How the Breast Works

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In most cases breasts of different sizes and shapes will produce enough breast milk.

Structure of the Breast

Alveoli

These are clusters of glandular tissue in the breast where breast milk is produced and stored until it is released in response to the infant's sucking. The alveoli are secretory acini cells surrounded by a contractile unit of myoepithelial cells (Riordan, 2010). Gaps between the alveolar cells close 2–3 days after birth, reducing permeability. These alveolar cells contract to eject the breast milk into the ducts during the letdown or breast milk ejection reflex. There is mammary glandular tissue throughout the breast extending into the axilla; much of the glandular tissue is located within a 30 mm radius of the base of the nipple (Ramsay et al., 2005).

Ducts

There are tubular structures where breast milk flows from the alveoli. Ducts and ductules begin branching under the areola and intertwine throughout the breast, surrounded by adipose and glandular tissue, and reaching to the alveoli (Ramsay et al., 2005). Breast milk is ejected into the upper ducts when letdown occurs. There are usually about 9 ducts, ranging from 4 to 14, opening at the surface of the nipple (Ramsay et al., 2005).

These ducts are for the transport of breast milk, rather than for breast milk storage (Geddes, 2007). Previously it was thought that breast milk was stored in widened areas of the ducts, known as milk or lactiferous sinuses, until it was removed through breastfeeding or breast milk expression. However, the work of the Hartmann et al. (1996), using real-time ultrasound imagery, has shown that these sinuses do not exist. The resting diameter of the duct near the areola is the same as the diameter farther up the lobe.

The ducts increase in diameter when letdown or breast milk ejection reflex occurs during breastfeeding or expression. Dilation of the breast milk duct is caused by a combination of shortening and widening of the duct, together with increased pressure within the duct, due to expulsion of breast milk from the alveoli and a change in the infant's sucking pattern (Ramsay et al., 2004). When breast milk is no longer being removed, duct size returns to the resting diameter within 2 minutes due to the backward flow of breast milk (Ramsay et al., 2004). The breast milk ducts at the base of the alveoli are superficial, very small (1.9 ± 0.6 mm), and easily compressed. They are easily occluded with gentle pressure (Ramsay et al., 2005).

Nipple

The mammary papillae form a conical elevation at the centre of the areola. This tissue is very flexible, able to stretch and mould to conform to the infant's mouth. There are usually about 9, ranging from 4 to 18, duct openings or pores where the breast milk ducts merge and from which breast milk exits the breast (Ramsay et al., 2005). The nerve endings are highly sensitive to stimulation, controlling the release of breast milk from the ductal openings.

Areola

The dark area around the nipple comes in a variety of shapes and sizes. It increases in size and colour in response to hormones during pregnancy and breastfeeding.

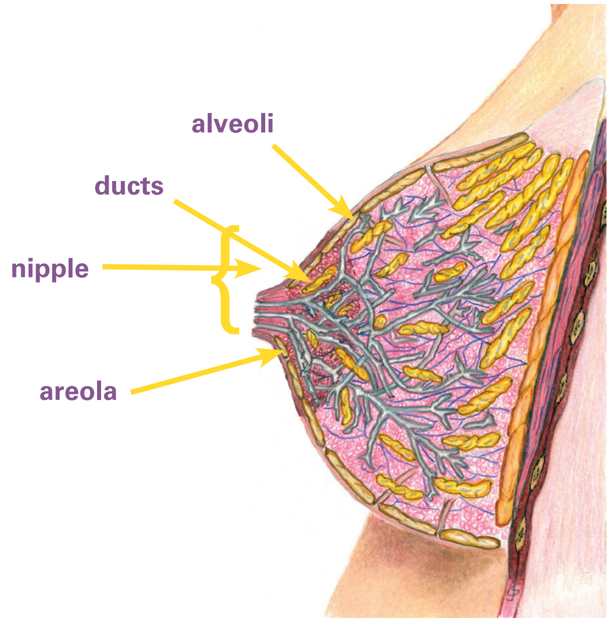
Both the nipple and areola are erectile tissue that responds to tactile, sensory and autonomic nervous stimuli (Lawrence, 2010).

Montgomery's tubercles contain openings of the ducts and sebaceous glands that lubricate the areola. The secretions provide olfactory stimuli for infants, playing a key role in establishing behavioural and physiological processes related to breast milk transfer and production (Doucet et al., 2009).

Breast Changes During Pregnancy

The hormones estrogen and progesterone are responsible for the increased size and sensitivity of the breast or mammary gland during pregnancy. Mammogenesis is the rapid growth and cell development of the alveolar and ductal tissue of the breast that occurs during early pregnancy.
These changes are signs that the breasts are preparing to make breast milk. Beginning from mid-pregnancy to late pregnancy, the breast has the capacity to produce the components of breast milk (Lactogenesis I). Lactation is normally inhibited during pregnancy because high levels of estrogen and progesterone inhibit the effect of prolactin. Lactogenesis II, the initial copious secretion of breast milk 2–4 days after childbirth, is triggered by the fall in progesterone and estrogen levels after expulsion of the placenta. This also triggers the closure of the tight junctions between the alveolar cells. At that time, the levels of sodium, chloride and protein drop in breast milk, together with an increase in lactose and breast milk lipid levels. Until then, large molecule immunoglobulins and medications pass easily into breast milk (Hale et al., 2007). The events of the first few days may either promote or delay Lactogenesis II (*Protocol #1: The Initiation of Breastfeeding*). Although the initial copious secretion of breast milk is driven by hormones rather than by breast milk removal, sustained lactation depends on regular breast milk removal (Cregan et al., 2002).

In most cases, breasts of different shapes and sizes will produce more than enough breast milk. Larger breasts have more fatty tissue but not necessarily more of the breast milk producing alveoli tissue. Storage capacity, the amount of breast milk stored between breastfeedings, does appear to be related to breast size but not to the potential for breast milk production. Mothers with smaller storage capacities may need to breastfeed more often and may have less flexibility in the frequency of breastfeeding (Hartmann et al., 1996).



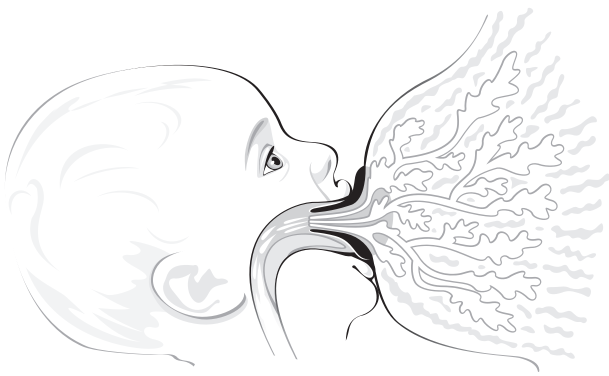
Lactating Breast at Rest

How Breast Milk is Produced

The amount of breast milk produced depends on how often and how effectively the infant removes breast milk from the breast.

More breast milk will be produced when the infant breastfeeds more frequently and has an effective latch and suck. The interaction between storage capacity, the degree of breast fullness or emptiness, and frequency of breast milk removal plays a significant role in breast milk synthesis (Cregan, 1999).

When the nipple and areola are stimulated by infant hand movements and suckling, a cascade of hormones are triggered. Hormones are released into the mother's bloodstream, sending messages to the brain via the hypothalamic-pituitary-adrenal or HPA axis. These trigger breast milk production and the letdown or breast milk ejection reflex, as well as other maternal and infant behaviours. Multiple letdowns occur during a single breastfeeding. Most mothers report sensing the initial letdown but not subsequent ones (Ramsay et al., 2004). Mothers may also not feel letdown but still have a normal letdown response.



Lactating Breast after Letdown

Prolactin is the hormone synthesized, stored and released from the anterior pituitary to stimulate the alveoli to produce and secrete breast milk. The greater the stimulation to the nipple and areola, the more prolactin that is secreted by the anterior pituitary gland, leading to more breast milk being produced. Prolactin levels have diurnal variations following a circadian rhythm, with higher levels occurring at night (Riordan, 2010; Hale et al., 2007). Levels of prolactin are highest in early lactation and decline as lactation progresses (Cox et al., 1996, Hale et al., 2007). Prolactin levels may be regulated by a feedback mechanism known as the Prolactin – Inhibiting Factor (PIF) or Feedback Inhibitor of Lactation (FIL), a dopamine-related substance that inhibits the uptake of prolactin by the prolactin receptors (Lawrence, 2010). Frequent breastfeeding in the early days may stimulate development of prolactin receptors, resulting in greater breast milk output (De Carvalho et al., 1983).

Oxytocin is the hormone that sends messages to the alveoli to eject breast milk into the ducts. In response to suckling and infant hand massage (Matthiesen et al., 2001), the posterior pituitary gland secretes oxytocin, causing breast milk ejection reflex or letdown to contract the myoepithelial cells of the alveoli and eject breast milk into the ducts. The breast milk is drawn down the dilated ducts toward the areola to be removed during breastfeeding or breast milk expression. Oxytocin dilates the ducts during breast milk ejection reflex and also sends messages to the uterus to contract. This helps to prevent maternal haemorrhaging and to promote uterine involution after birth. Mothers may experience this as cramps or "after pains". These cramps may continue for up to 20 minutes after a breastfeeding (Riordan, 2010). Oxytocin is also understood to be a neuropeptide that plays a role in influencing emotional and physiological responses. These include cardiovascular, digestion, appetite and metabolism, pain threshold, kidney function, thermoregulation and stress response behaviours (Uvnus-Moberg, 1998), as well as attachment behaviours. These early maternal attachment behaviours promote infant brain development and plasticity (Schore, 2001). A feeling of calm often reported by women during breastfeeding is partly mediated by oxytocin (Riordan, 2010). It has been termed an agent of the calm and connection response (Uvnus-Moberg et al., 2005).

Prolactin and oxytocin play a role in maternal adaptation to stress, whereby the responses of the HPA axis and the sympathetic nervous system to emotional and physical stressors are attenuated or blunted (Slattery et al., 2008), facilitating right-brain and intuitive behaviours.

Other hormones also have significant roles in lactation. These include but are not limited to:

- Glucosteroids, which contribute to alveolar development, the regulation of fat, protein and lactose synthesis, and water transport across cell membranes.
- Cortisol, important to stress mediation and normally lactogenic; the high levels produced during stress may be antagonistic to lactation.
- Thyroid-stimulating hormone, which facilitates mammary growth and lactation.

Breast milk is a dynamic, living substance (Walker, 2010). It has many, many bioactive components, and transitions continually to meet the changing needs of the infant. These transitions occur on a continuum, with the composition of breast milk varying according to the stage of lactation, the time of day, the sampling time during a given feeding, maternal nutrition and individual variation (Lawrence, 2010).

Traditional nomenclature suggests distinct differences between "colostrum", "transitional milk" or "mature milk", and between "foremilk" and "hindmilk", which can imply limited value and use (Lawrence, 2010). Some cultures discard the first milk. However, it is important to acknowledge that all breast milk is "milk" and is valuable for infants.

The first breast milk (sometimes known as colostrum) is produced during late pregnancy and in the early postpartum period, and provides the infant with nutrition and protection against infectious disease (Lawrence, 2010). Typically, it is a clear yellow, viscous fluid rich in proteins (reflecting the presence of a large number of immunoglobulins), fat soluble vitamins, and some minerals, but has less fat and sugar than mature breast milk (Riordan, 2010). It is produced in tiny volumes; in the first 3 days postpartum the volume per feeding ranges from 2 to 30 ml (Lawrence, 2010). The higher concentrations of proteins and minerals gradually change over the first few weeks to reflect the infant's needs as breastfeeding becomes well established and more mature breast milk is produced (Riordan, 2010). Changes continue in later lactation when increases in sodium and protein, including lactoferrin, lysozyme and secretory IgA (Dewey, 1984; Goldman, 1984) increase to enhance protection from infection for the older infant and toddler.

Breast milk also changes throughout each breastfeeding, particularly related to fat content. At the initiation of a breastfeeding, the breast milk has a small amount of fat, but the fat content rises throughout the breastfeeding in relation to the degree of breast emptiness, not the duration of time at the breast, or the time interval between breastfeedings. The breast milk secreted at the early part of a breastfeeding, sometimes referred to as "foremilk", has high water and carbohydrate content to help hydrate and energize the infant. It is also a source of water-soluble vitamins (Riordan, 2010). The breast milk produced towards the latter part of a breastfeeding, sometimes referred to as "hindmilk", has progressively higher fat content, although the fat content of both "fore" and "hind" breast milk increases as the breast is emptied (Daly et al., 1993). There is no clear distinction between foremilk and hindmilk. The composition also varies with the time of day and between breasts (Lawrence, 2010).

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