche League International. (n.d.). Breastfeeding and the law: A current summary of breastfeeding legislation in the US. Retrieved June 4, 2006, from <http://www.lelecheleague/lawMain.com>
- Lewin, A. M. (2005). Breast-feeding moms take action: "lactivists" and lawmakers push to allow public nursing. *ABC News*, December 20, 2005.

- Lovelady, C. A. (2005). Is maternal obesity a cause of poor lactation performance? *Nutrition Reviews*, *63*, 352–355.
- Lu, M. C., Lange, L., Slusser, W., Hamilton, J., & Halfon, N. (2001). Provider encouragement of breast-feeding: Evidence from a national survey. *Obstetrics and Gynecology*, *97*, 290–295.
- McIntyre, E., Hiller, J. E., & Turnbull, D. (2001). Attitudes towards infant feeding among adults in a low socioeconomic community: What social support is there for breastfeeding? *Breastfeeding Reviews*, *9*, 13–24.
- Merewood, A., Mehta, S. D., Chamberlain, L. B., Philipp, B. L., & Bauchner, H. (2005). Breastfeeding rates in US baby-friendly hospitals: Results of a national survey. *Pediatrics*, *116*, 628–634.
- Meyerink, R. O., & Marquis, G. S. (2002). Breastfeeding initiation and duration among low-income women in Alabama: The importance of personal and familial experiences in making infant-feeding choices. *Journal of Human Lactation*, *8*, 38–45.
- Mitra, A. K., Khoury, A. J., Hinton, A. W., & Carothers, C. (2004). Predictors of breastfeeding intention among low-income women. *Maternal and Child Health Journal*, *8*, 65–70.
- National Conference of State Legislatures. 50 State Summaries of Breastfeeding Laws. Retrieved April 20, 2006, from <http://www.ncsl.org/programs/health/breast50.htm>
- Noel-Weiss, J., Bassett, V., & Cragg, B. (2006). Developing a prenatal breastfeeding workshop to support maternal breastfeeding self-efficacy. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *35*, 349–357.
- Nommsen-Rivers, L. (2003). Cosmetic breast surgery—is breastfeeding at risk? *Journal of Human Lactation*, *19*, 7–8.
- Oregon Department of Human Services. (n.d.). Retrieved June 5, 2006, from <http://www.dhs.state.or.us/policy/admin/safety/breastfeeding.htm>
- Organization for Economic Cooperation and Development. (2001). Balancing work and family life: Helping parents into paid employment. In *Employment Outlook* (pp. 129–166). Paris, France: Organization for Economic Cooperation and Development.
- Palmer, G. (1988). *The Politics of Breastfeeding*. London: Pandora Press.
- Piper, S., & Parks, P. L. (1996). Predicting the duration of lactation: Evidence from a national survey. *Birth*, *23*, 7–12.
- Plastic Surgery Information Service. (n.d.). Retrieved June 3, 2006, from <http://www.plasticsurgery.org>
- Rasmussen, K. M., & Kjolhede, C. L. (2004). Prepregnant overweight and obesity diminish the prolactin response to suckling in the first week postpartum. *Pediatrics*, *113*, e465–e471.
- Rea, M. F., & Morrow, A. L. (2004). Protecting, promoting, and supporting breastfeeding among women in the labor force. *Advances in Experimental Medical Biology*, *554*, 121–132.
- Ryan, A. S., & Zhou, W. (2006). Lower breastfeeding rates persist among the special supplemental nutrition program for women, infants, and children participants, 1978–2003. *Pediatrics*, *117*, 1136–1146.
- Ryan, A. S., Zhou, W., & Acosta, A. (2002). Breastfeeding continues to increase into the new millennium. *Pediatrics*, *110*, 1103–1109.
- Shealy, K. R., Li, R., Benton-Davis, S., & Grummer-Strawn, L. M. (2005). *The CDC Guide to Breastfeeding Interventions*. Washington, DC: U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention.
- Stuart-Macadam, P., & Dettwyler, K. A. (1995). *Breastfeeding: Biocultural Perspectives*. Hawthorne, NY: Aldine De Gruyter.
- Scott, J. A., Binns, C. W., & Aroni, R. A. (1995). Infant feeding practices in Perth and Melbourne: Report 1, p. 72 (breastfeeding rates in Australia).
- Scott, J. A., Binns, C. W., Oddy, W. H., & Graham, K. I. (2006). Predictors of breastfeeding duration: Evidence from a cohort study. *Pediatrics*, *117*, e646–e655.
- Souto, G. C., Giugliani, E. R., Giugliani, C., & Schneider, M. A. (2003). The impact of breast reduction surgery on breastfeeding performance. *Journal of Human Lactation*, *19*, 43–49; quiz 66–69, 120.
- Swanson, V., & Power, K. G. (2005). Initiation and continuation of breastfeeding: Theory of planned behaviour. *Journal of Advanced Nursing*, *50*, 272–282.
- Sweden's Statistics in Health and Diseases. (1998). Retrieved June 3, 2006, from <http://www.sos.se/FULLTEXT/0042-007/0042-007.pdf>
- Taveras, E. M., Capra, A. M., Braveman, P. A., Jensvold, N. G., Escobar, G. J., & Lieu, T. A. (2003). Clinician support and psychosocial risk factors associated with breastfeeding discontinuation. *Pediatrics*, *112*, 108–115.
- U.S. Department of Health and Human Services. (2000). *HHS Blueprint for Action on Breastfeeding*. Washington, DC: U.S. Department of Health and Human Services, Office on Women's Health.
- U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention. (n.d.). Healthy People 2010: Maternal, Infant, and Child Health. Retrieved July 1, 2007, from <http://www.healthypeople.gov/Document/HTML/Volume2/16MICH.htm>
- U.S. Department of Labor. (1996). *A Workable Balance. Report to Congress on Family and Medical Leave Policies*.
- U.S. Food and Drug Administration. Breast implants: An information update—2000. Retrieved July 1, 2007, from <http://www.fda.gov/cdrh/breastimplants/index.html>
- van der Wal, M. F., de Jonge, G. A., & Pauw-Plomp, H. (2001). Increased percentages of breastfed infants in Amsterdam. *Ned Tijdschr Geneesk*, *18*, 1597–1601. In Dutch.
- Vance, M. R. A current summary of breastfeeding legislation in the U.S. Retrieved July 1, 2007, from <http://www.lalecheleague.org/LawBills.html>. Also A current summary of proposed breastfeeding legislation in the U.S. Retrieved July 1, 2007, from <http://www.lalecheleague.org/Law/proposedsummary.html>

- Visness, C., & Kennedy, K. (1997). Maternal employment and breast-feeding: Findings from the 1988 National Maternal and Infant Health Survey. *American Journal of Public Health, 87*, 945–950.
- Vogel, A., Hutchison, B., & Mitchell, E. (1999). Factors associated with the duration of breastfeeding. *Acta Paediatrica, 88*, 1320–1326.
- Waldfogel, J. (2001). Family and medical leave: Evidence from the 2000 surveys. *Monthly Labor Review, 124*. Retrieved October 4, 2007, from <http://www.bls.gov/opub/mlr/2001/09/art2full.pdf>
- Walker, M. (2002). Breastfeeding after breast augmentation. *Journal of Human Lactation, 19*, 70–71.
- WHO/UNICEF International Code of Marketing of Breast Milk Substitutes. (1981). Geneva, Switzerland.
- Yalom, M. (1997). *A History of the Breast*. New York: Ballantine.

## Special Section: Postpartum Depression and Maternal Nutrition

Rachelle Lessen, MS, RD, IBCLC

During fetal development the growth of the brain depends on the accumulation of large amounts of omega-3 fatty acids. DHA and AA are incorporated into the neural cell membranes during the period of rapid fetal brain development in the third trimester of gestation. A portion of this fatty acid can be endogenously synthesized by the fetus or newborn from its precursor alpha-linolenic acid; however, it is likely that most is provided directly from the mother through the placenta or in breast milk. Although the needs of the growing fetus and infant have been extensively studied, less is known about the needs of the mother, who is the primary source of DHA for her fetus or breast-fed child. Makrides and Gibson (2000) reported that there does not appear to be a detectable reduction of omega-3 fatty acids during pregnancy but there is a clear decrease of approximately 30% in the postpartum period. This decline occurs gradually from birth to 6 weeks and persists until 12 weeks or beyond. The decrease is largely independent of whether or not the mother is breast-feeding, suggesting that lactation is not contributing to this postpartum depletion. This decline is preventable and reversible with DHA supplementation.

Literature reports that an AI of omega-3 fatty acids is associated with major depression and other affective disorders, and there are reports of decreased levels of omega-3 fatty acids in depressed patients. DHA supplementation has been reported to be effective in treatment of bipolar disorder and schizophrenia. DHA is thought to modulate synaptic function directly through its effect on membrane structure. Because of the evidence supporting a relationship between DHA and brain function and the

knowledge that DHA levels decrease in late pregnancy and lactation, researchers have proposed a relationship between DHA and postpartum depression.

Seafood is a major source of DHA, and studies have shown that women who regularly consume fish have higher levels of DHA in their breast milk than women who rarely or never eat fish. Also reported is an association between increased seafood consumption and decreased depression. Hibbeln (2002) proposed that the DHA content of mother's milk and seafood consumption would predict the prevalence rates of postpartum depression. Hibbeln hypothesized that because seafood consumption protects women from omega-3 fatty acid depletion during pregnancy, rates of postpartum depression would be lower in countries with greater rates of seafood consumption. Because the DHA content of breast milk serves as a marker of maternal DHA status postpartum, they also hypothesized that higher concentrations of DHA in breast milk would predict lower rates of postpartum depression. Their findings did indeed support the conclusion that lower DHA content in mothers' milk and lower seafood consumption were both associated with higher rates of postpartum depression. Because data on confounding variables were not available for all countries in the study, it could not be proved that higher levels of DHA caused a lower prevalence of rates of postpartum depression.

Llorente and colleagues (2003) found that DHA supplementation of 200 mg/day for 4 months after delivery prevented a decrease in plasma DHA that is often seen in postpartum women. In a randomly assigned, double-masked, interventional study they found that the mothers who received DHA supplementation

increased their DHA levels by 8% compared with the placebo group, which had a 31% decrease in DHA. After 4 months of supplementation the supplemented group had a 50% higher DHA level than the unsupplemented group. However, these changes were not found to be associated with rates of depression. Repeated measurements of depression at 3 weeks, 2 months, and 4 months showed no difference between the groups at any time. Rates of depression were equally low in both groups. The authors conceded that perhaps a higher dose of DHA, or a combination of DHA and AA, or initiating supplementation during pregnancy may have more beneficial effects on postpartum depression.

## References

### Postpartum Depression and Maternal Nutrition

- Hibbeln, J. R. (2002). Seafood consumption, the DHA content of mothers' milk and prevalence rates of postpartum depression: A cross-national, ecological analysis. *Journal of Affective Disorders, 69*, 15–29.
- Llorente, A., Jensen, C. L., Voigt, R. G., Fraley, J. K., Berretta, M. C., & Heird, W. C. (2003). Effect of maternal docosahexaenoic acid supplementation on postpartum depression and information processing. *American Journal of Obstetrics and Gynecology, 188*, 1348–1353.
- Makrides, M., & Gibson, R. (2000). Long-chain polyunsaturated fatty acid requirements during pregnancy and lactation. *American Journal of Clinical Nutrition, 71*, 307S–311S.