Lecture 17: Lactation

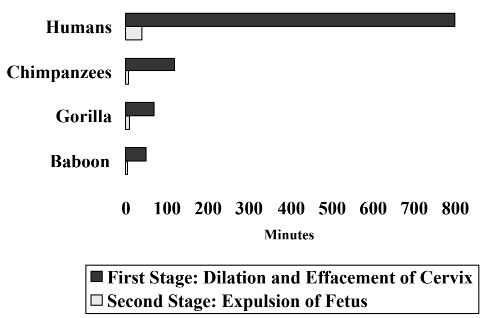
- Labor Pain
- Morphology of the Breast
- Hormonal Control of Lactation
- Milk Composition
- Benefits of Lactation
- Energetics of Lactation

Why is Labor Long in Humans?

Stage 1:
- Dilation and Effacement of cervix
- Mean = 14 hours in first birth

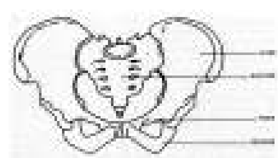
Stage 2:
- Expulsion of fetus
- Mean = 50 minutes in first births
- 20 minutes in later births

Why is Labor Long in Humans?



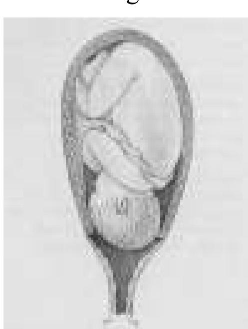
Why is Labor Painful in Humans?

The size of fetal head going through pelvis?



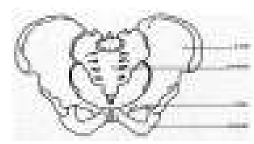
Why is Labor Painful in Humans?

The need for the cervix to dilate to 10 cm to accommodate the large fetal head?

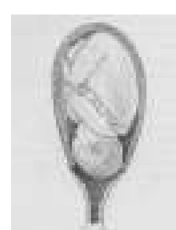


How is Human Birth Different?

Although rotation through the pelvis contributes to the duration and degree of difficulty during labor …



Difficult labor in humans is primarily due to the the degree of cervical dilation necessary to accommodate the size of the human fetal head (3x greater than in apes).



Why is Labor Painful in Humans?

- Humans spend significantly more time in the later stages of dilation when pain is greatest.
- Apes probably experience relatively little pain during labor because they have relatively little dilation

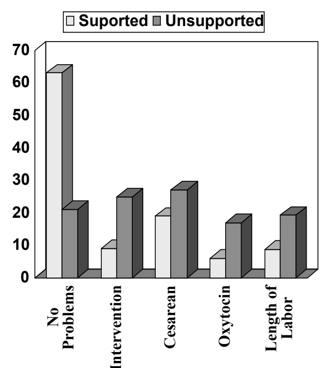
Labor Pain

- Why does relaxation help?
  - Autonomic nervous system
    - Parasympathetic (relaxation)
    - Sympathetic (fight or flight response)

Assisted Birth in Humans

- Birth is routinely performed with assistance in humans.
  - Emotional support to the mother
  - Mechanical assistance

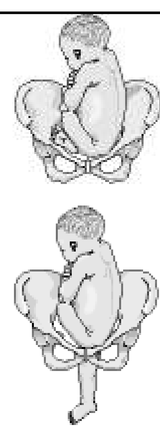
Birth Support (doula effect)



Sosa, et al. (1980)

Assisted Birth in Humans

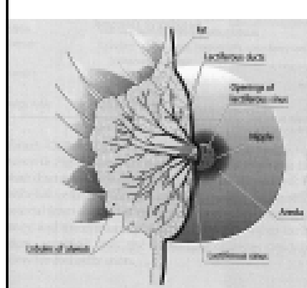
- Birth is routinely performed with assistance in humans.
  - Emotional support to the mother
  - Mechanical assistance
    - May be particularly important for breech births (2 - 4% of births)

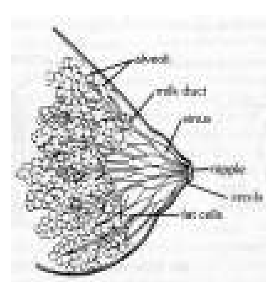


(Gregory et al. 1999)

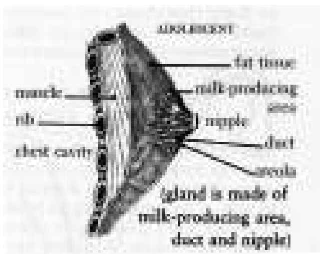
Survivors owe lives to a mother's gift

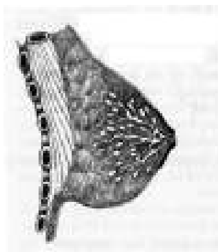
Morphology of the Breast





Breast Development





Breast Changes during Pregnancy (mammogenesis)

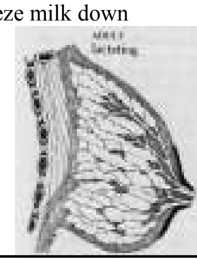
- Estrogen causes growth of ducts and proliferation of alveoli

Breast Changes during Pregnancy

- Estrogen causes growth of ducts and proliferation of alveoli
- Progesterone causes the alveolar milk glands to mature

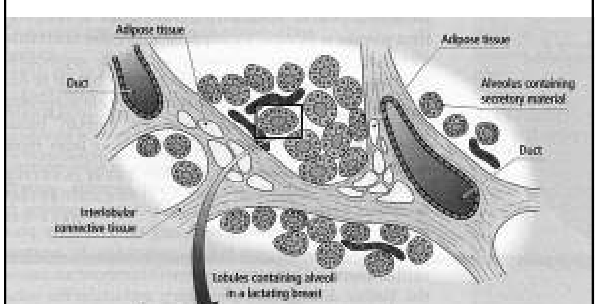
Breast Changes during Pregnancy

- Prolactin, cortisol and growth hormone turn breast cells into:
  - > Secretory cells that make milk
  - > Muscle cells that will squeeze milk down through ducts



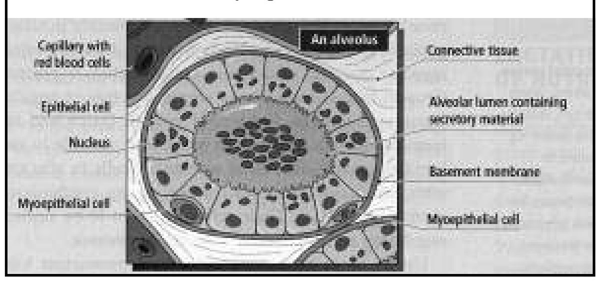
Morphology of Alveolus

- Site of milk synthesis



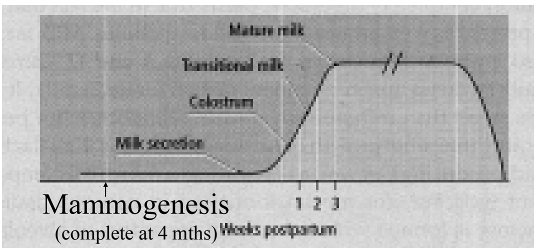
Morphology of Alveolus

- Site of milk synthesis
- Contained with a capsule of basement membrane which contains contractile myoepithelial cells.



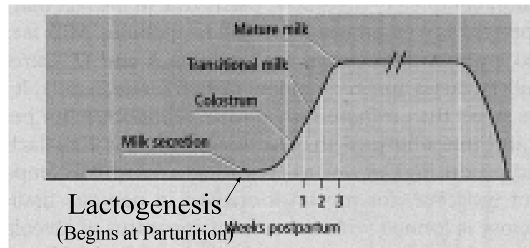
Stages of Breast Milk Production

- Mammogenesis: establishment of glandular morphology capable of producing large quantities of milk



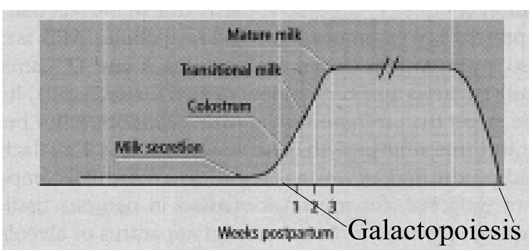
Stages of Breast Milk Production

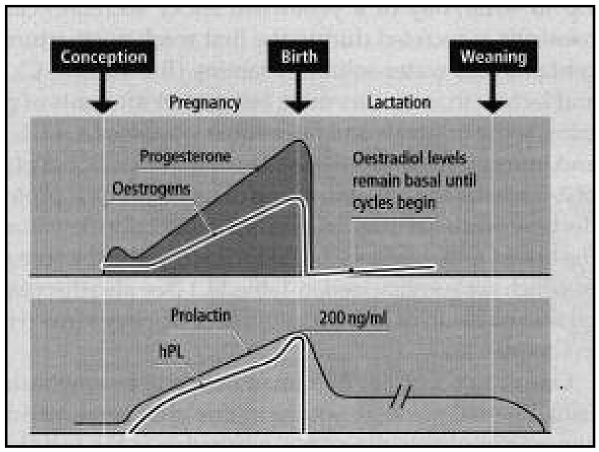
- Lactogenesis: establishment of actively secreting mammary gland



Stages of Breast Milk Production
Hormones of Lactation

- Galactopoiesis: maintenance of milk secretion





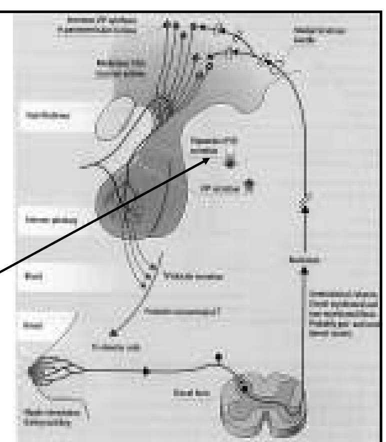
Prolactin & Milk Production

Neuroendocrine Reflex

- Nipple stimulation

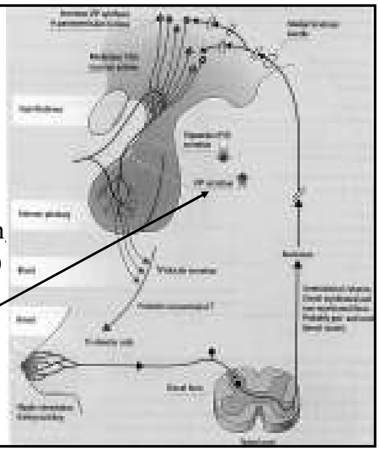
Prolactin & Milk Production

- Nipple stimulation
- Hypothalamus stops producing prolactin-inhibiting factor (dopamine)



Prolactin & Milk Production

- Hypothalamus stops producing prolactin-inhibitin factor (dopamine)
- Hypothalamus secretes VIP (vasoactive intestinal polypeptide)



Prolactin & Milk Production

- Nipple stimulation
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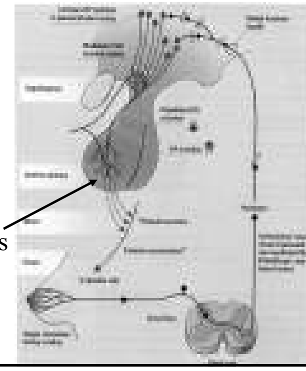
- Hypothalamus secretes VIP (vasoactive intestinal polypeptide)
- In response, Prolactin is secreted from lactotrophs in the anterior pituitary



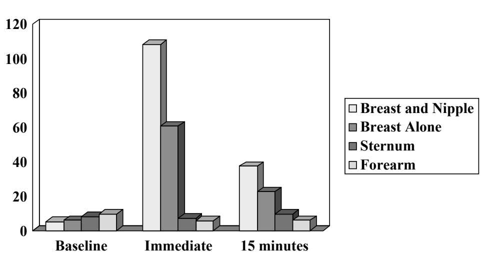
Prolactin & Milk Production

- Nipple stimulation
- Hypothalamus stops producing prolactin-inhibiting factor
- Hypothalamus secretes VIP (vasoactive intestinal polypeptide)
- In response, Prolactin is secreted frm lactotrophs in the anterior pituitary
- Prolactin stimulates mammary glands to produce milk

Suckling and Prolactin

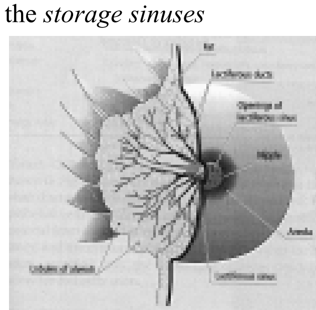
- Increased suckling produces increased milk production.
- Prolactin approaches level of non-lactating women in 4-6 hours

Prolactin in Non-Lactating Women after stimulation



Milk Letdown & Oxytocin

- Milk passes from alveoli, via ducts, to the *storage sinuses*



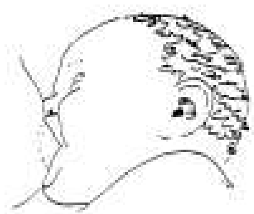
Milk Letdown & Oxytocin

- Milk passes from alveoli, via ducts, to the *storage sinuses*
- Suckling stimulates mothers autonomic sensory nerves in the breast

Latching on

Latching on

- Babies latch on to the areola, NOT the nipple



Milk Letdown & Oxytocin

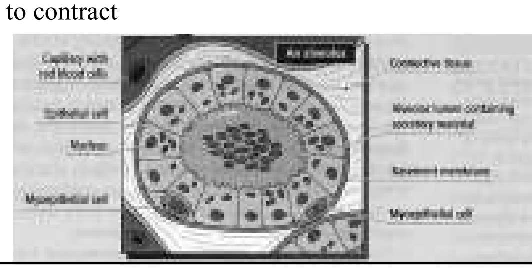
- Suckling stimulates mothers autonomic sensory nerves in the breast
- Sends message to hypothalamus

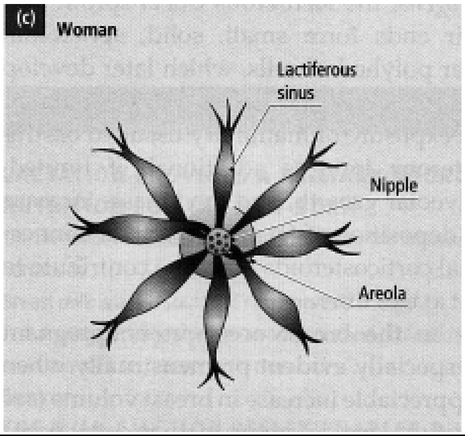
Milk Letdown & Oxytocin

- Sends message to hypothalamus
- Causes posterior pituitary to produce oxytocin

Milk Letdown & Oxytocin

- Causes posterior pituitary to produce oxytocin
- Stimulates muscle cells in breast to contract





Milk Composition: Colostrum

- Produced in first few days after birth

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- High in protein, low in fat and lactose (milk sugar)

Milk Composition: Colostrum

- Rich in immunoglobulins (esp. IgA and IgG)
- Establish normal bacterial flora of infant's digestive track
- Provides epidermal growth factors for final maturation of infant gut.

Breast Milk Immunity

- Immunoglobulins in breast milk protects newborns against infectious disease

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- Peyer's patches in maternal gut

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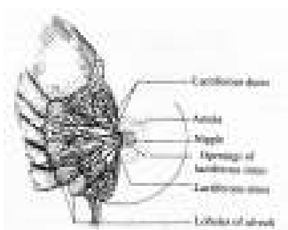
- Immunoglobulins in breast milk protects newborns against infectious disease
- Peyer's patches in maternal gut
- Lymphocytes lodge in breast and produce IgA in breast milk which coats baby's intestines and prohibit foreign objects from getting through

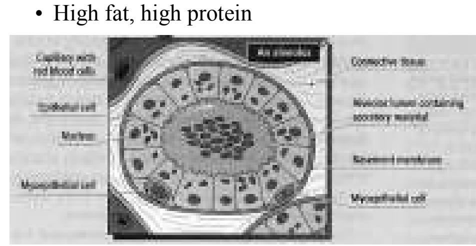
Milk Composition

- Foremilk—milk stored in ducts
  - Low fat, low protein, watered-down
  - 1/3 of total milk volume each nursing



Milk Composition

- Hindmilk—milk stored in alveolar cells and released during let down
  - High fat, high protein



Benefits of Lactation

- Ingestion by Newborn Humans:
  - Lipids in human milk better absorbed than cows milk

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  - Amino acids in cow's milk difficult for newborn's liver to break down into important proteins

Benefits of Lactation

- Ingestion by Newborn Humans:
  - Lipids in human milk better absorbed than cows milk
  - Amino acids in cow's milk difficult for newborn's liver to break down into important proteins
  - Form of iron not well absorbed

Benefits of Lactation

- Composition
  - Cow's milk low in nucleotides: 25% human, 6% cow

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  - Nucleotides -- 25% human, 6% cow
  - Processing of cow's milk destroys lactoferrin and transferrin and other immunological cells

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- Composition
  - Nucleotides -- 25% human, 6% cow
  - Processing of cow's milk destroys lactoferrin and transferrin and other immunological cells
  - Cow's milk has different ratios of calcium, phosphorous, magnesium, sodium and zinc

Benefits of Lactation

- Infant Health:
  - Bottle fed babies have 2x the illness rate and
  - 3x hospital admission rate as breast fed babies

Benefits of Lactation

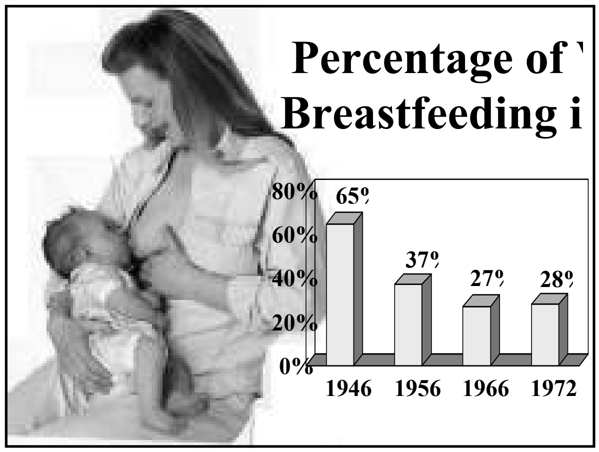
- Breast fed babies have lower rates of:
  - Ear infection
  - Pneumonia
  - Bronchitis
  - Vomiting
  - Diarrhea

Benefits of Lactation

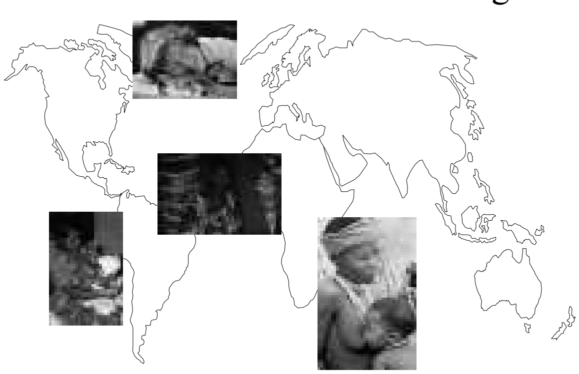
- Effects in adults
  - Lower rates of diabetes
  - Lower rates of asthma
  - Lower cholesterol levels
  - Lower heart disease
  - Lower risk of breast cancer

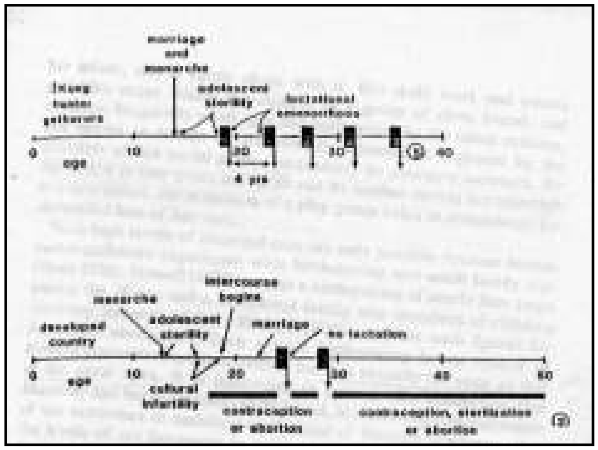
Lactation and Public Policy

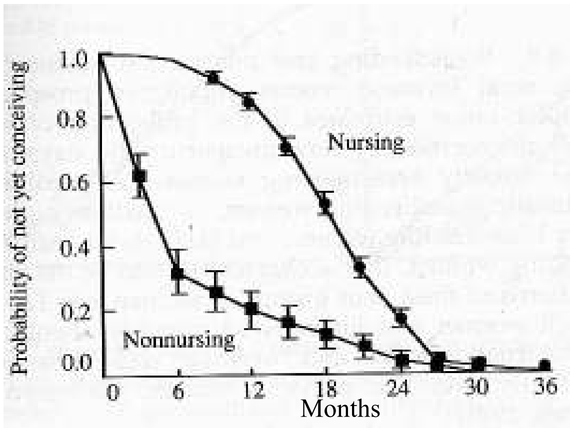
How do we create a more 'breast feeding" friendly society?



Field Studies of Breastfeeding

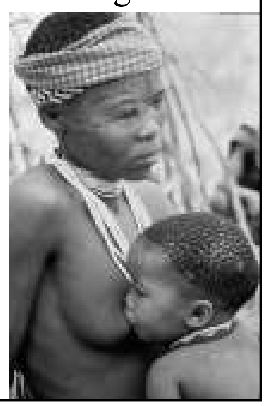






Lactation in the !Kung

- Long interbirth intervals - 44.1 mths
- Patterning of lactation
  - 4.06 bouts/hour
  - 7.83min/hour
  - 1.92 min/bout
- As child gets older — increase in length *between* bouts



Lactation in the !Kung

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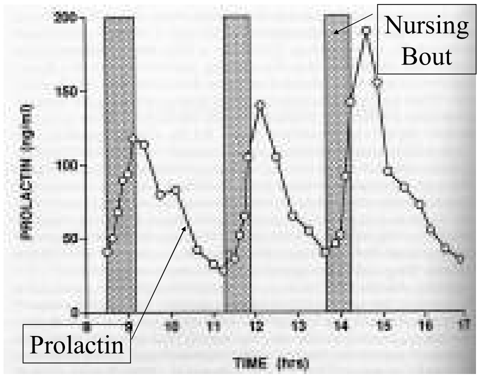
- Correlated with age of infant and mean time between nursing bouts

Lactation in the !Kung

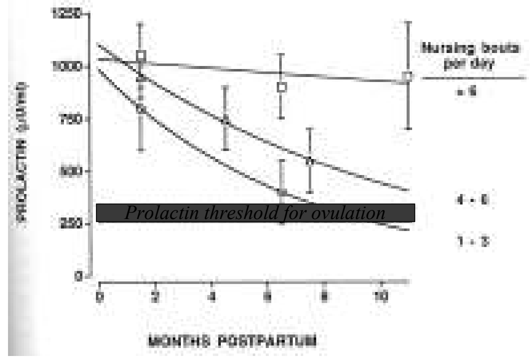
- Lower estradiol and progesterone in nursing mothers
- Correlated with age of infant and mean time between nursing bouts
- Suggested inter-bout interval key variable in lactation subfecundity

(Konner & Worthman)

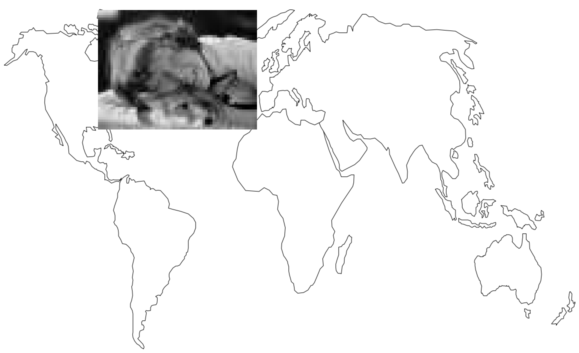
Prolactin & Nursing Bout Length



Prolactin, # Nursing Bouts, & Time



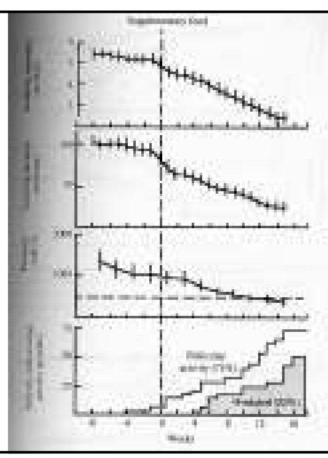
Edinburgh Study of Breastfeeding



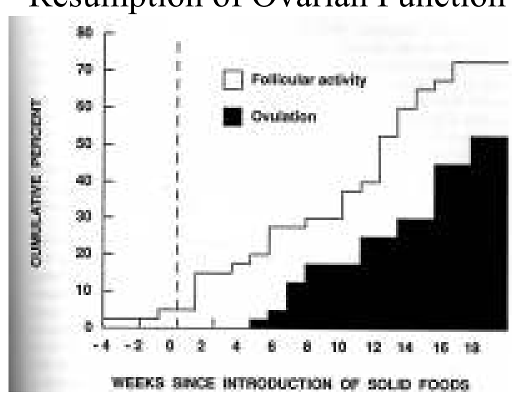
Howie and McNeilly

Edinburgh Study

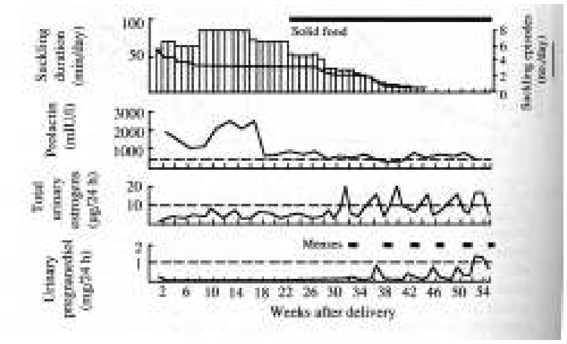
- Studied 27 breastfeeding and 10 bottle feeding mothers
- Lactation/supplementation diaries
- Measured urinary hormones
- Measure prolactin in blood



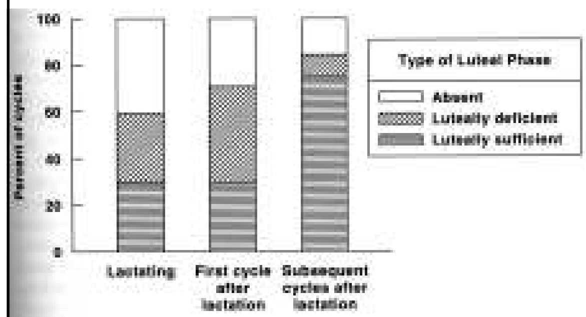
Resumption of Ovarian Function



Supplementation & Ovarian Function



Resumption of Ovarian Function



Edinburgh Study

- Lactating women resumed ovarian function later postpartum than did bottle feeding women

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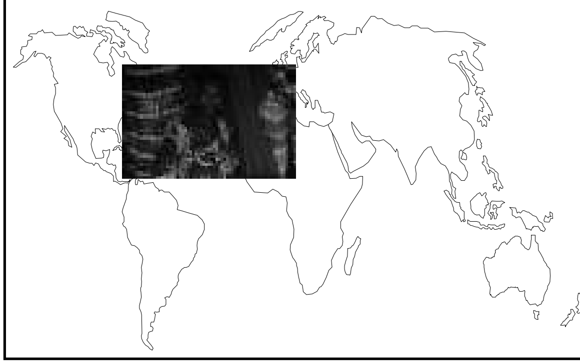
- Frequency of ovulation increased with time as lactation was phased out
- Rapid resumption of ovarian function in bottle feeders; gradual resumption in breast feeders
- Importance of introduction of supplementary foods
- Women who conceived while nursing decreased the frequency to 3 or fewer times/day.

Lactation & Supplementation: The Gambia



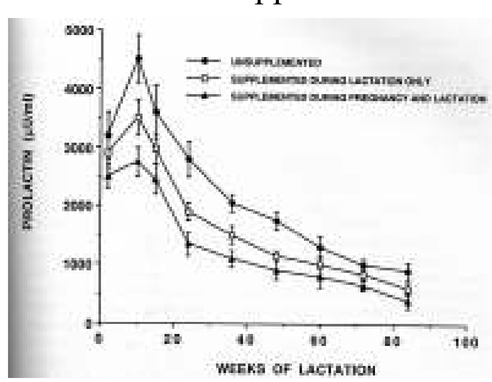
Supplementation and Breast Milk

- Gave 130 women supplement increased calories from 1568 to 2291 + vitamin
- No effect on breast milk volume!!

Supplementation and Breast Milk

- Gave130 women supplement increased calories from 1568 to 2291 + vitamins
- No effect on breast milk volume
- Protein content slightly increased (6.6%)
- Milk fat increase (7.9%)
- Lactose decrease (-7.6%)
- No change in calories
- Vitamin increase from supplement

Prolactin & Supplementation



Gambian Study

- Supplementation had only a small effect on quantity and quality of breast milk
- Supplementation had a dramatic effect on prolactin levels

Prolactin & Lactational Amenorrhea

- High levels of prolactin associated with reduced ability for egg to produce estradiol (in culture)
- Evidence now is role may be more indirect.

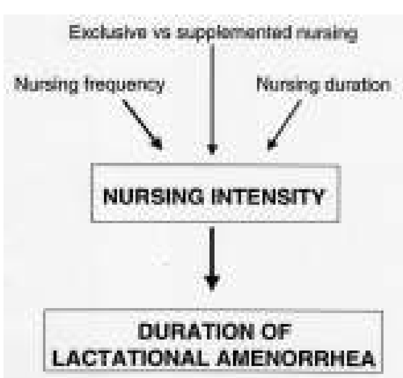
The Toba: Positive Energy Balance and High Nursing Frequency

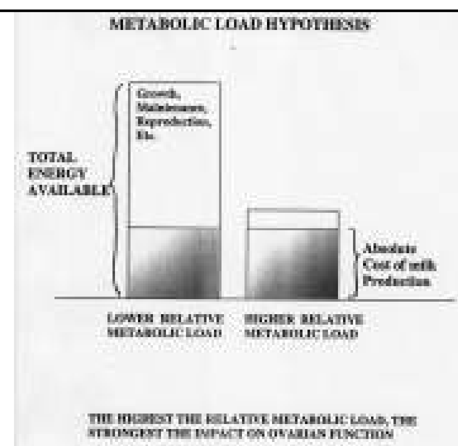
Breast Feeding Hypotheses

- How to explain variation in duration of postpartum period of infecundity
  - Nursing Intensity Hypothesis
  - Metabolic Load Hypothesis

Valeggia & Ellison

Nursing Intensity Hypothesis





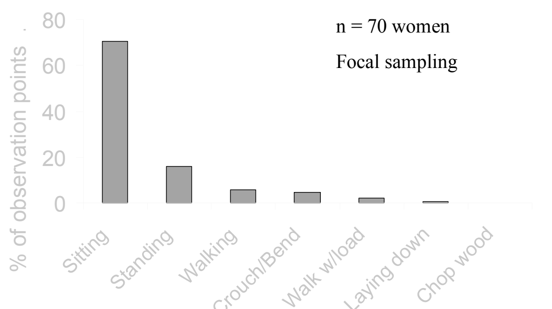
Nursing intensity hypothesis:

The more intensive the nursing, the longer the period of lactational amenorrhea

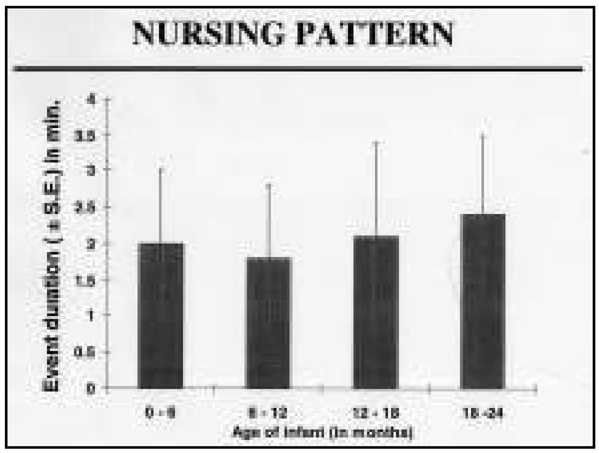
Relative metabolic load hypothesis:

The higher the relative cost of nursing, the longer the period of lactational amenorrhea

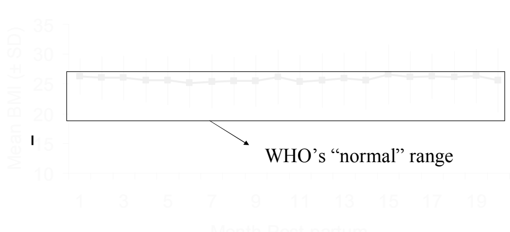
Physical activity postpartum



(Valeggia &

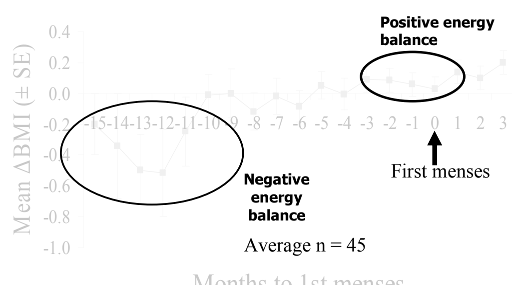


Toba women remain well-nourished during the entire postpartum period



Valeggia & Ellison (2003)

Changes in energy balance in relation to time to first postpartum menses



Valeggia & Ellison (2003)

!Kung-like nursing intensity

US-like nutritional status

↓

Mean duration of postpartum amenorrhea
10 (± 4) months (n = 122)

Lactational Amenorrhea in Toba

- Mean = 10.3 months

Valeggia & Ellison

Lactational Amenorrhea in Toba

- Mean = 10.3 months
- High nutritional status and high nursing intensity — leads to short periods of lactational amenorrhea

Valeggia & Ellison

Lactational Amenorrhea in Toba

- Mean = 10.3 months
- High nutritional status and high nursing intensity — leads to short periods of lactational amenorrhea
- Thus, nursing intensity alone is insufficient explanation

Valeggia & Ellison

Lactational Amenorrhea in Toba

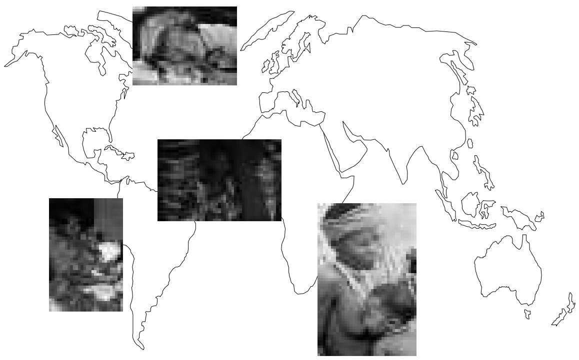
- Mean = 10.3 months
- High nutritional status and high nursing intensity — leads to short periods of lactational amenorrhea
- Thus, nursing intensity alone is insufficient explanation
- Interaction between nursing intensity and nutritional status

Valeggia & Ellison

Next time ...

- Mother-Infant Bonding
- Fatherhood and changes in paternal hormones
- Co-sleeping and SIDS
- Parenting styles cross-culturally

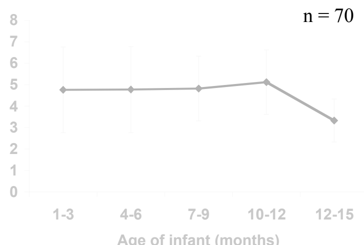
Field Studies of Breastfeeding



Proximate determinants of lactational amenorrhea

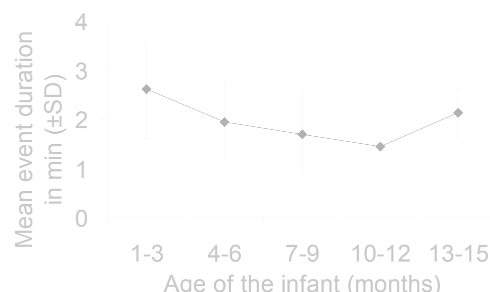
Toba women nurse their infants very frequently

n = 70



Valeggia & Ellison (2003)

Nursing events duration



Valeggia & Ellison (2003)

Maternal diet

- One main meal + snacks
- Monotonous, calorie-dense diet
- Rich in complex carbohydrates and fats (e.g., fried dough, white bread, noodles, rice, polenta)

Determinants of duration of lactational amenorrhea

- No association with nursing behavior (frequency, duration of individual bouts, total duration of nursing, all regression p > 0.11)
- No association with **static** measures of maternal energetics (e.g., pre-pregnancy BMI, average postpartum BMI, BMI at time of 1st menses, % fat; all p's > 0.09)

Significant correlation with **<u>dynamic, time-dependent</u>** measures of maternal energetics (e.g, postpartum energy balance)

Conclusion

The pattern of resumption of postpartum fertility could be explained by differences in individual metabolic budgets.