A Neurobehavioral Approach to Breastfeeding

Dr Nils Bergman

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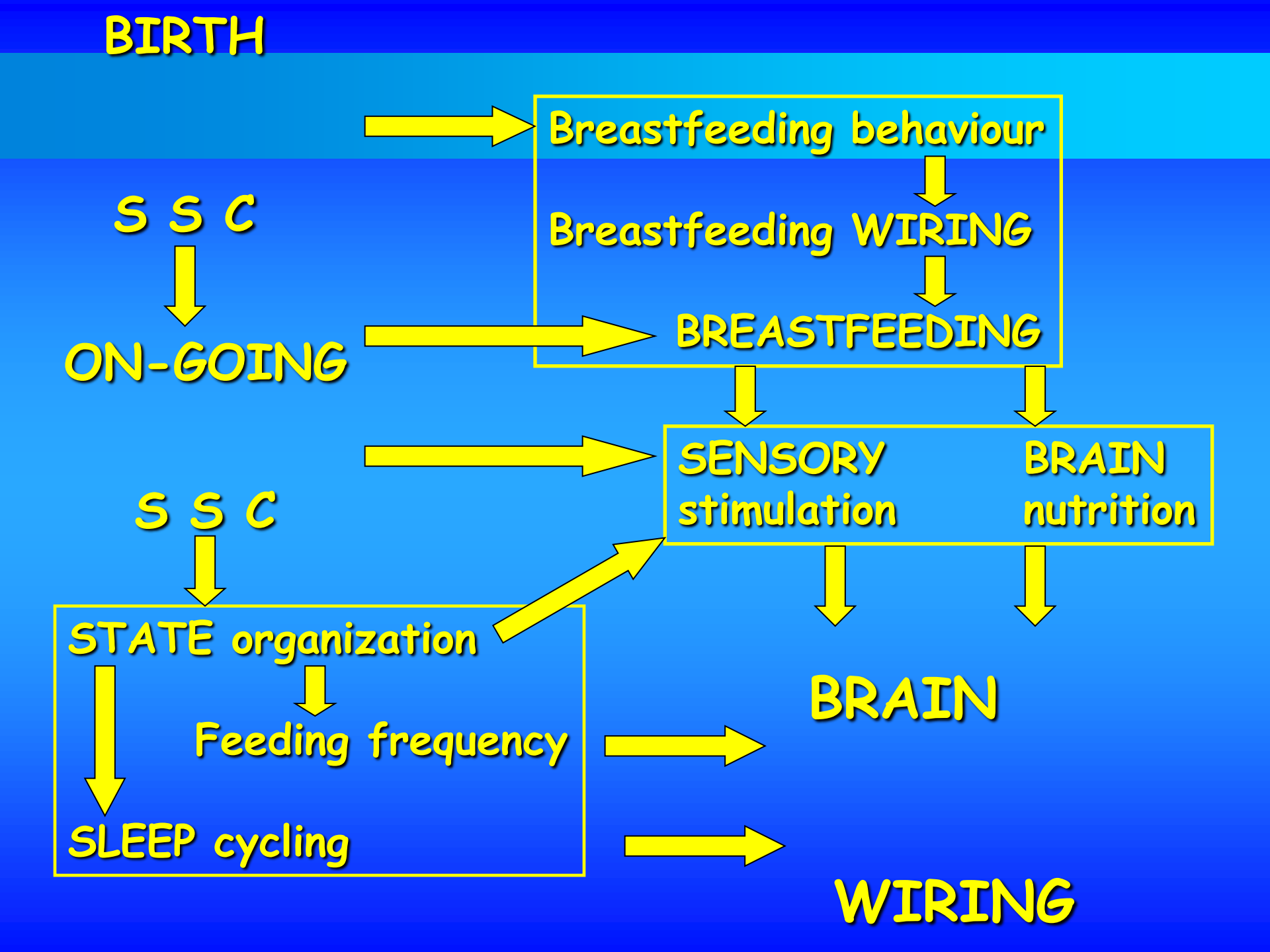
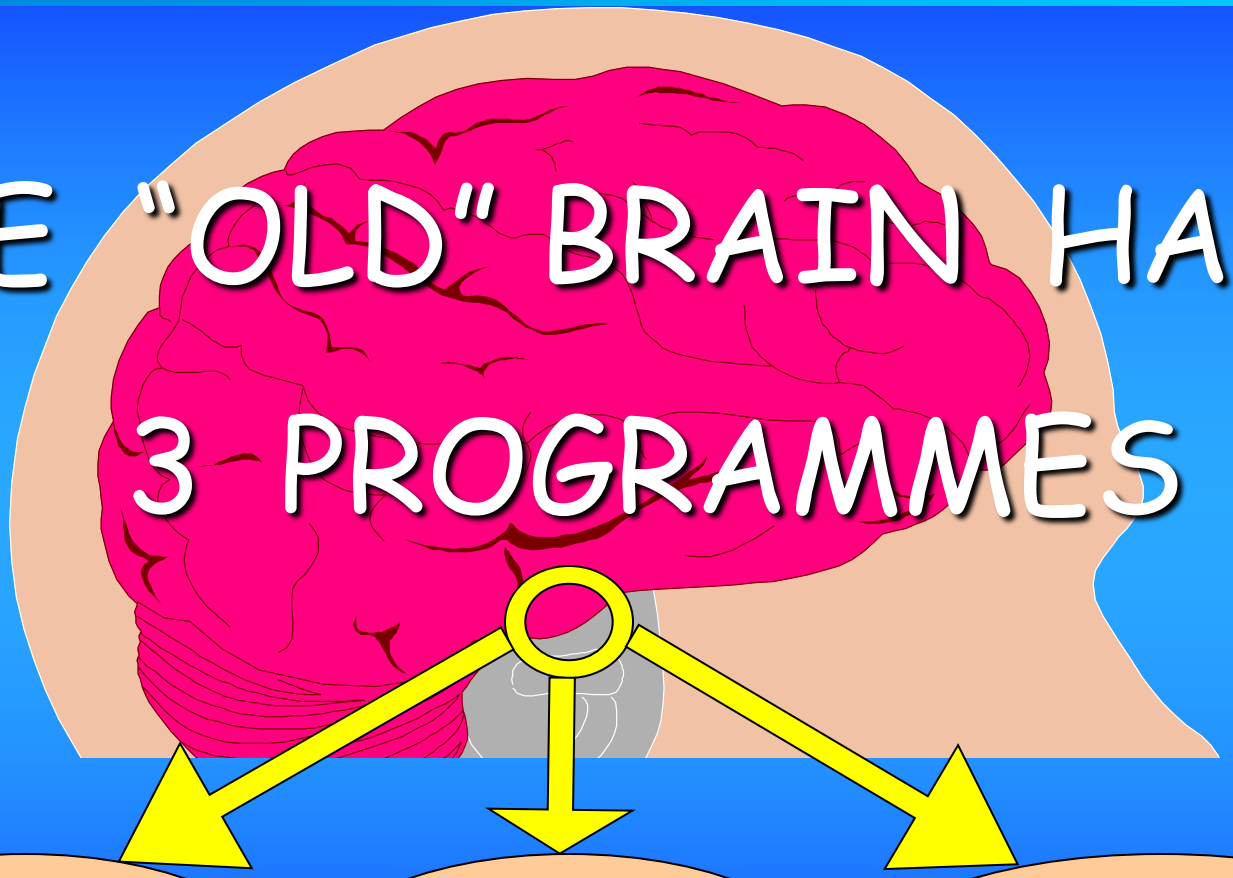
www.kangaroomothercare.com


BIRTH
Breastfeeding behaviour
Breastfeeding WIRING
BREASTFEEDING
S S C
ON-GOING
SENSORY stimulation
BRAIN nutrition
S S C
STATE organization
Feeding frequency
SLEEP cycling
BRAIN
WIRING

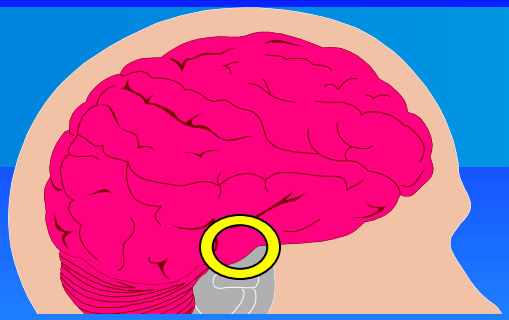
THE "OLD" BRAIN HAS 3 PROGRAMMES



DEFENCE

NUTRITION

REPRODUCTION



DEFENCE **NUTRITION** **REPRODUCTION**

HORMONES NERVES MUSCLES

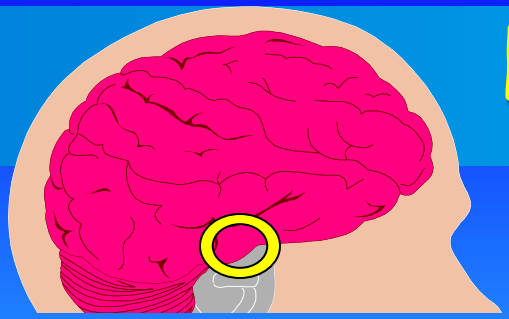
The neurobehavioural programmes originate in the **LIMBIC SYSTEM**

Expressed through

hypothalamus **NEURO**
(autonomic nervous system)

hypophysis **ENDOCRINE**
(endocrine system, hormones)

cerebellum etc **BEHAVIOR**
(somatic system)



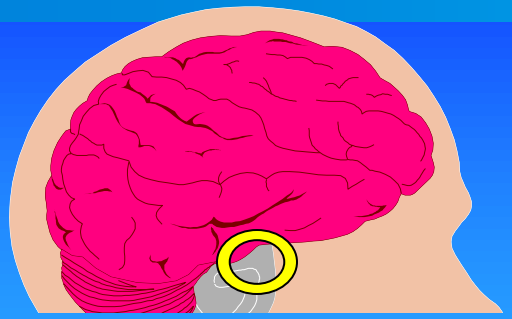
HIGHLY CONSERVED NEURO-ENDOCRINE BEHAVIOR

DEFENCE **NUTRITION** **REPRODUCTION**

HORMONES NERVES MUSCLES

endocrine autonomic NS somatic

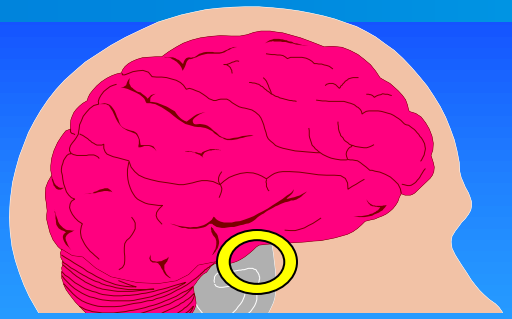
HIGHLY CONSERVED NEURO-ENDOCRINE BEHAVIOR



DEFENCE **NUTRITION** **REPRODUCTION**

HORMONES NERVES MUSCLES

HIGHLY CONSERVED NEURO-ENDOCRINE BEHAVIOR



DEFENCE

~~NUTRITION~~

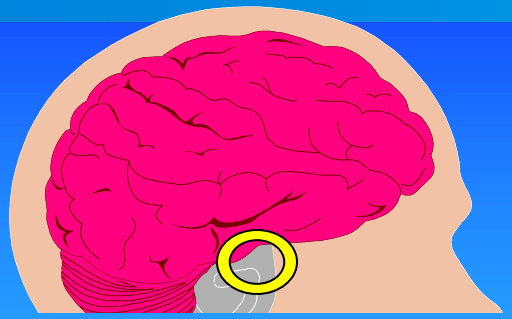
~~REPRODUCTION~~

HORMONES

NERVES

MUSCLES

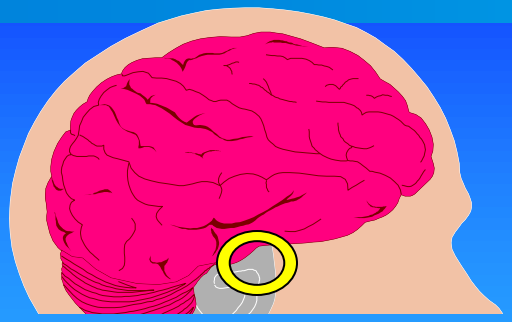
HIGHLY CONSERVED NEURO-ENDOCRINE BEHAVIOR



DEFENCE **NUTRITION** **REPRODUCTION**

HORMONES NERVES MUSCLES

HIGHLY CONSERVED NEURO-ENDOCRINE BEHAVIOR



HORMONES

NERVES

MUSCLES

WHOLE BODY

Clinics in Perinatology,
June 2004, Vol 31(2) page 210
Stanley Graven
Early neurosensory visual development of fetus and newborn.

"It is a serious mistake to assume that the principles derived from careful animal studies do not apply to human infants.
The risk of suppression or disruption of

needed neural processes ...

is very significant and potentially lasts a life time.

All mammals have set sequence of behaviours at birth ……

……. All with a single purpose : to

BREASTFEED

After birth, events are determined …

… by the neonate stimulating the mother!

(Rosenblatt 1994)

Breast-feeding is “established through a set of mutual, complex sensory stimulations in mother and child.”

(Kjellmer & Winberg 1994)

HABITAT DETERMINES BEHAVIOUR

BEHAVIOUR ENSURES

BIOLOGICAL NEEDS

Warming, feeding and protection **behaviours** are intricately, inseparably linked to the right place.

(Alberts 1994)

= **NUTRITION PROGRAMME**

In all mammals …….

….. the newborn is responsible for initiating breastfeeding,

not the mother !!

In all mammals .....

..... the newborn is responsible for initiating breastfeeding,

not the mother !!

EXCEPT IN HUMAN ???

Sequence human newborn breast-feeding

Pre-requisite = habitat

- hand to mouth
- tongue moves
- mouth moves
- eye focuses nipple
- crawls to nipple
- latches to nipple
- suckles

(Widstrom et al 1994)

ACTA PÆDIATRICA
NURTURING THE CHILD

Acta Pædiatrica ISSN 0803–5253

REGULAR ARTICLE

Newborn behaviour to locate the breast when skin-to-skin: a possible method for enabling early self-regulation

A-M Widström (ann-marie.widstrom@ki.se)[1], G Lilja[2], P Aaltomaa-Michalias[3], A Dahllöf[3], M Lintula[4], E Nissen[1,5]

Conclusion: Inborn breastfeeding reflexes were depressed at birth, possibly because of a depressed sensory system. It is hypothesized that when the infant is given the option to peacefully go through the nine behavioural phases birth cry, relaxation, awakening, activity, crawling, resting, familiarization, suckling and sleeping when skin-to-skin with its mother this results in early optimal self-regu

Table 2 Definitions of behaviours not restricted to a specific phase

Behaviours	Definition
Eyes	Closed or opened
	Looks mainly at mother's breast
	Looks mainly in the direction of the mother's face
Soliciting sounds	An affirmative, short, ringing so sound
Hand-to-mouth	Hand in/or touching the mouth
Hand-breast-mouth	Infant moves hand across mother's breast and brushes the nipple/areola and brings hand to mouth
Rooting	Twisting movement where face is brought across or lifted above mother's chest and turned to side or hand
Rocking/pushing	Rocking activity without shifting position

Table 1 Definition of phases/behaviours identified

Phases	Behaviours
Birth cry	Intense crying just after birth
Relaxation phase	Infant resting/recovering. No activity of mouth, head, arms, legs or body
Awakening phase	Infant begins to show signs of activity. Small thrusts of head: up, down, from side-to-side. Small movements of limbs and shoulders
Active phase	Infant moves limbs and head, is more determined in movements. Rooting activity, 'pushing' with limbs without shifting body
Crawling phase	'Pushing' which results in shifting body
Resting phase	Infant rests, with some activity, such as mouth activity, sucks on hand
Familiarization	Infant has reached areola/nipple with mouth positioned to brush and lick areola/nipple
Suckling phase	Infant has taken nipple in mouth and commences suckling
Sleeping phase	The baby has closed its eyes

“The newborn may appear helpless, but displays an impressive and purposeful motor activity which, without maternal assistance, brings the baby to the nipple.

(Michelson et al 1996)

“The newborn may appear helpless, but

raises its own temperature,
has a higher blood glucose,
metabolic adaptation faster.

(Widstrom 1987)

METABOLIC ADAPTATION

SSC started in the first 20 minutes after birth

	SSC	Cot
Blood glucose (1 hr)	3.17	2.56
Base excess drop	3.4	1.8

(Christenson 1992)

Warming,
feeding and
protection
behaviours are
intricately, inseparably
linked to the right place.

(Alberts 1994)

Animal literature does not talk
about mammalian lactation,
it talks about mammalian birth.

Ruin the birth – and
there is no lactation
With a good birth,
lactation follows

Diane Weissinger

PSN envisions a community that embraces its mothers and babies, and

values the unique opportunity at birth

to impact the physical and emotional well-being of the newborn.

Target #1 for 2005:

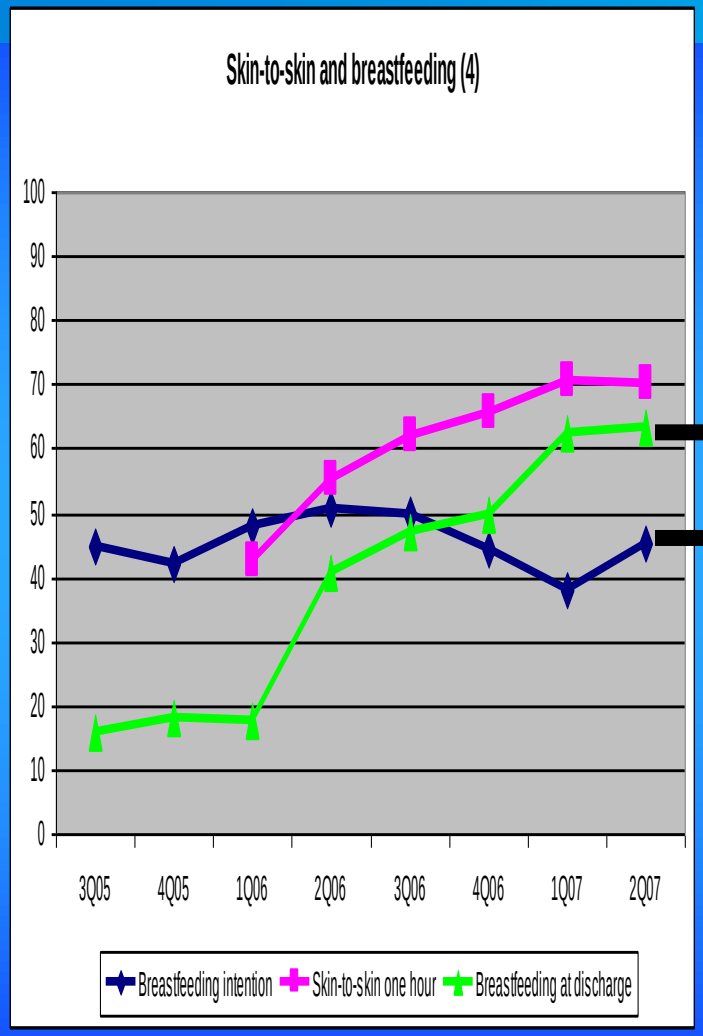
Report that 65% of infants are placed and remain in

direct skin to skin contact

with their mothers

for at least one hour

during the first 3 hours after birth.



Babies breastfeeding

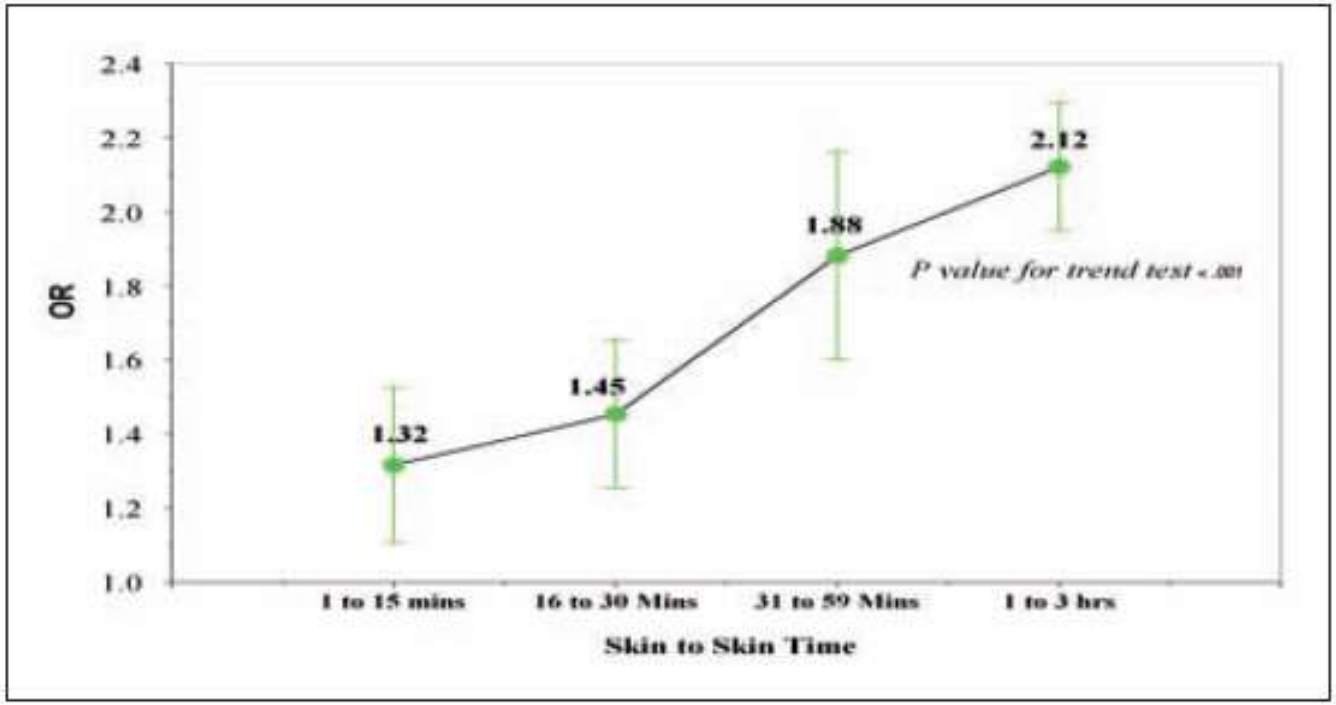
Mothers intending to breastfeed

Used with permission: Ruth Stanhiser, MD

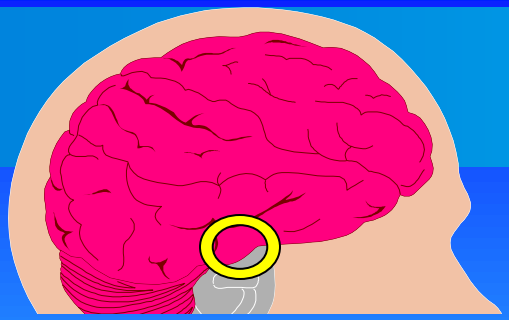
Journal of Human Lactation
http://jhl.sagepub.com

Effect of Early Skin-to-Skin Mother Infant Contact During the First 3 Hours Following Birth on Exclusive Breastfeeding During the Maternity Hospital Stay

Leslie Bramson, Jerry W. Lee, Elizabeth Moore, Susanne Montgomery, Christine Neish, Khaled Bahjri and Carolyn Lopez



More skin-to-skin → more breastfeeding



… highly conserved neuro-endocrine behaviors

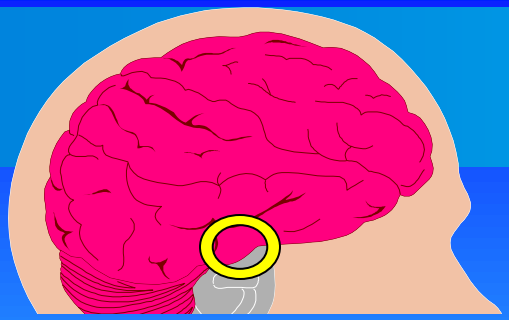
DEFENCE **NUTRITION** **REPRODUCTION**

HORMONES NERVES MUSCLES

endocrine autonomic NS somatic

BREASTFEEDING IS A BEHAVIOUR OF THE NEWBORN

Not the mother !!



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Ruin the birth – and
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With a good birth,
lactation follows

Diane Weissinger

BREASTFEEDING THE PREMATURE

Premature babies will need help.

BERLITH PERSSON
has provided that help …

PERSSON'S WHEEL !

KERSTIN HEDBERG-NYQVIST:

(Early Human Dev 55 (1999) 247 -264.)

PIBBS

Preterm Infant Breastfeeding Behaviour Scale

rooting	0 - 2
areolar grasp	0 - 3
latch (and fixation) time	0 - 3
sucking	0 - 4
longest sucking burst	1 - 6
swallowing	0 - 2

KERSTIN HEDBERG-NYQVIST:

PIBBS

Preterm Infant Breastfeeding Behaviour Scale

Nutritive sucking = >5ml swallowed

Full breastfeeding = exclusive Brf

KERSTIN HEDBERG-NYQVIST:

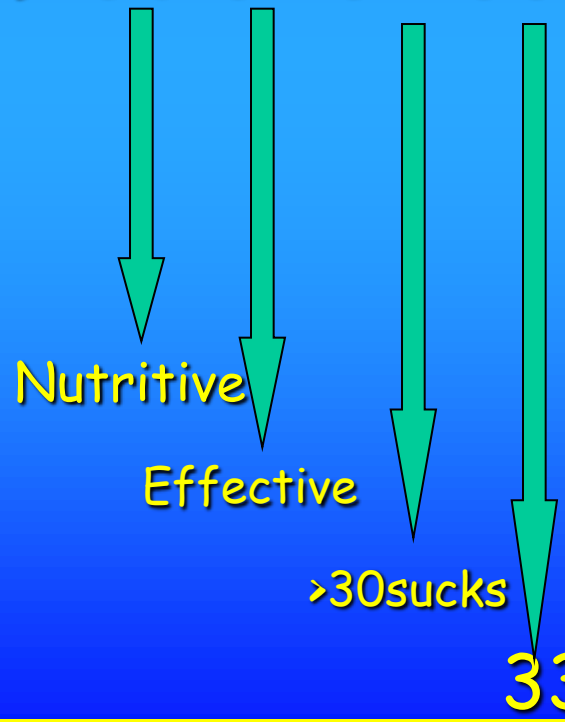
(Early Human Dev 55 (1999) 247 -264.)

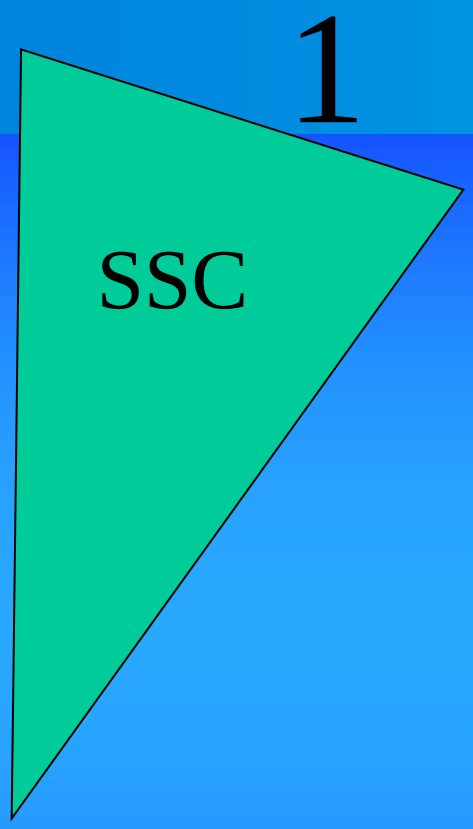
PIBBS

Preterm Infant Breastfeeding Behaviour Scale

EARLIEST OBSERVATION:

(weeks PMA)	28	29	30	31	32	33	34	35	36
rooting	90%								
grasp	50%								
latch	95%								
sucking	90%								
swallow									
burst									
Full breastfeeding									





Step 1 SKIN-TO-SKIN

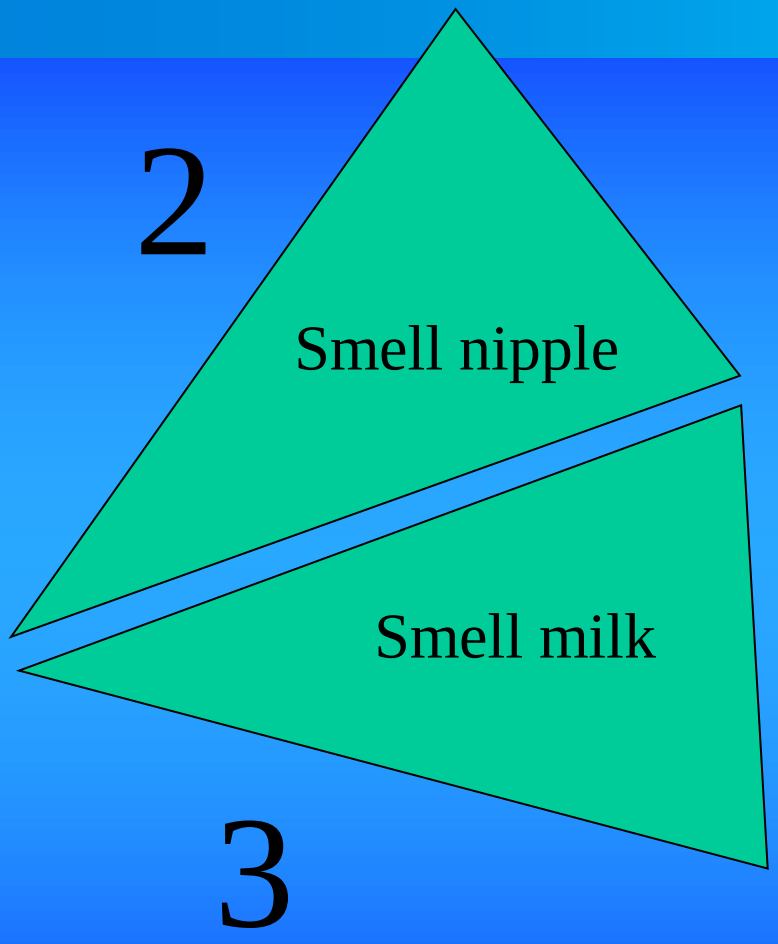
Continuous skin contact

The newborn must be in the right environment for the behaviours that it is capable of to be expressed. It requires protection from stress and provision of warmth.

KMC provides the “maternal nest”

Ideally this should be done on prematures AT BIRTH. However it can be done later, even with nasogastric tube providing expressed breast milk in the meantime

Step 2 and 3 Olfactory



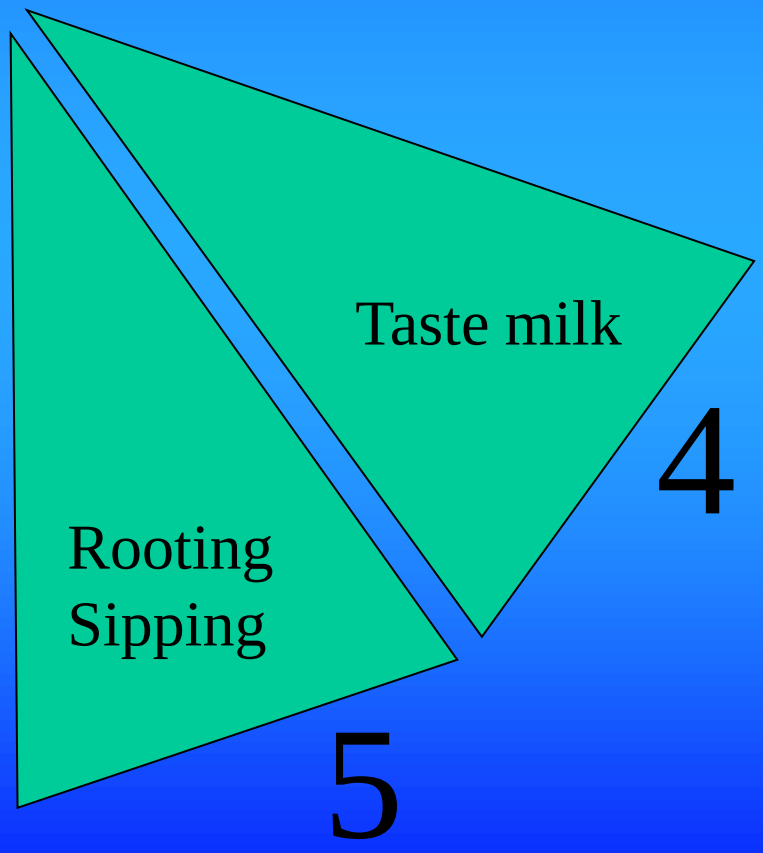
The first steps in sequence require smell of the nipple which may take longer in the premature,

and then the smelling of milk.

Babies can identify smells and tastes from their time in the uterus in the mother's milk!

Step 4 Taste

This is re-inforcing the smell.
Fullterm seems to skip this!

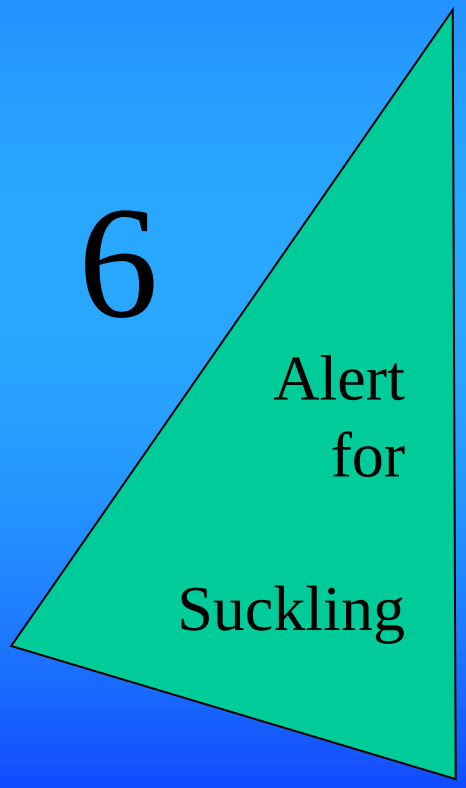


Step 5 Rooting

These are mouth movements the normal sequence described in the full-terms.

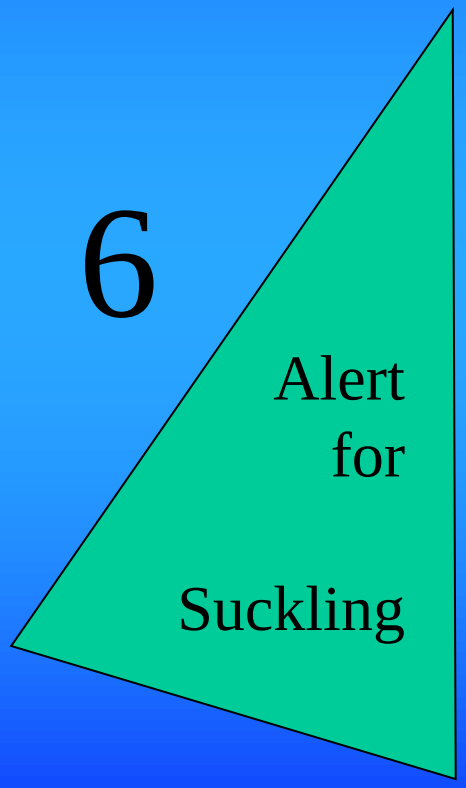
Here the premature requires help, with position and “sipping”
= feeling milk in mouth

Step 6 First suckling.



Key step, builds on steps 1 to 5.
Must be awake and alert.
Alert period is maximal at birth, and lasts 45 - 90 minutes.
If missed then, will require feeding, and several hours delay.

Step 6 First suckling.



Note difference suckling vs sucking!

“ … myographically distinct”

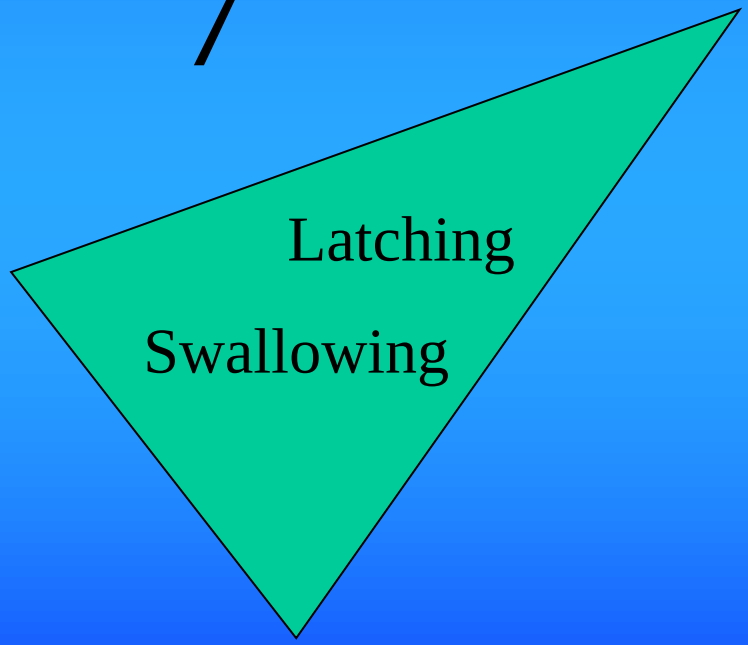
For late premature lactation, allow suckling to develop in successive alert periods, while feeding by tube.

Breastfeeding & Suckling

From 16 or 20 weeks gestation,
the fetus is swallowing.
From 26 or 28 weeks gestation
the fetus can SUCKLE
From 36 weeks gestation the
fetus is able to SUCK

SUCKING and SUCKLING
sound same, but VERY different

Step 7 Latching & swallowing



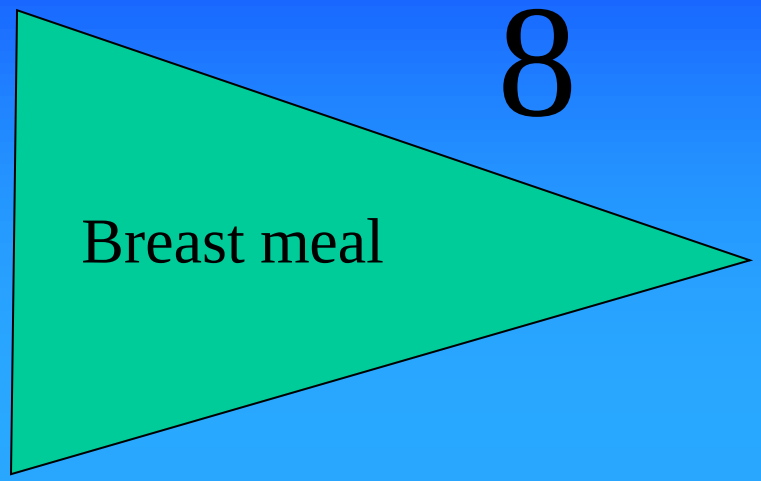
Premature is too physically weak to crawl to nipple, but if held to nipple will at this stage latch on.

Once latched, suckling follows.

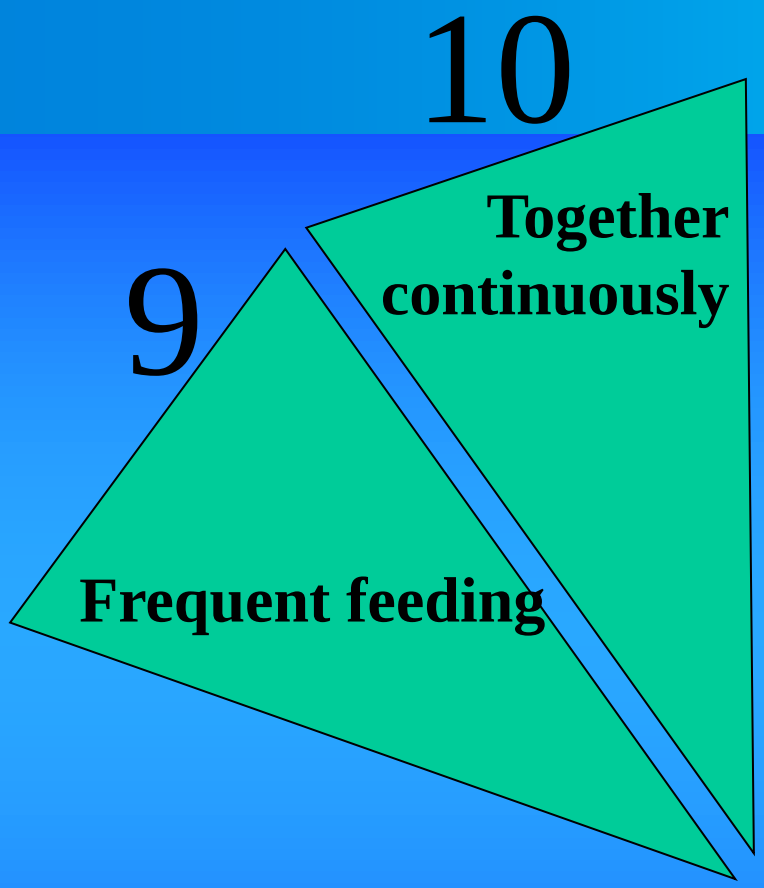
Suckling squirts a controlled dose of milk to the back of throat, which is safely swallowed without any interference of breathing

This is INNATE.

Step 8 First breast milk meal.



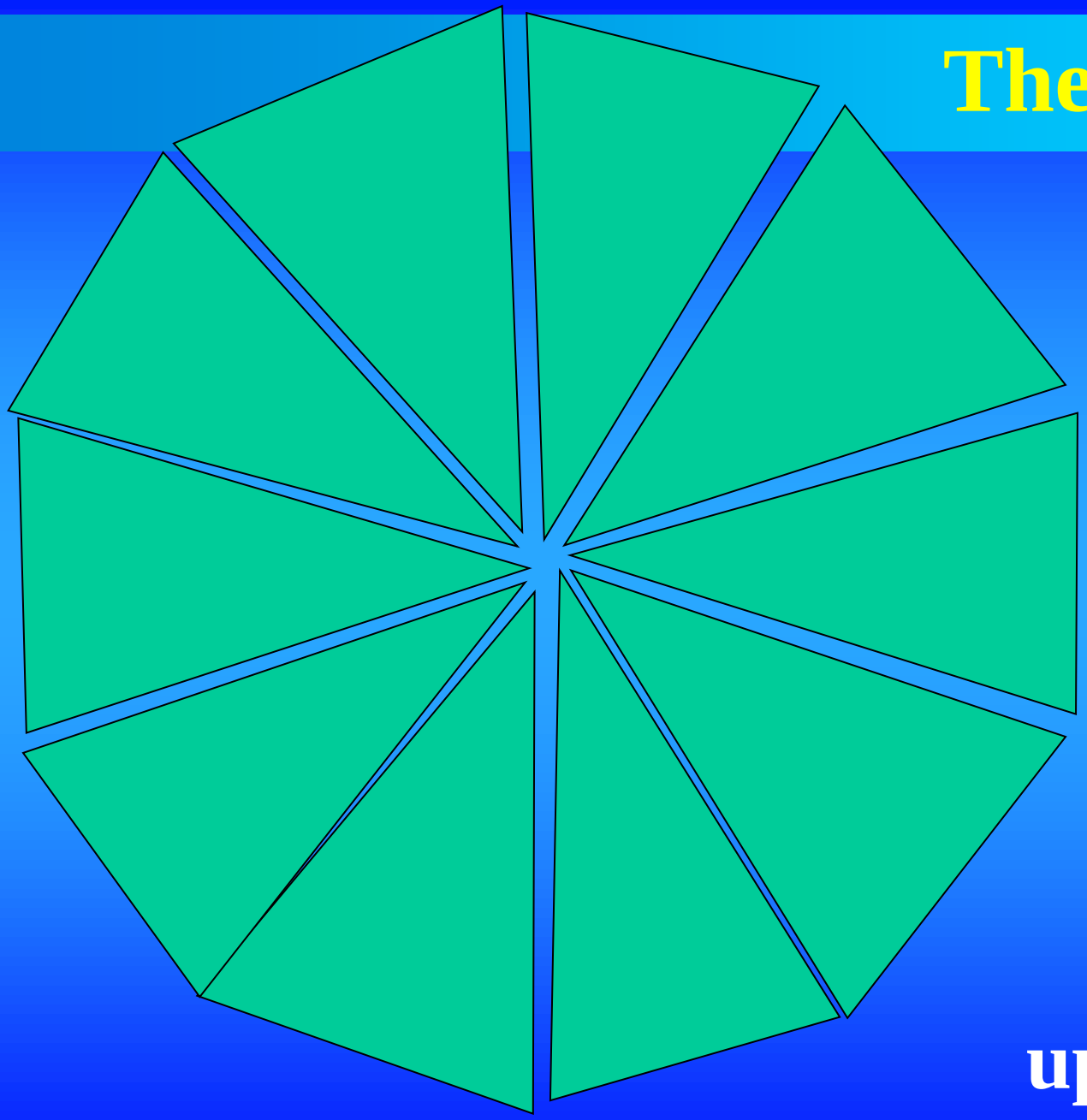
Steps 1 to 7 and on take place rapidly in the fullterm. They can occur in the first alert period after birth in a premature if allowed to,but may require a longer period of defined steps in successive alert periods. For late prem lactation, step 8 is the first time milk is swallowed Enough to feed the baby.



Step 9 Frequent feeding

In utero, baby is feeding Continuously.
Demand feeding is NOT SUITABLE f or prematures.
Feeds should be at most 2 hours apart.

Step 10
Together continuously



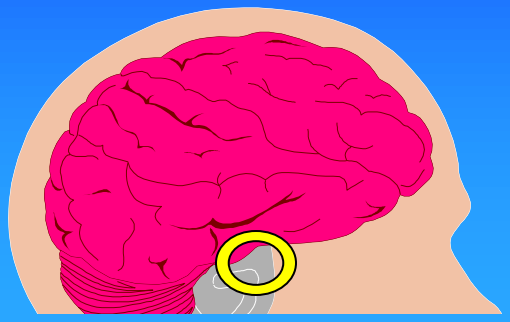
The wheel

is not round

Turns slow at first

but then picks up speed!

BREASTFEEDING A PREMATURE



NUTRITION

STEP 1	SSC
STEP 2	ALLOW TIME
STEP 3	State organisation: alert awake
STEP 4	SMELL
STEP 5	TASTE
STEP 6	LATCH
STEP 7	SUCKLE

BABY STOHM PREM BREASTFEED:

SEE WEBSITE

http://www.kangaroomothercare.com/stohm-breastfeeding.aspx

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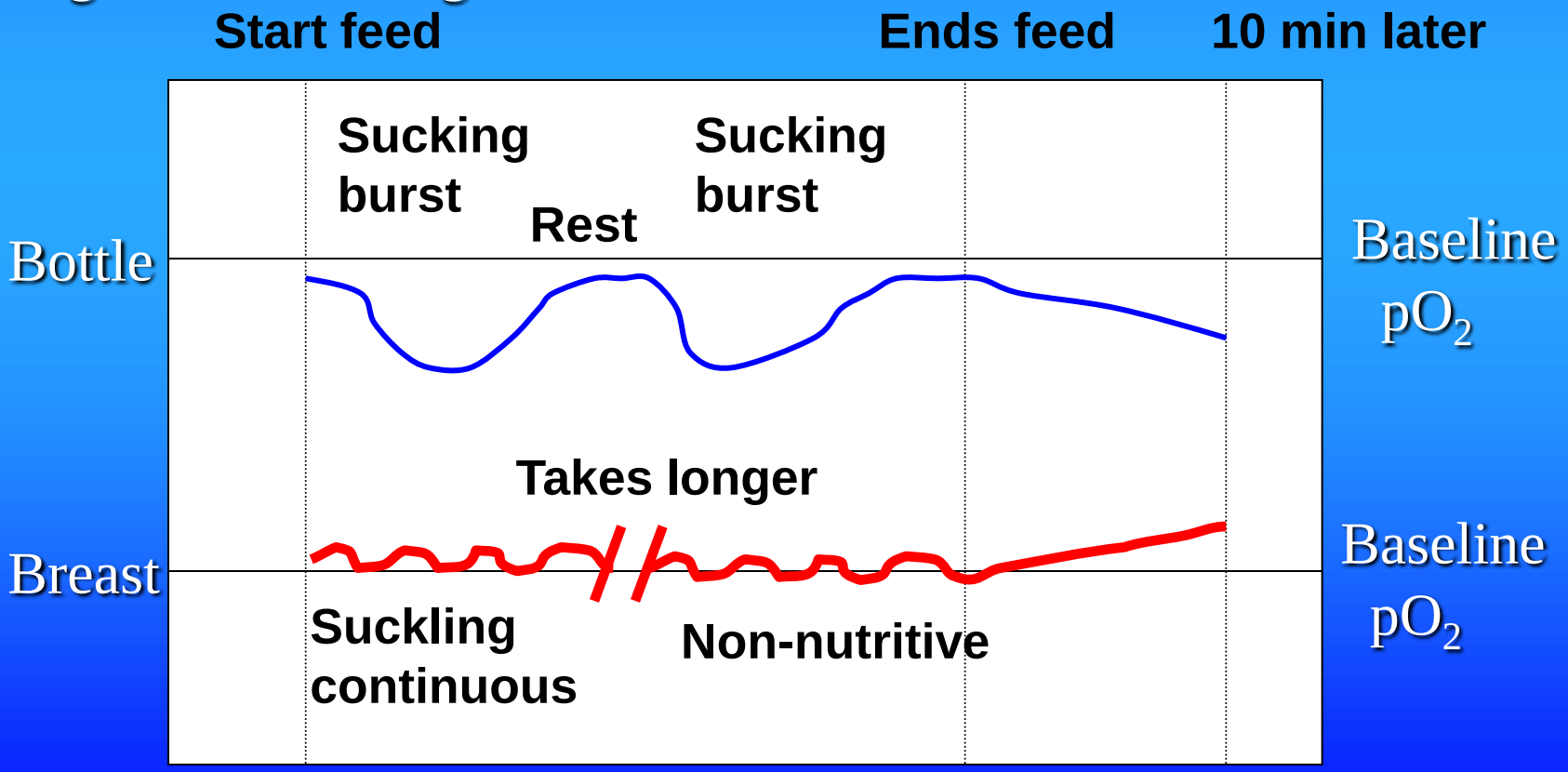
THE NEWBORN

also has a larynx that meets the uvula, designed to separate the respiratory tract from the gastrointestinal tract , enabling the newborn to feed and breathe simultaneously.

Meier 1988

BOTTLE AND BREASTFEEDING IN PREMATURE

Prematures babies weighing 1300g and 34/40 PCA, given alternating bottle and breastfeeds.



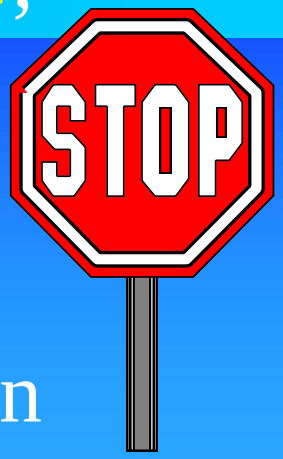
BOTTLEFEEDING IS STRESSFUL and DANGEROUS

(Chen et al 2000)
25 babies in 80 sessions, all <1800g

"There were 2 episodes of apnea and 20 episodes of oxygen desaturation during bottle-feeding and none during breastfeeding.
We conclude that breastfeeding is a more physiological feeding method for the preterm infant and bottle-feeding may be more stressful."

SUCKLING	uses the largest muscle in the baby's head, making the smallest movement
SUCKING	requires lots of tiny and weak muscles, making maximum effort,
	… also causes hypoxia,
	… and is STRESSFUL !

Bottle feeding requires SUCKING,



which requires completely different muscles, and does NOT allow co-ordination between swallowing and breathing. Bottle feeding causes STRESS in prematures, and relative post-prandial hypoxaemia.

SUCKLING - in and of itself,
apart from nutrition intake -
has beneficial effects
on both mother and baby.
SENSORY STIMULATION ....

Suckling

induces simultaneous endocrine
effects in the gut
of both mother and child

there is a physiological
symbiosis between them.

Breast feeding also has psychic effects;
CCK is produced,
which induces sedation and sleep.

STATE ORGANISATION.

The ability to appropriately control the level of sleep and arousal.

STATE ORGANISATION.

Simplified scale -	
HARD CRYING	L to R shunting, IVH risk
CRYING	Stressful, wastes calories,
FUSSING	… build up to stress
ACTIVE AWAKE	This is feeding zone!
QUIET AWAKE	Time to connect - stimulation
ALERT INACTIVE	… transition zone
DROWSY	… transition zone
ACTIVE SLEEP	… activity consumes calories
IRREGULAR SLEEP	
QUIET SLEEP	Good sleep - digestion zone
DEEP SLEEP	Apnoea zone !!

Simplified scale -

HARD CRYING

CRYING

FUSSING

ACTIVE AWAKE

QUIET AWAKE

ALERT INACTIVE

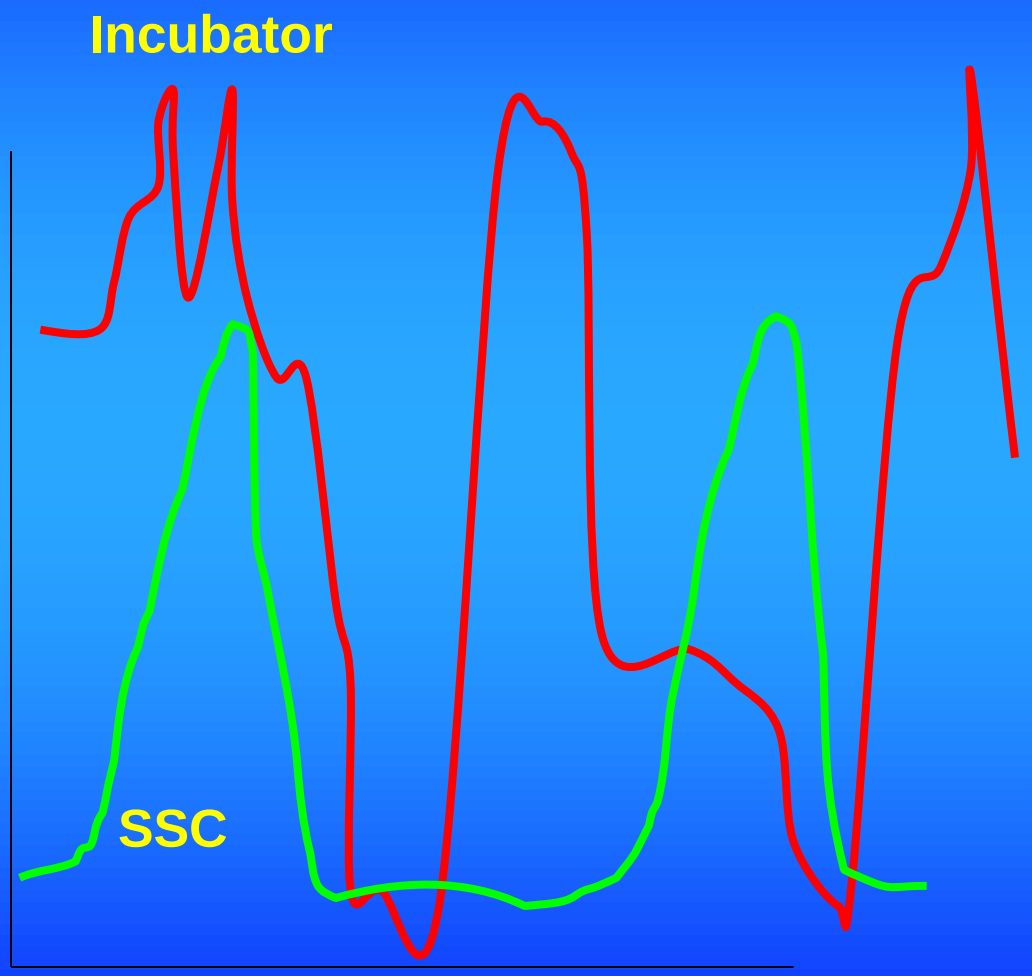
DROWSY

ACTIVE SLEEP

IRREGULAR SLEEP

QUIET SLEEP

DEEP SLEEP



KMC babies oscillate slowly in safe zones

Simplified scale -

HARD CRYING

CRYING

FUSSING

ACTIVE AWAKE

QUIET AWAKE

ALERT INACTIVE

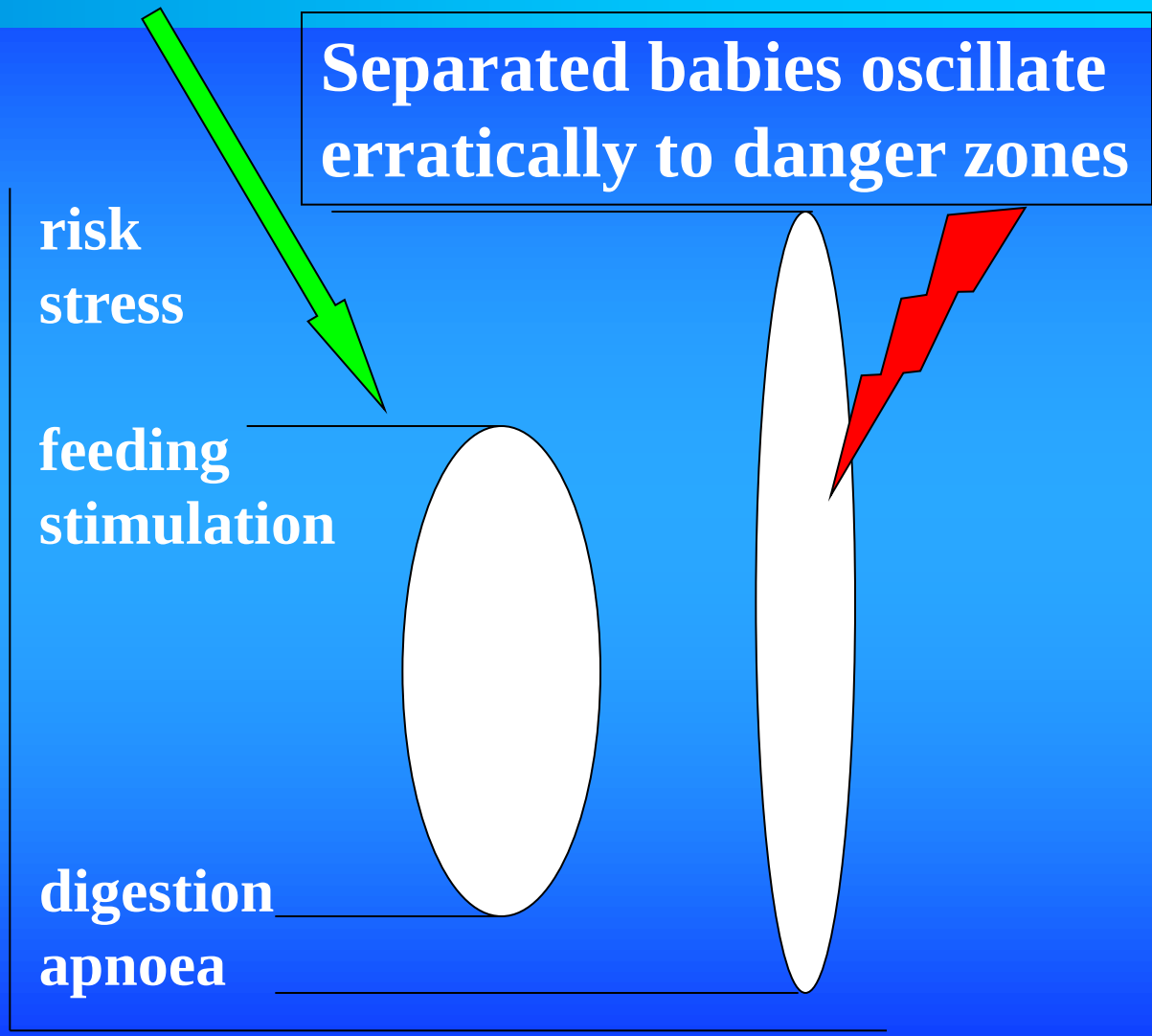
DROWSY

ACTIVE SLEEP

IRREGULAR SLEEP

QUIET SLEEP

DEEP SLEEP



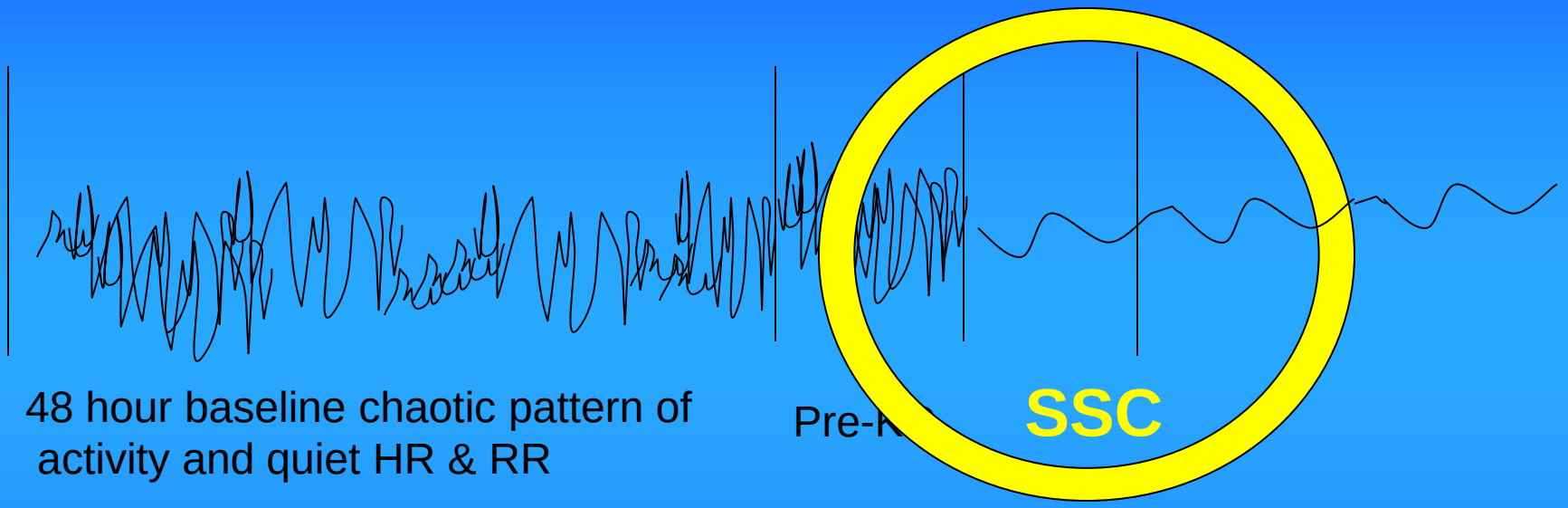
rest-activity cycle
is approx 60 minutes long
(Ludington 2006)

Not so much duration,
or density of any sleep stage,
or number of sleep stage episodes, but,

cycling between quiet sleep and active sleep

is what is important

SLEEP CYCLING – Separation vs contact



48 hour baseline chaotic pattern of activity and quiet HR & RR

Pre-K

In SSC:

- Normal cycling
- Non-chaotic pattern

“The newborn may appear helpless, but displays an impressive and purposeful motor activity which, without maternal assistance, brings the baby to the nipple.

(Michelson et al 1996)

Gut hormones.

(Uvnas-Moberg 1989)

20 different hormones
work in the gut –
regulated by the vagal nerve.

Each has a specific function.

Gut hormones.

"Bad guy" - SOMATOSTATIN:
(produced by fetus, rise 10-fold under stress)

inhibits gastrointestinal secretion,
inhibits motility ,
reduces blood flow to gut
and absorption,
causes gastric retention,
vomiting, constipation.

SOMATOSTATIN:

inhibits the good hormones, contributes to **slow weight gain.**

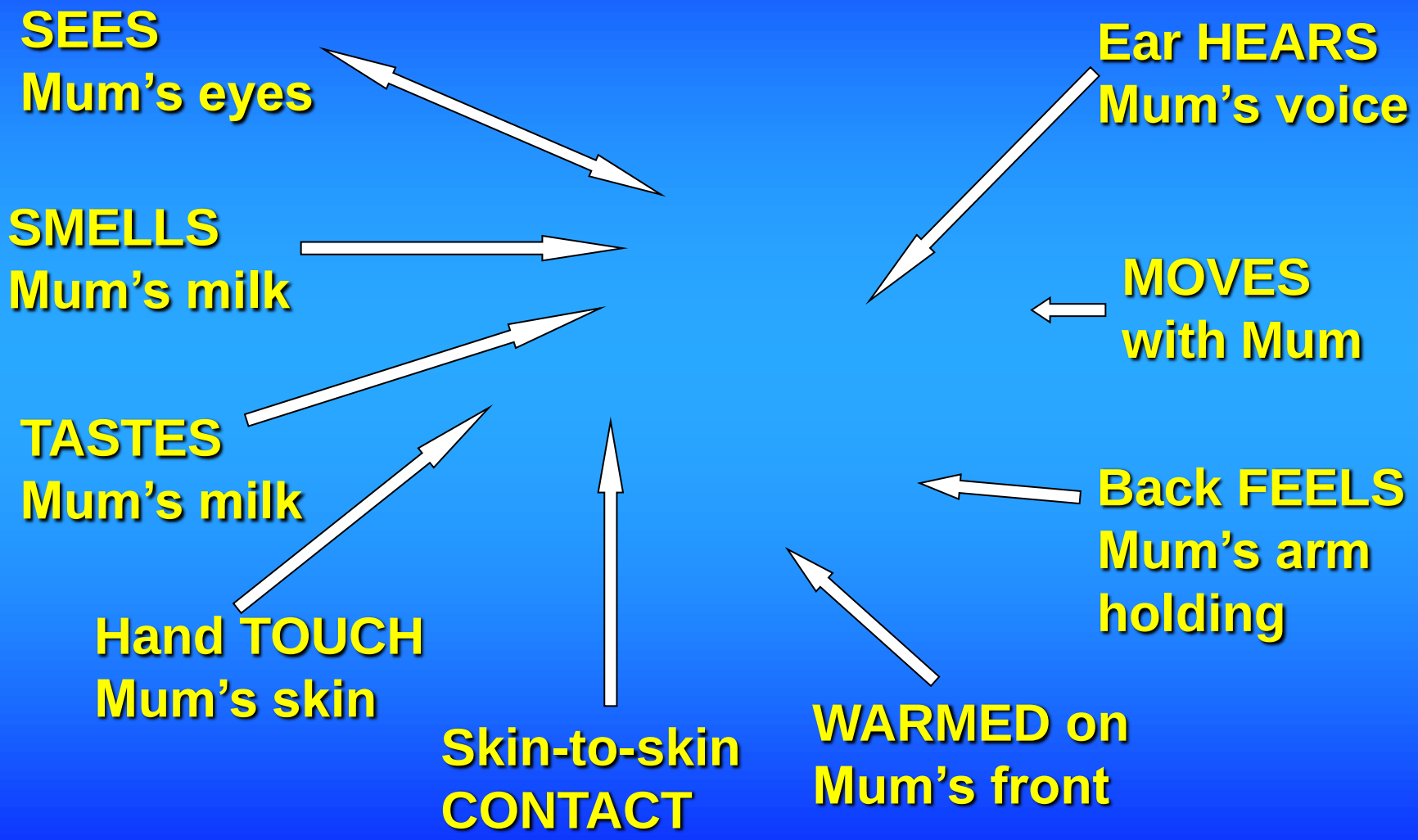
At high levels also inhibits release of growth hormone.

It takes 30 to 60 minutes to lower somatostatin and other stress hormones

SLEEP
VITAL !!!

DISSOCIATED INFANT WILL NOT SHOW FEEDING CUES

SENSATIONS THAT WIRE BRAIN



Slide from JILL BERGMAN

TRIGLYCERIDE

Left : glycerol,
Right: palmitic acid,
oleic acid, alpha-linolenic acid

In phosphoglycerides,
glycerol molecule same:
two fatty acids esterified

Phospholipids are
a major component of all
biological membranes,

Sphingomyelin particularly
concentrated in BRAIN
major part of MYELIN.

TRIGLYCERIDE

MYELIN.

FATTY ACIDS ARE SPECIES SPECIFIC

Dendirification and myelinisation peaks occur
at 2 and 6 months
is maximal at one year ....

At one year: human milk has less protein,
but MORE TRIGLYCERIDE !!!

Fat and Energy Contents of Expressed Human Breast Milk in Prolonged Lactation

Dror Mandel, Ronit Lubetzky, Shaul Dollberg, Shimon Barak and Francis B. Mimouni

Pediatrics 2005;116;e432-e435
DOI: 10.1542/peds.2005-0313

Up to 6 months,
milk is 7.4% fat,

but after 12 months it is 10.7%

CC homozygote for "FADS2", "missing"

	NOT Brf	DID Brf	DID Brf
NZ	98.4	103.2	98.9
UK	97.3	104.0	100.7

Evidence on the long-term effects of breastfeeding

SYSTEMATIC REVIEWS AND META-ANALYSES

Bernardo L. Horta, MD, PhD

Universidade Federal de Pelotas, Pelotas, Brazil

Rajiv Bahl, MD, PhD

Department of Child and Adolescent Health and Development, World Health Organization, Geneva, Switzerland

José C. Martines, MD, PhD

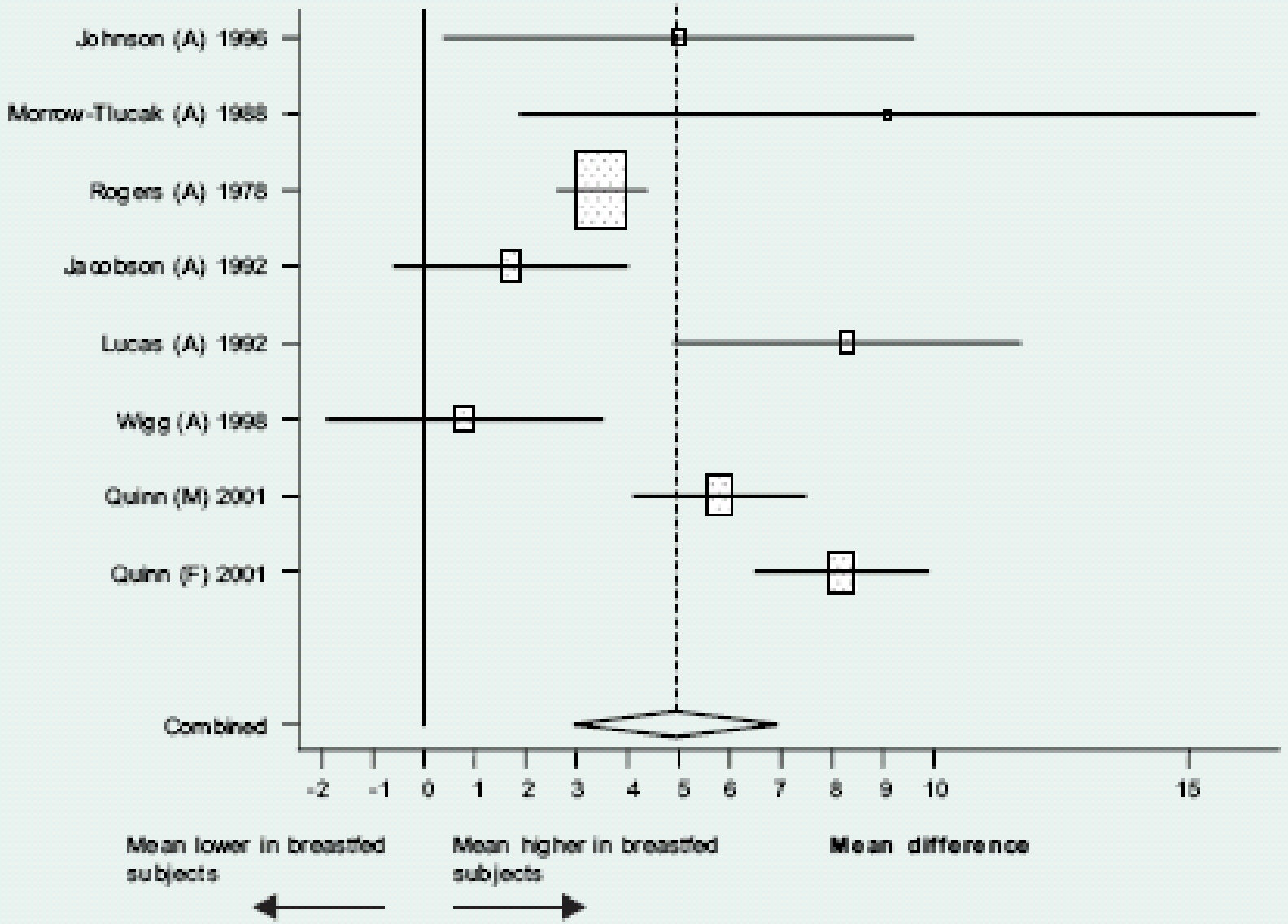
Department of Child and Adolescent Health and Development, World Health Organization, Geneva, Switzerland

Cesar G. Victora, MD, PhD

Universidade Federal de Pelotas, Pelotas, Brazil

World Health Organization

Figure 5.1. Mean difference in cognitive development scores and its 95% confidence interval between breastfed and non-breastfed subjects in different studies. Whether the estimate was for males (M), females (F) and all (A) is indicated in parenthesis



BREASTFEEDING AND BREAST MILK

INCREASE IQ

BOTTLE FEEDING & FORMULA

DECREASE IQ

Be sure the wet nurse has plenty of milk … because if she lacks it she may give the baby milk of a goat or sheep or some other animal, because the child … nourished on animal milk does not have perfect wits like one fed on woman's milk and always looks stupid and vacant and not right in the head.

14th century Tuscan text

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

FROM THE AMERICAN ACADEMY OF PEDIATRICS

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of all Children

POLICY STATEMENT

Breastfeeding and the Use of Human Milk

abstract

FREE

Breastfeeding and human milk a[illegible]he normative standards for [illegible]fant feeding and nutrition. Given the docu[illegible] med-ical and neurodevelopmental advantages of breastfeeding, infant nutrition should be considered a public health issue and not only a lifestyle choice. The American Academy of Pediatrics reaffirms its recommendation of exclusive breastfeeding for about 6 months, followed by continued breastfeeding as complementary foods are introduced, with continuation of breastfeeding for 1 year or longer as mutually desired by mother and infant. Medical contraindications to

PEDIATRICS Volume 129, Number 3, March 2012

BOTTLE FEEDING & FORMULA

DECREASE IQ

Human Milk Banking Association of North America

•*Setting the Standards for Human Milk Banking*
•*Meeting the Milk Banking Needs for North America*

•*A Safe Alternative in the Absence of Infant's Own Mother's*

This website is designed to provide information on milk banking and how to contact a milk bank to donate milk or to order donor human milk. This site is also a resource for health care providers and others who are looking for information on HMBANA's resources and services.

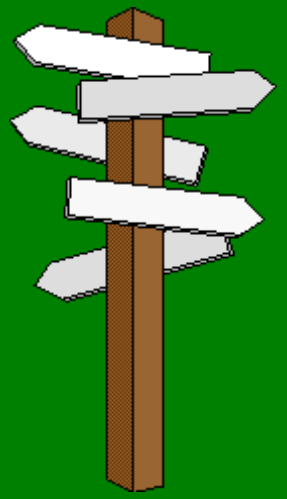
http://www.hmbana.org/

"Where it is not possible for the biological mother to breastfeed, the first alternative, if available, should be the use of human breast milk from other sources. Human milk banks should be made available in appropriate situations."

World Health Organization/United Nations Children's Fund

http://www.breastmilkproject.org/

INFANT FEEDING FREQUENCY: available evidence & neuroscience



OVERVIEW:

New section this background

Neuroscience
Anatomy & physiology
Available evidence
Proposal feeding frequency
Implications

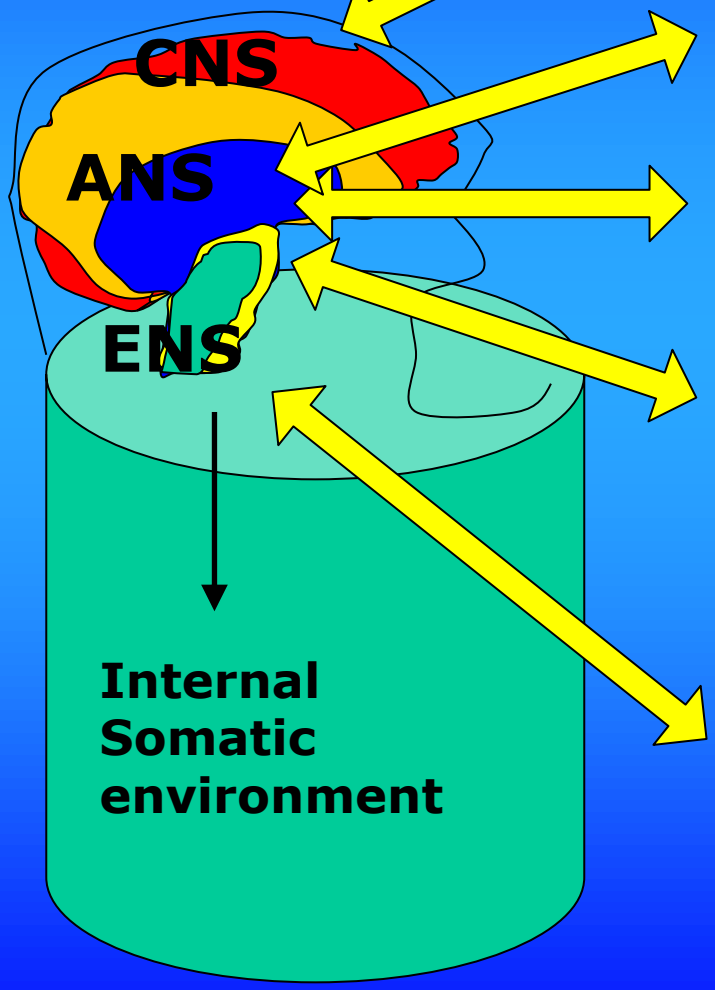
References in this format

konklusion

that a good reliable set ov bowels

iz worth more to a man than enny quantity of brains.“

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/stomach/anatomy.html



CNS: cortical / subcortical
(also to PNS)

ANS: emotional / limbic brain
(incl SNS)

ANS: myelinated vagus (NA)

ANS: unmyelinated vagus (DMC)
sub-diaphragmatic

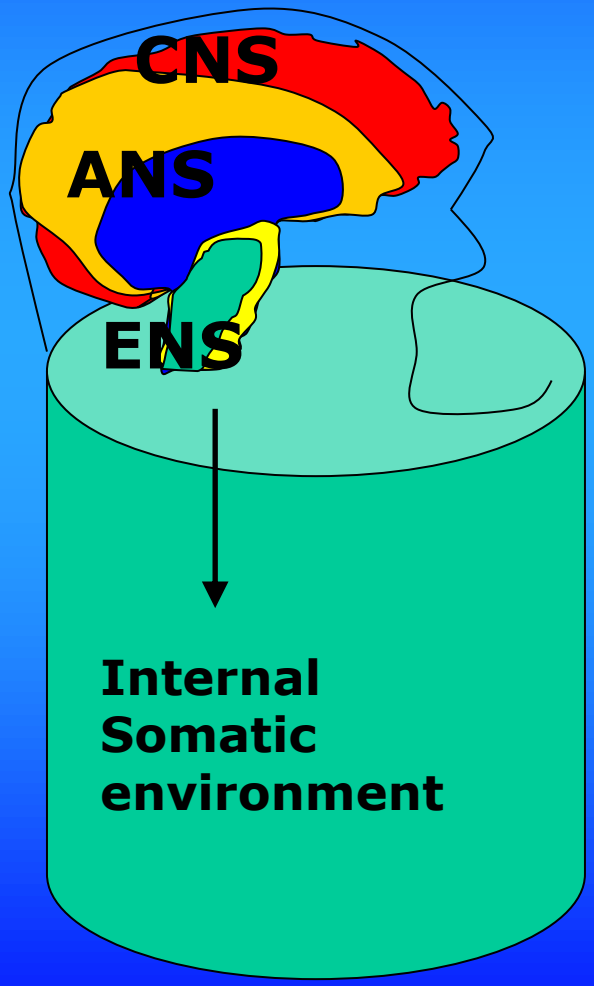
ENS: submucous plexus
myenteric plexus

ENTERIC NERVOUS SYSTEM !!

The digestive system is endowed with its own, local nervous system referred to as the enteric or intrinsic nervous system.

The magnitude and complexity of the enteric nervous system is immense - it contains as many neurons as the spinal cord.

CEPHALIC PHASE
GASTRIC PHASE
INTESTINAL PHASE

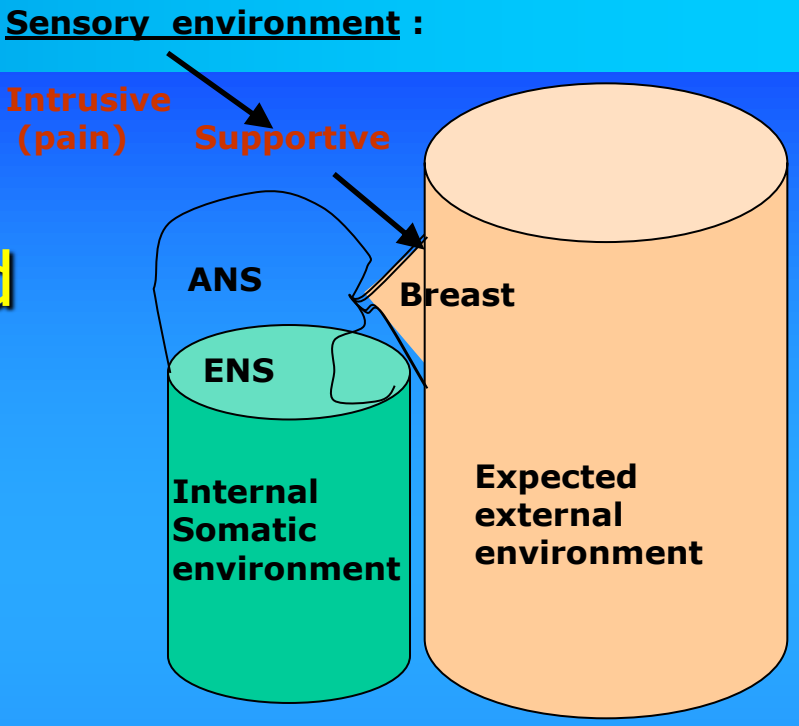


FEEDBACK LOOPS

Benoist SCHAAL

SMELL

"Olfaction in the fetal and premature infant: functional status and clinical implications"



Functional at end of first trimester, begins very early, experience dependent "effective from 29w GA" → significant

Schaal 2004

SMELL

modulates state organisation
elicits emotional behaviours
activates pre-feeding actions
anticipatory digestive physiology
regulates pace of ingestive behaviour

Schaal 2004

Perinatal brains show orientations towards

"neonatal olfactory expectations"

When provided:

calming, autonomic orientation, active approach, metabolic conservation.

When not fulfilled:

withdrawal, autonomic defense & distress behaviours, metabolic expenditure

Schaal 2004

DOUCET

The secretion of Areolar (Montgomery's) Glands from Lactating Women Elicits Selective, Unconditional Responses in Neonates

"… breast chemosignals
activate oral activity on the
nipple that releases a cascade
of behavioral, neural, neuroendocrine
and endocrine processes
in the newborn and the mother."

Doucet 2009

The secretion of Areolar (Montgomery's) Glands

"In early ontogeny the sleeping brain may thus remain sentient of an organism's odor environment."

Doucet 2009

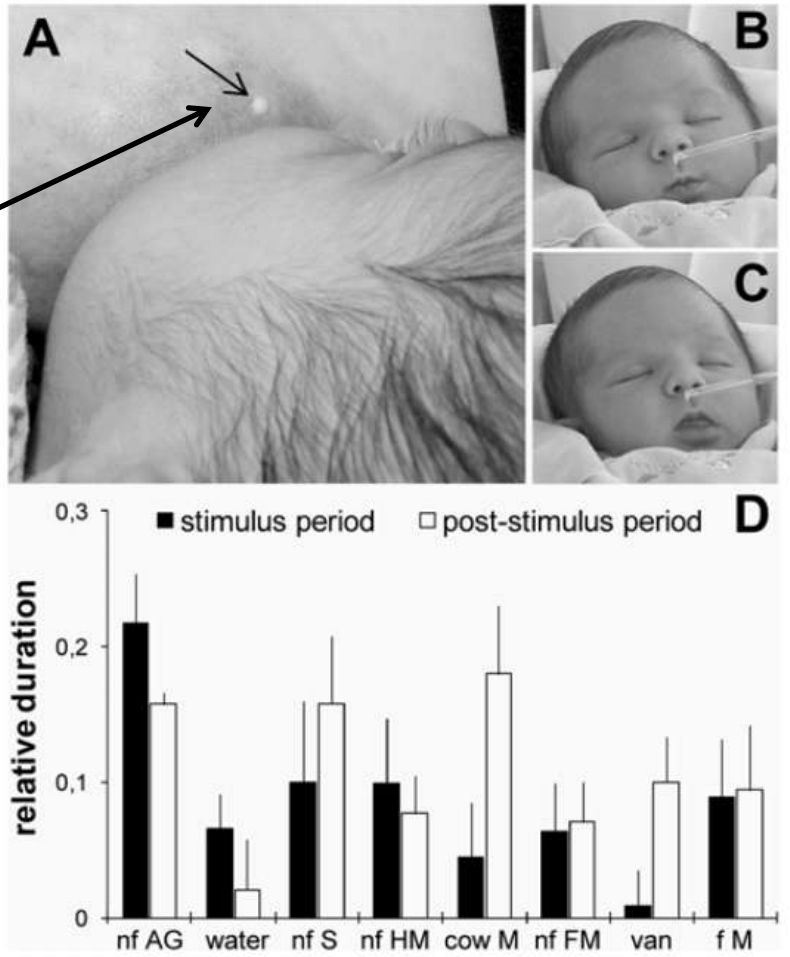
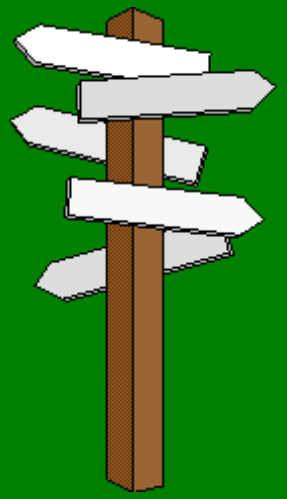


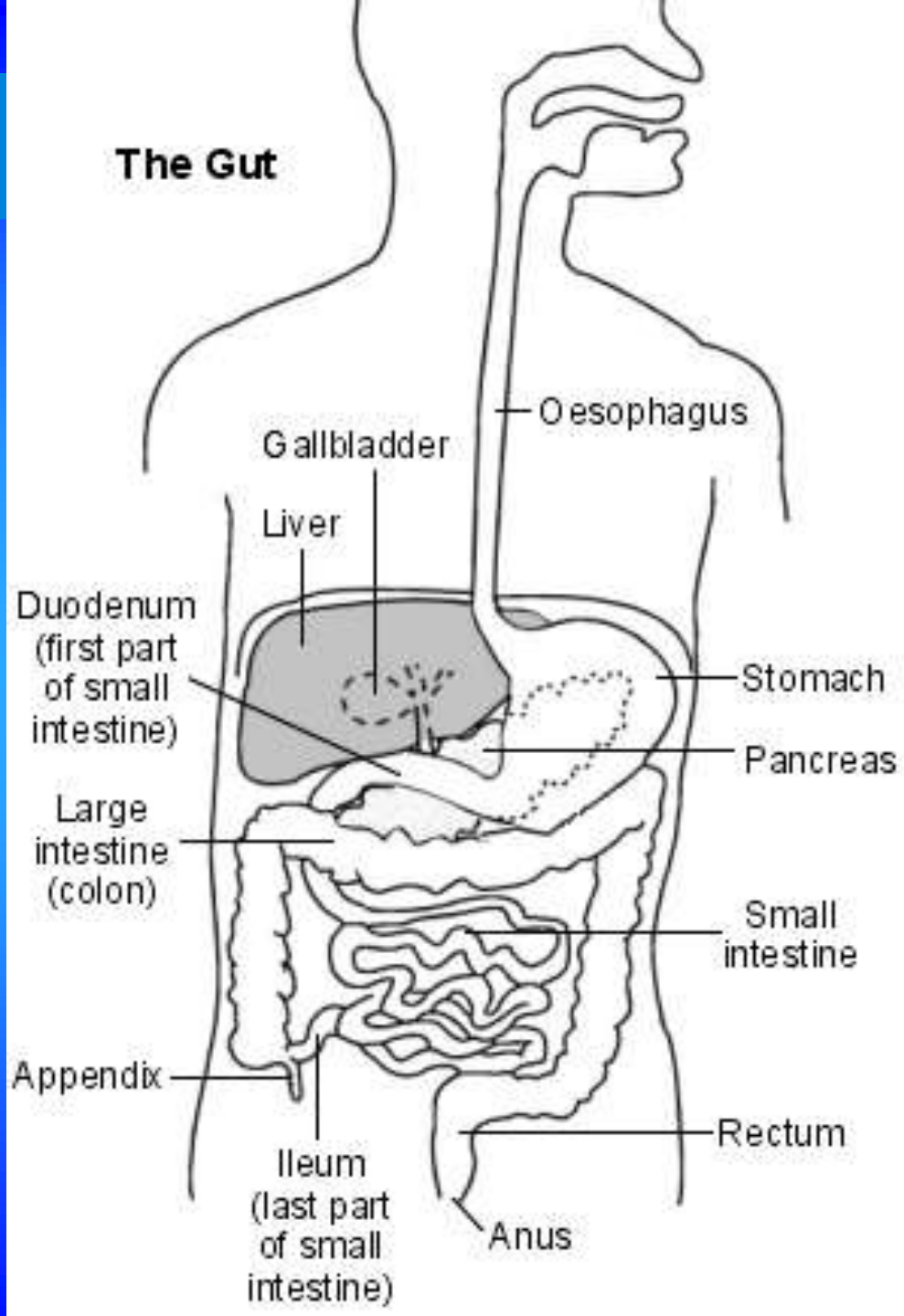
Figure 1. Areolar glands and infant behavior. A) Areola of a lactating woman (day 3 postpartum) with Montgomery's glands giving off their secretion (arrow). B and C) Newborns' oro-cephalic responses to the secretion of Montgomery's areolar gland (B: lip pursing; C: tongue protrusion). D) Mean (± sem) relative durations of newborns' oro-cephalic responses during (10-sec stimulus period) and after (10-sec post-stimulus period) presentation of various olfactory stimuli (Abbreviations: AG: secretions of areolar glands; S: sebum; HM: human milk; cow M: cow milk; FM: formula milk; van: vanillin; M: milk; f: familiar; nf: non-familiar; n = 19).
doi:10.1371/journal.pone.0007579.g001

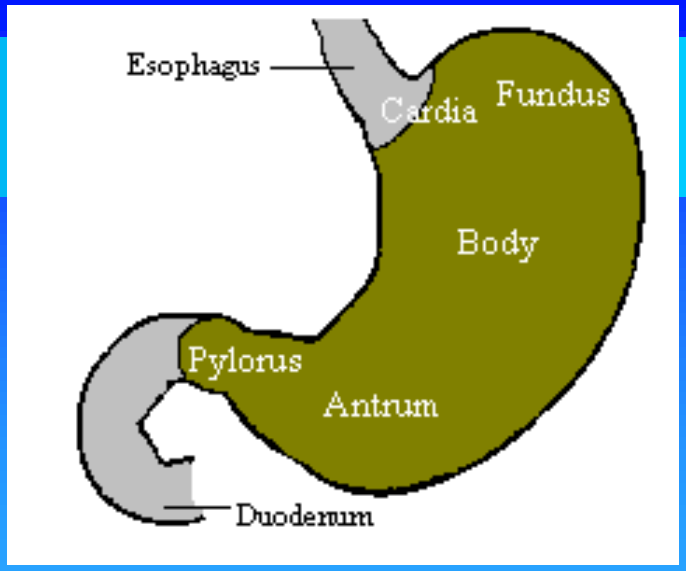
INFANT FEEDING FREQUENCY: available evidence & neuroscience

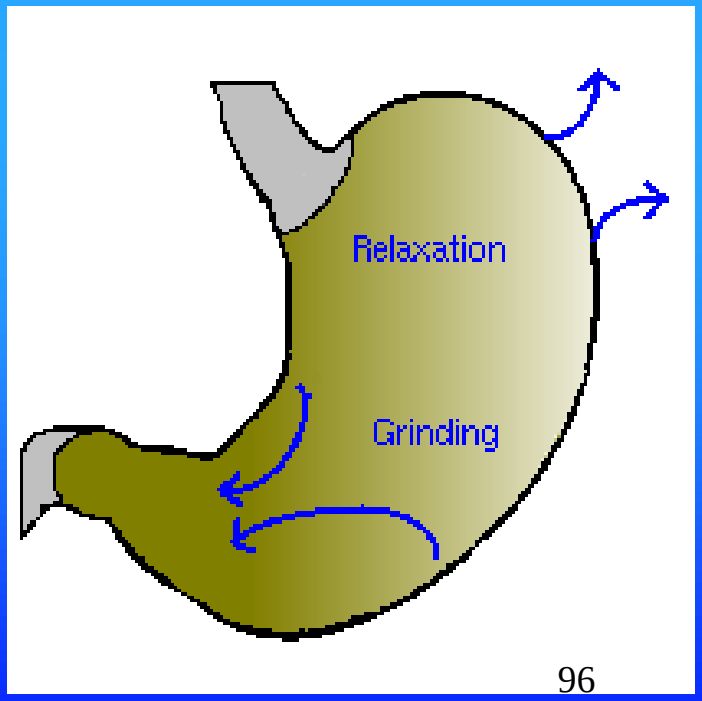


OVERVIEW:

Neuroscience
Anatomy & physiology
Available evidence
Proposal feeding frequency
Implications


The Gut
Oesophagus
Gallbladder
Liver
Duodenum (first part of small intestine)
Stomach
Pancreas
Large intestine (colon)
Small intestine
Appendix
Rectum
Ileum (last part of small intestine)
Anus


Esophagus
Cardia
Fundus
Body
Pylorus
Antrum
Duodenum


Relaxation
Grinding

Fetal stomach appears 4 weeks GA.
By 11 weeks, wall capable of muscular contraction.

"Patterns of antropyloric motility in fed healthy preterm infants"

... the neuroregulatory mechanisms responsible for the coordination of antro-pyloric motility and gastric emptying are <u>well developed</u> by 30 weeks of PMA.

Hassan 2002

Hydrochloric acid

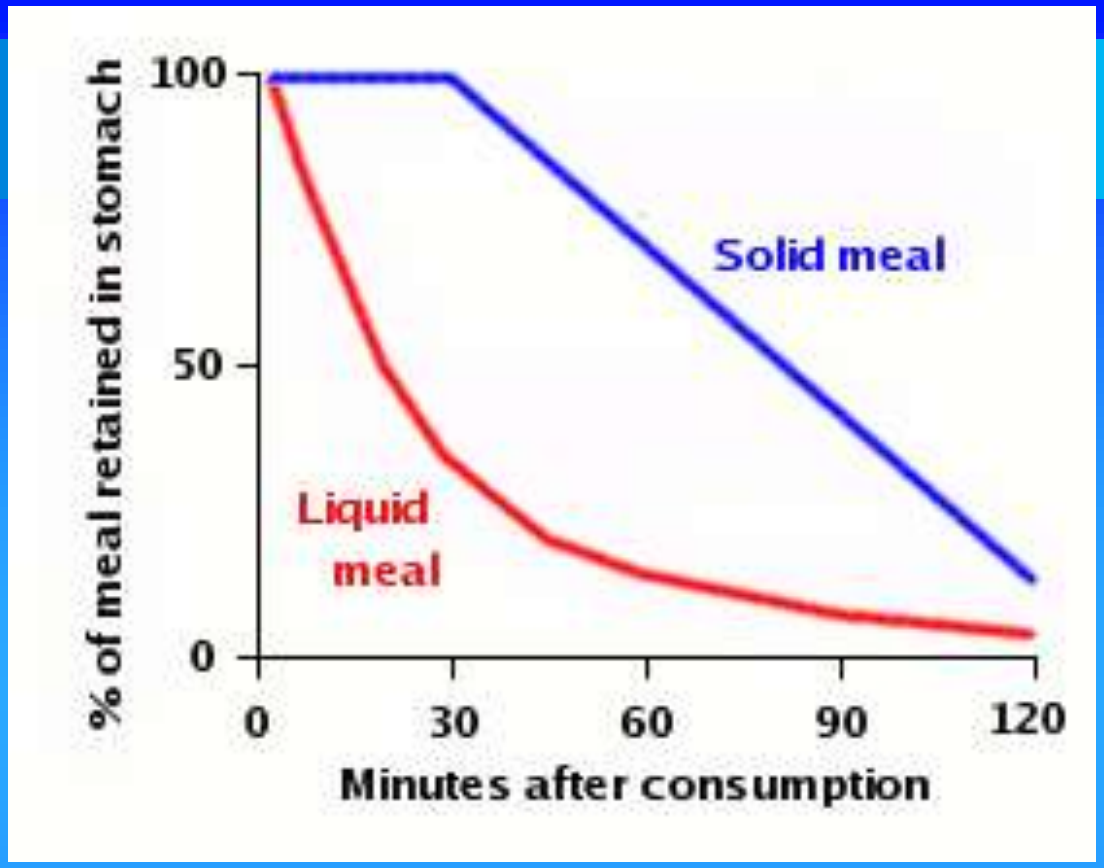
important for activation of pepsinogen, inactivation of microorganisms such as bacteria.

Pepsinogen

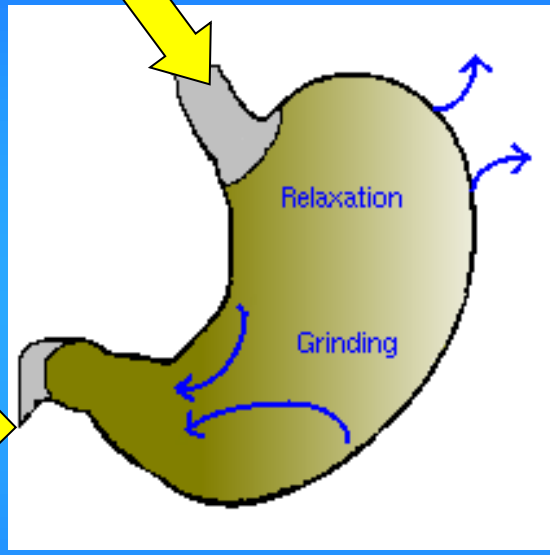
activated by acid into active pepsin, responsible for the stomach's ability to initiate digestion of proteins.

Chymosin

is an enzyme whose role is to curdle or coagulate milk in the stomach, a process of considerable importance in the very young animal.



milk



Chymosin

makes the milk into "cheese"

halfway between liquid and solid

stomach empties in 60 minutes

Gut hormones.

20 different hormones
work in the gut –
regulated by the vagal nerve.

Each has a specific function.

Uvnas-Moberg 1989

CEPHALIC PHASE

GASTRIC PHASE

INTESTINAL PHASE

FEEDBACK LOOPS

Gut hormones.

"Bad guy" - SOMATOSTATIN:
(produced by fetus, rise 10-fold under stress)

inhibits gastrointestinal secretion,
inhibits motility ,
reduces blood flow to gut
and absorption,
causes gastric retention,
vomiting, constipation.

Uvnas-Moberg 1989

SOMATOSTATIN:

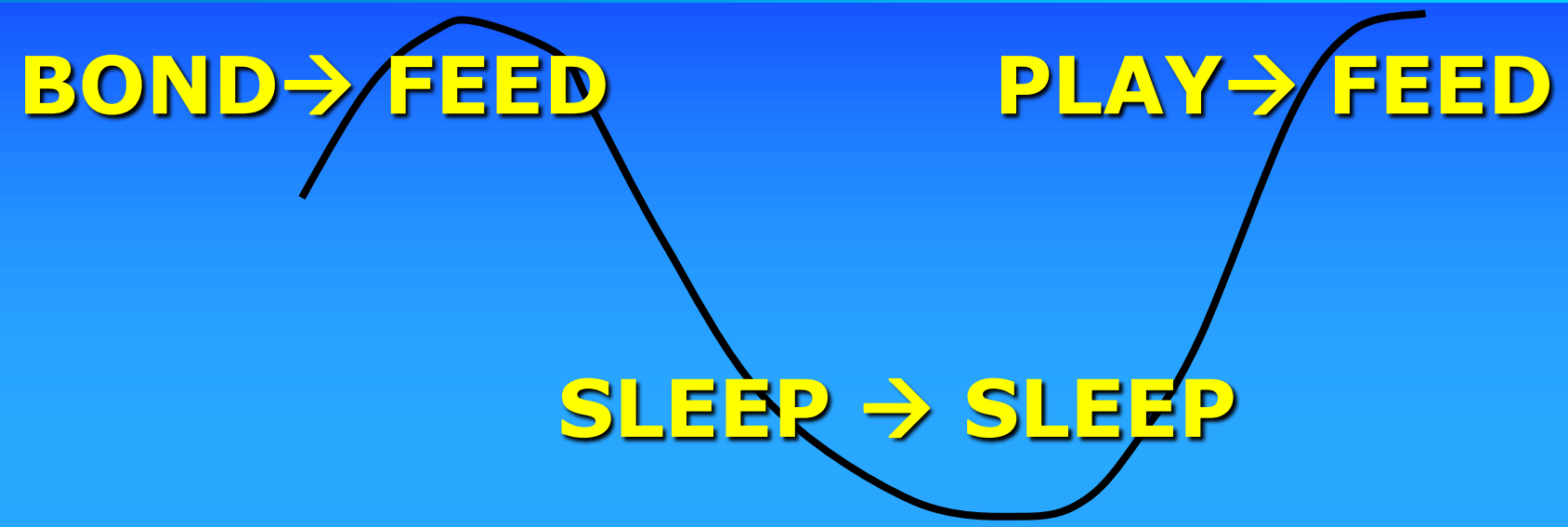
inhibits the good hormones,
contributes to
slow weight gain.
At high levels also
inhibits release of
growth hormone.

Uvnas-Moberg 1989

It takes 30 to 60 minutes of SSC to lower somatostatin and other stress hormones

SSC &
SLEEP
VITAL !!!

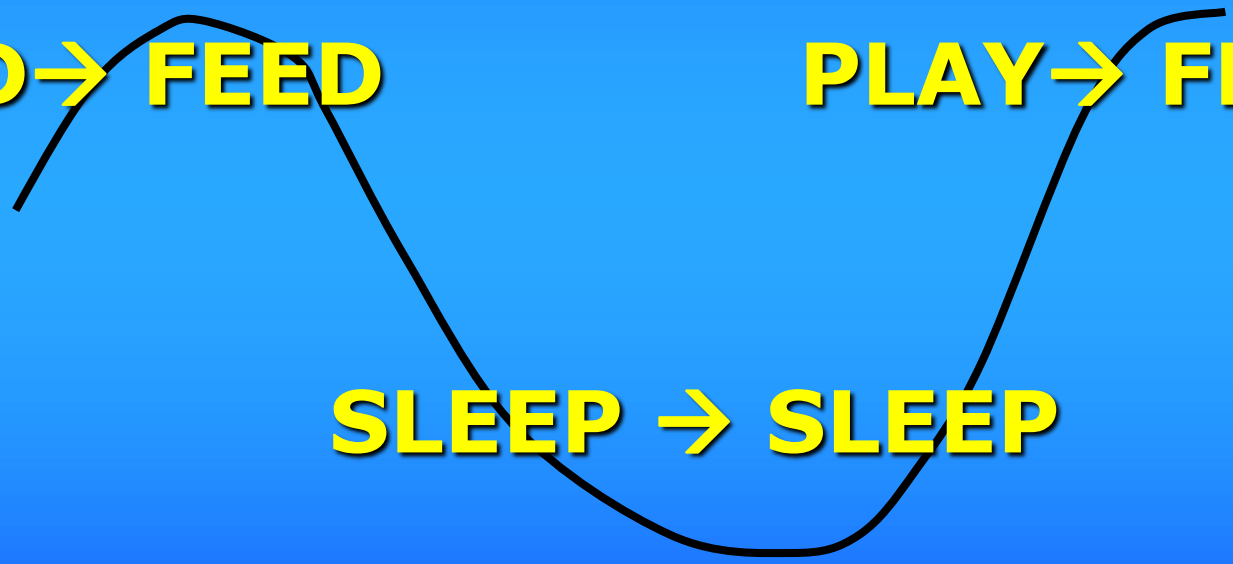
The "niche" (occupation) of a neonate (Alberts)



Alberts 1994

Enteric Nervous System

The "niche" (occupation) of a neonate (Alberts)



EVIDENCE FOR FEEDING FREQUENCY ????

Edmond 2006

Findings of the review

What to feed

Choice of milk

Breastfeeding or mother's own expressed milk. There is strong and consistent evidence that feeding mother's own milk to pre-term infants of any gestation is associated with a lower incidence of infections and necrotising enterocolitis, and improved neurodevelopmental outcome as compared with formula feeding. Feeding unsupplemented mother's own milk to pre-term infants <1500 g resulted in slower weight and length gains, but the implications of this slower growth are unclear and there is not enough evidence to assess if it increased the risk of malnutrition. Long-term beneficial effects of breastfeeding on blood pressure, serum lipid profile or pro-insulin levels have also been reported for pre-term infants. There are limited data on most outcomes in term LBW infants; the available data suggest that improved infection and neurodevelopmental outcomes associated with feeding mother's milk in pre-term infants are also seen in this group.

Breastfeeding and mother's milk: Strong and consistent evidence

How to feed

Feeding methods

Cup feeding compared with bottle feeding. In pre-term infants, cup feeding leads to higher rates of full (exclusive or predominant) breastfeeding, compared with bottle feeding at the time of discharge from hospital. Cup feeding was also associated with greater physiological stability, e.g. lower risk of bradycardia or desaturation, than bottle feeding. No data are available for term LBW infants. When cup feeding is correctly done, i.e. with the infant upright and the milk is not poured into the mouth, there is no evidence that there is an increased risk of aspiration.

Cup feeding versus bottle feeding: Cup feeding higher breastfeeding greater stability

FEED FREQUENCIES AND INTERVALS

Results

Effects on mortality, serious morbidity, neurodevelopment or malnutrition

No RCTs or observational studies were located which examined the impact of feeding frequencies or intervals on mortality, serious

Effects on other important outcomes

Only case series and descriptive studies were located which examined outcomes such as *feed tolerance* and *biochemical measures* (Level IV evidence) (*270*, *282*). These studies indicated

Conclusions and implications

Only case series and descriptive studies were located in this section. These describe the

about the safest or most effective regimens. No implications can be drawn for infants of particular gestational ages or birth weights.

Recommendations

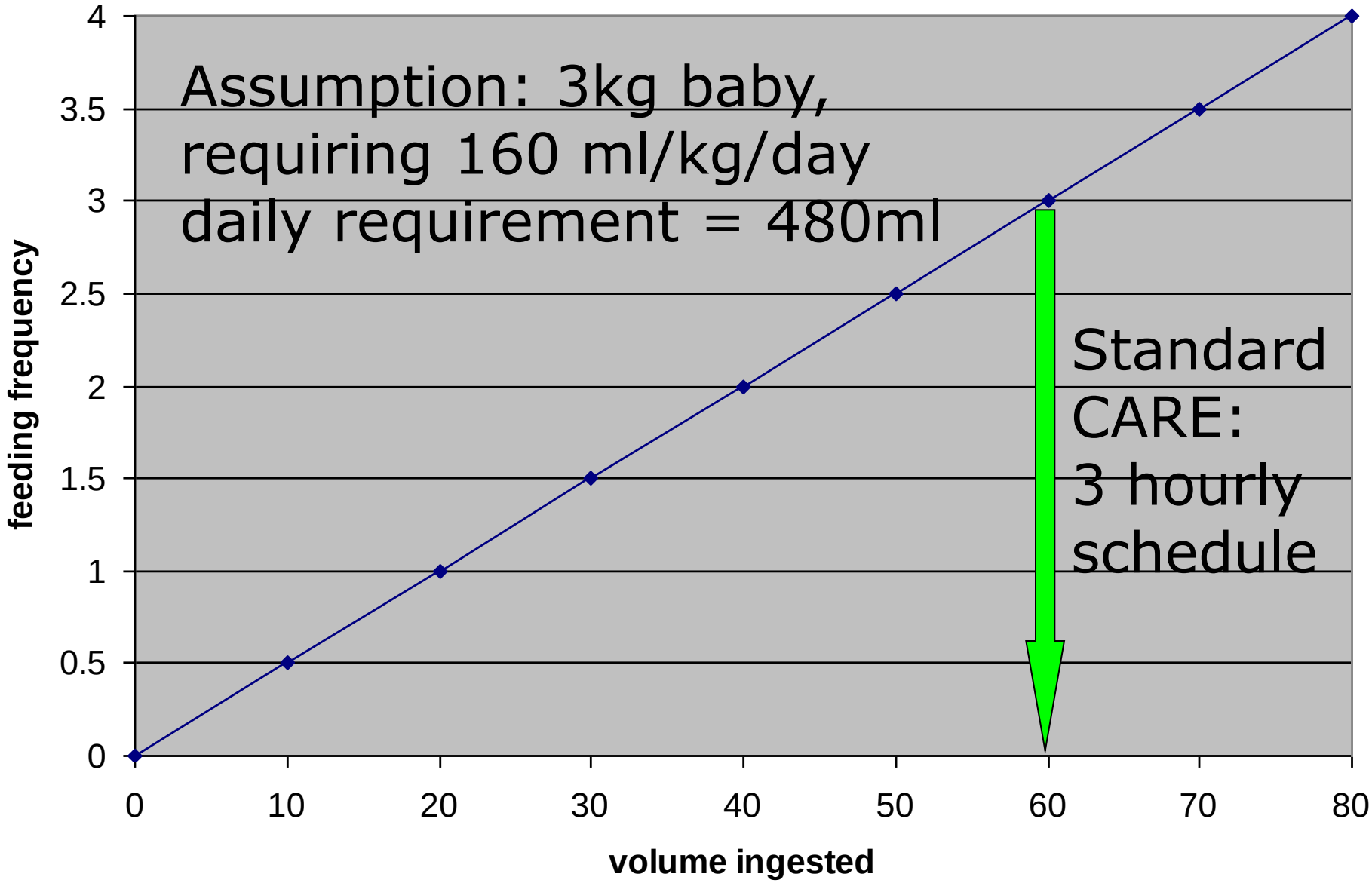
No policy statements from international or national organizations were located which examined the frequency of feeding in LBW infants. Standard practice in many neonatal units is to commence feeding 4-hourly for infants >2000 g, 3-hourly for infants 1500–2000 g, 2-hourly for infants 1000–1500 g, and hourly in infants <1000 g. Feeding intervals are then extended on an individual basis depending on feed tolerance, gastric aspirates and physiological stability. It was not possible to provide additional recommendations due to insufficient evidence.

Only case series …
Insufficient evidence

No mention of stomach capacity

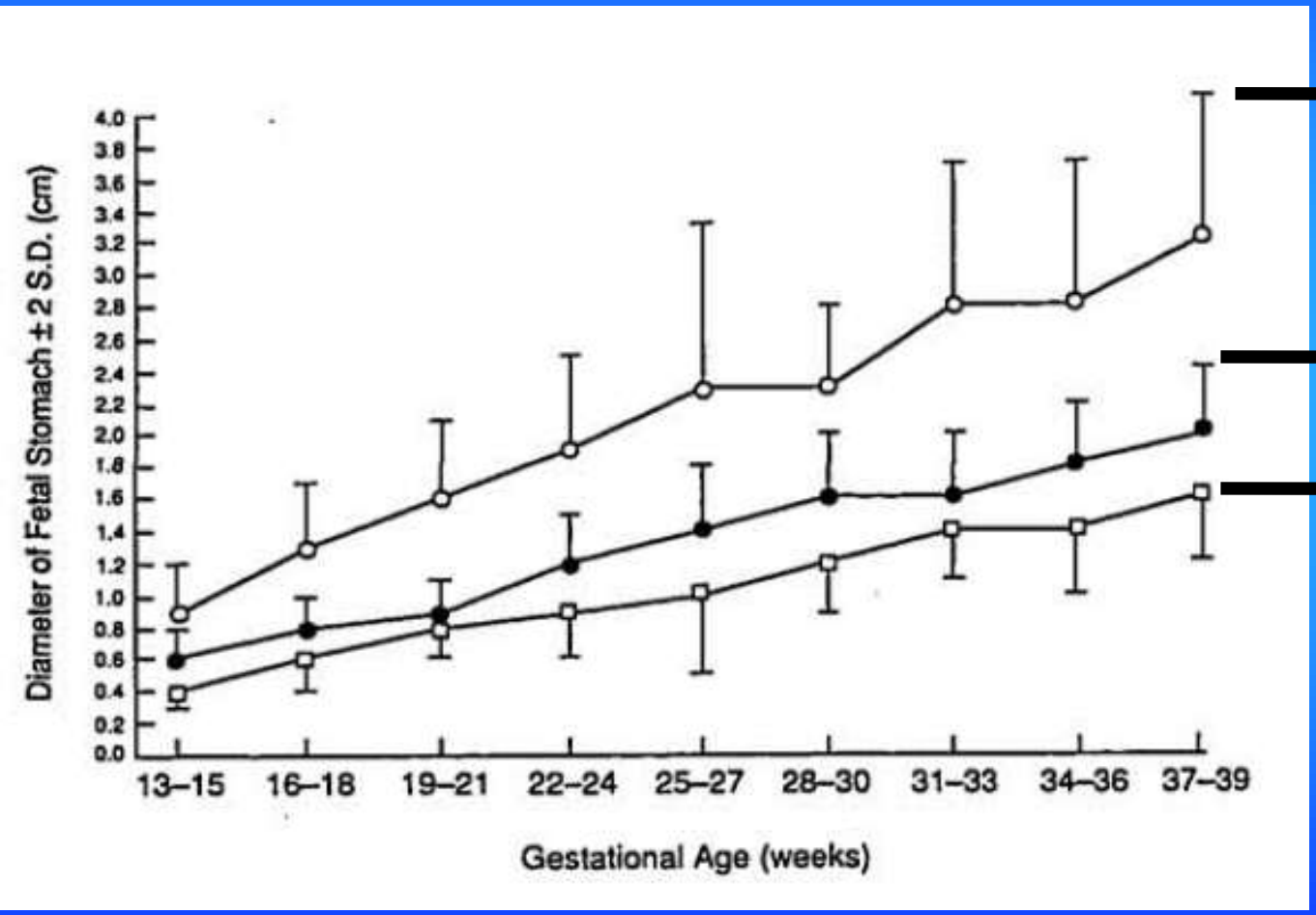
EVIDENCE FOR STOMACH CAPACITY ????

Edmond 2006


Assumption: 3kg baby,
requiring 160 ml/kg/day
daily requirement = 480ml
Standard
CARE:
3 hourly
schedule
feeding frequency
volume ingested
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70
80

KEY QUESTION:

WHAT IS THE STOMACH VOLUME OF THE NEONATE ???



Length

Transverse

AP diameter

Using
+2SD →

Goldstein 1987

BRADSHAW formula

Formula for calculation of stomach capacity (Charles Bradshaw, UCT)
Assumptions: the stomach can be approximated by dividing into three sections, namely a ellipsoidal hemisphere, an ellipsoidal cylinder, and a skewed ellipsoidal cone.
Variables: a = anteroposterior radius, t = transverse radius, l = length stomach
Relations: the height of the cone and the hemisphere are both the same as 'a'.

Ellipsoid = 4/3 * Pi* r1*r2*r3 = 4/3 *Pi * a * a * t;
therefore volume of hemisphere = 2/3 Pi * a *a * t
Cylinder = Area of base * height = (Pi * a * t) * (l - 2a)
Skewed cone = 1/3 * base *height = 1/3 * Pi * a * t * a
Total volume = 2/3 * Pi *a*a*t + Pi * a * t * (l- 2a) + 1/3 * Pi * a * t * a
=Pi a*t*l -Pi * a *a*t
= Pi * a * t*(l-a)

Goldstein and Sase data:
Stomach capacity at term 10 - 15 ml

Assumption: 2,5 kg baby 33w GA,

requiring 150 ml/kg/day = 375 ml

45 MIN CYCLES (32 cycles/day)

12 ML PER CYCLE = 384 ml

Newborn stomach volume.

Gastric volumes at birth
Correlated with gastric pH, gastrin and somatostatin →

"fetus drinks 10 ml portions of amniotic fluid …"

Widstrom 1988

Only recent study located:
"Autopsy" capacity was determined in Indian post-mortem studies

"An Autopsy Study of Relationship between Perinatal Stomach Capacity and Birth Weight."

100 autopsies (63 SB, 37 ENND)
Tied at cardia and pylorus, filled with water, emptied & measured, repeated,
"… obliteration of the gastric curvatures"
"due care to minimize stretch artifacts"

Naveed 1992

"An Autopsy Study of Relationship between Perinatal Stomach Capacity and Birth Weight."

Infants above 2500g only:

	Ave	Range
Stillborn (n 11)	19.6 ml	(10-35)
Early death (n 9)	17.8 ml	(10-25)
All cases (n 20)	**18.8 ml**	

Naveed 1992

KERNESSUK 1997 (Russian)

Postmortem: in situ measures

(applied Bradshaw formula)

	Ave
Newborn (n 11)	15 ml
2 months (n 11)	35 ml
2-4 m (n 10)	50 ml
4-6 m (n 8)	100 ml

Known references with data:

Scammon and Doyle 1920

"Observations of the capacity of the stomach in the first ten days of post natal life."

Zuccarelli's method: stomach filled at autopsy to "a pressure of between 15 and 20 centimeters of water"

Scammon 1920

"Observations of the capacity of the stomach in the first ten days of post natal life."

Anatomic capacity was determined
in post-mortem studies
Main data set → Alliot 1905 (n 25)
Scammon own cases ? (n 13)

30 – 35 ml at birth –
almost regardless of birth weight

Scammon 1920

Known references with data:

Scammon and Doyle 1920

quoted in Silverman 1961

"Observations of the capacity of the stomach in the first ten days of post natal life."

14571 feeding records from 323 newborns
"physiologic capacity" → all breastfed
test weighing before and after feeding

Scammon 1920

"… modern infant feeding." →

"infants were breastfed 5 times per day"

INFERENCE?? If fed 5 x per day
and daily requirement 160 ml x 3kg = 480
Required volume: 480 / 5 = 96 mls

Did not measure stomach capacity:
Pre-determined a feeding frequency!

Scammon 1920

"… modern infant feeding." → 5 per day

Did not measure stomach capacity:
Pre-determined a feeding frequency!

" … the figures … presented here are distinctly higher than those of earlier investigators … not surprising considering … (they) made their observations upon infants which were fed eight or more times per day."

Scammon 1920

Imagine a study !!

Let us measure the stomach capacity
with a balloon ... at end of NGT
Test the pressure on adults
must not be uncomfortable

Once the pressure starts to rise:
→ there is risk for reflux
→ to be avoided – expected physiology

THIS SHOULD BE THE
STOMACH CAPACITY

Imagined study was done!!

Zangen S et al 2001

Rapid Maturation of Gastric Relaxation in Newborn Infants

75 ml per feeding

No reference given ....

Zangen 2001

Zangen S et al
Rapid maturation of gastric relaxation in newborns

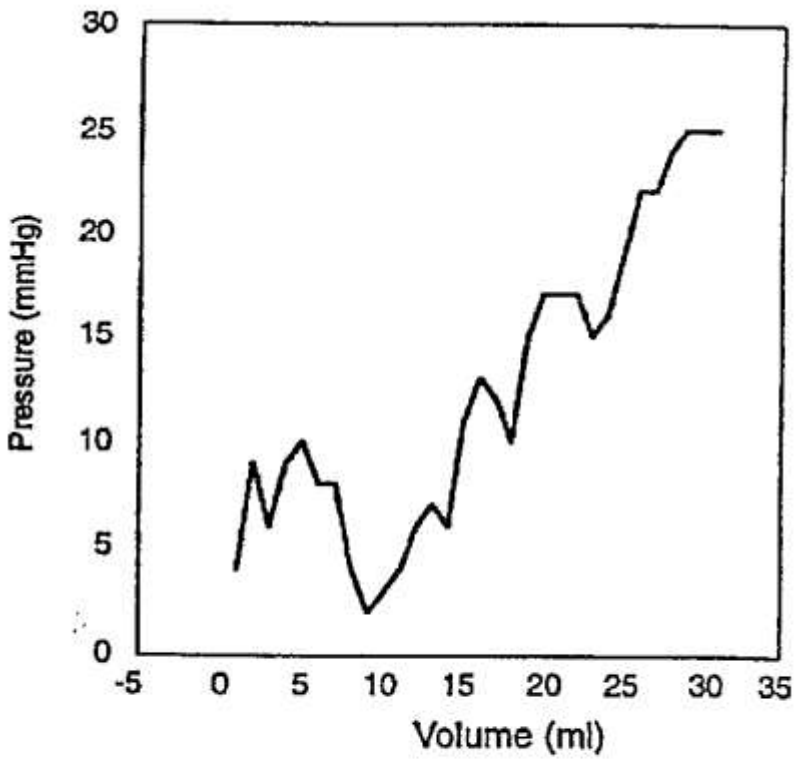


Figure 1. An intragastric pressure–volume plot from a single distention in one newborn. The flat portion of the curve between 0 and 15 mL is an artifact caused by the volume required to open the balloon. Note the linear pressure–volume relationship from 5 mm Hg to the maximal pressure tested, 30 mm Hg. There is no plateau with a 0 slope, as expected in adults.

Pressures (mmHg)

Balloon inflates to

15 ml no increase

functional capacity

TERMINOLOGY PROPOSALS

"Functional capacity"
equivalent to "expectation volume",
for which optimal pepsin / acid is made,
- does not cause distention
- allows adequate time for curdle
- allows protein breakdown
- allows controlled pyloric passage

Zangen S et al
Rapid maturation of gastric relaxation in newborns

Pressures (mmHg)

Balloon inflates to

15 ml no increase
20 ml pressure OK

physiological capacity ...

TERMINOLOGY PROPOSALS

Physiological capacity
Maximal amount stomach can handle without undue stress.

"Receptive capacity" of STOMACH
maximal amount stretched organ holds

"Ingestive capacity" of BABY
amount baby or infant swallowed,
(note, excess not in stomach)

Scammon and Doyle did draw attention to this also ....

Physiological capacity
Maximal amount stomach can handle without undue stress.

"Receptive capacity" of STOMACH
maximal amount stretched organ holds

"Ingestive capacity" of BABY
amount baby or infant swallowed,
(note, excess not in stomach)

EVIDENCE: (NBn 111009)

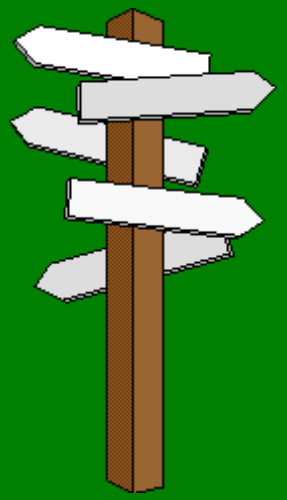
Author	Capacity	Note:
Sase	10-15 ml	Live, term fetus
Goldstein	10-15 ml	Live, term fetus
Widstrom	10 mls	Live, newborn
Zangen	20 mls	Live, (pressure)
Naveed	20 mls	Autopsy (SB)
	20 mls	Autopsy (ENND)
Kernessuk	15 mls	Autopsy (in situ)
Scammon (Alliot)	30-35 ml	Autopsy (water pressure)

PROPOSAL:

The CAPACITY of a week old baby's stomach is

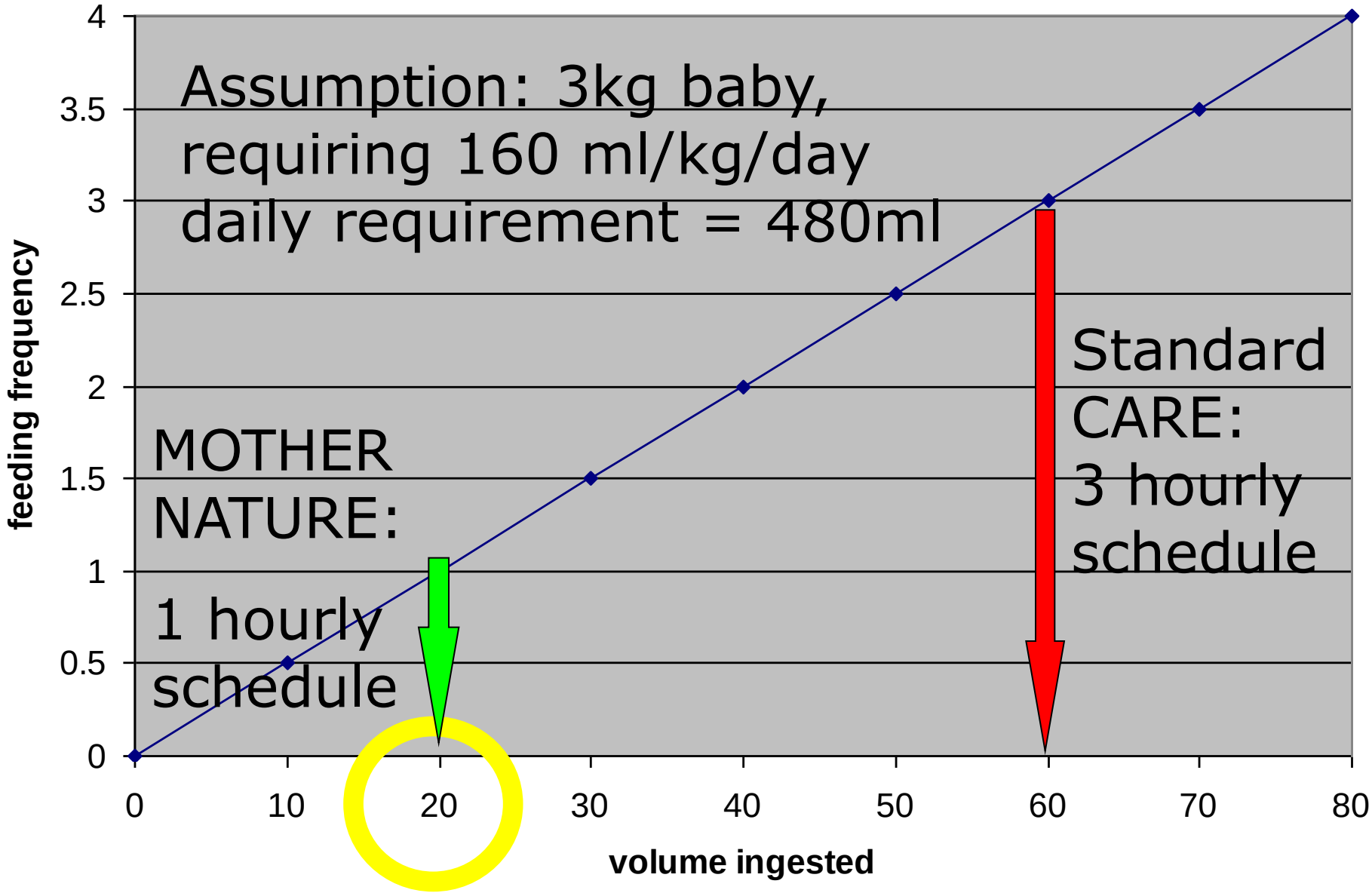
approx **20 ml.**

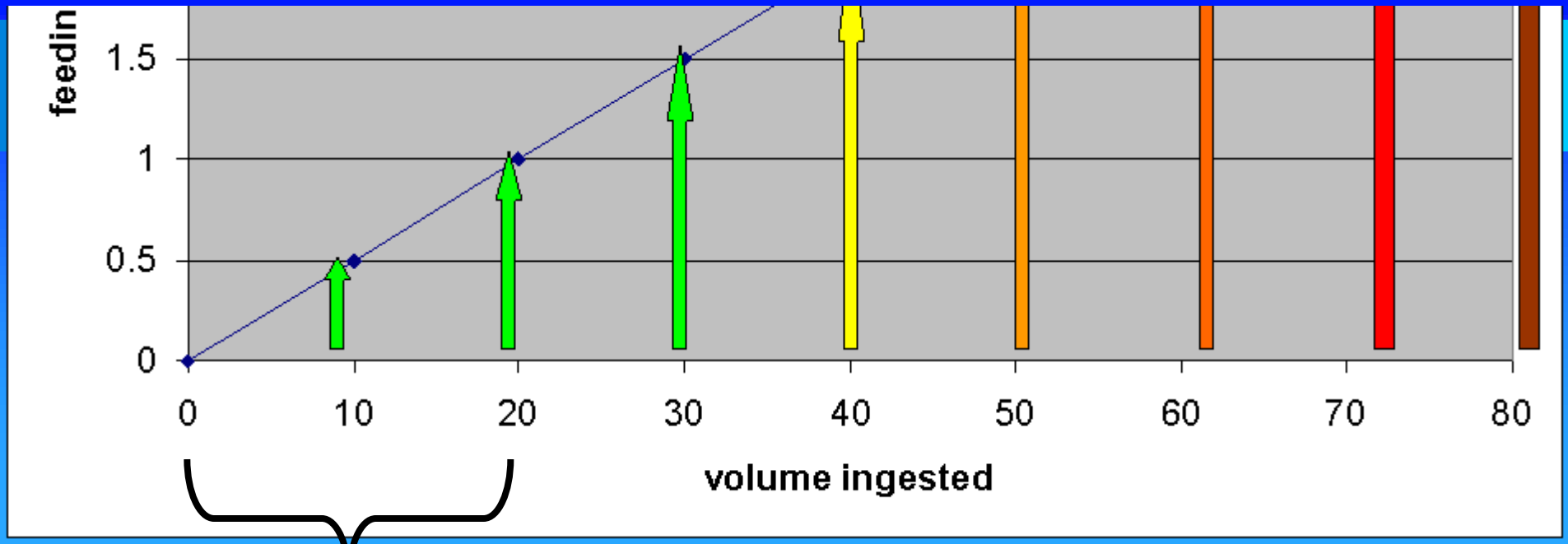
INFANT FEEDING FREQUENCY: available evidence & neuroscience



OVERVIEW:

Neuroscience
Anatomy & physiology
Available evidence
Proposal feeding frequency
Implications


Assumption: 3kg baby,
requiring 160 ml/kg/day
daily requirement = 480ml
MOTHER
NATURE:
1 hourly
schedule
Standard
CARE:
3 hourly
schedule
feeding frequency
volume ingested
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70
80



FUNCTIONAL CAPACITY

PHYSIOLOGICAL CAPACITY

RECEPTIVE CAPACITY of stomach

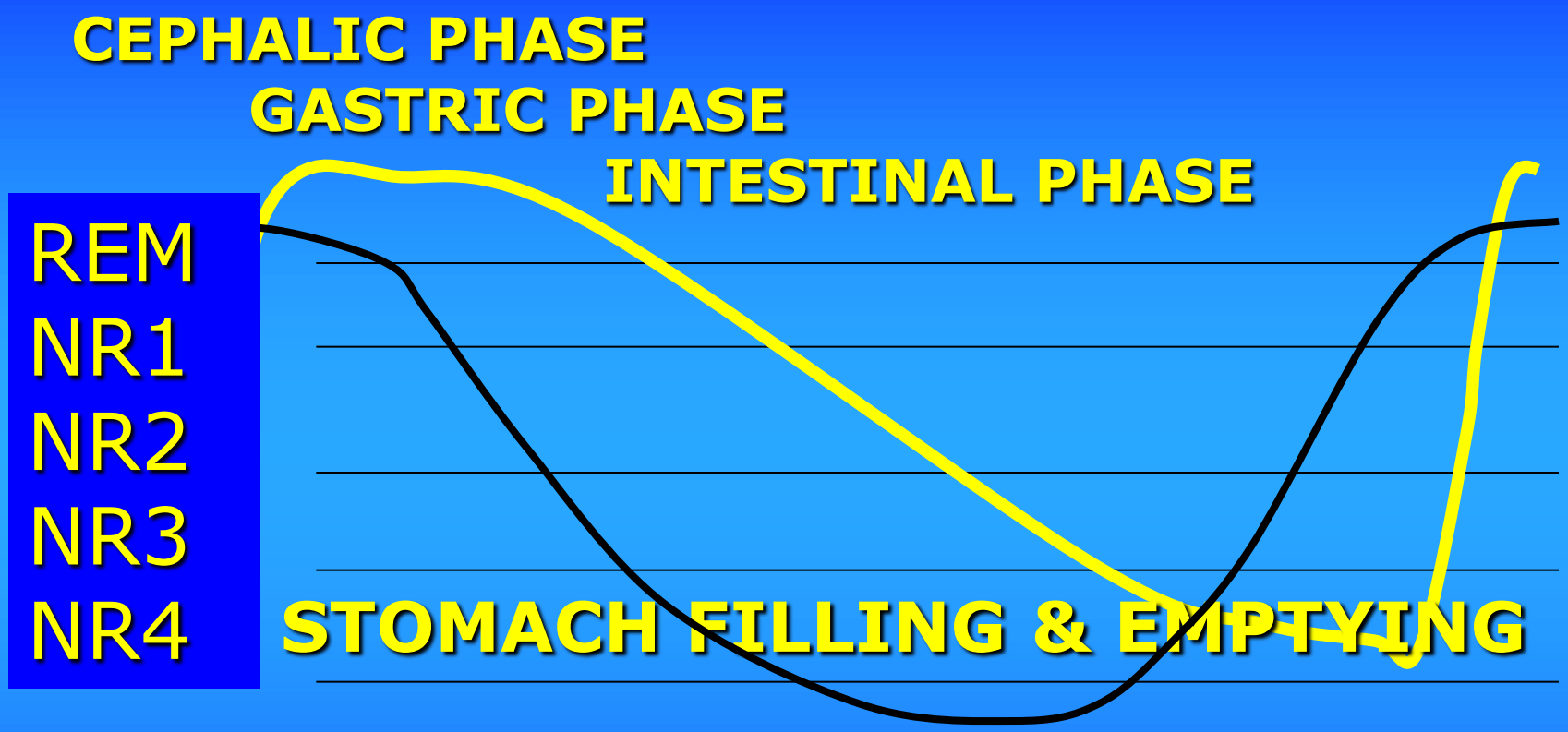
INGESTIVE CAPACITY of BABY

PROPOSAL:

The FEEDING FREQUENCY of the NEONATE is

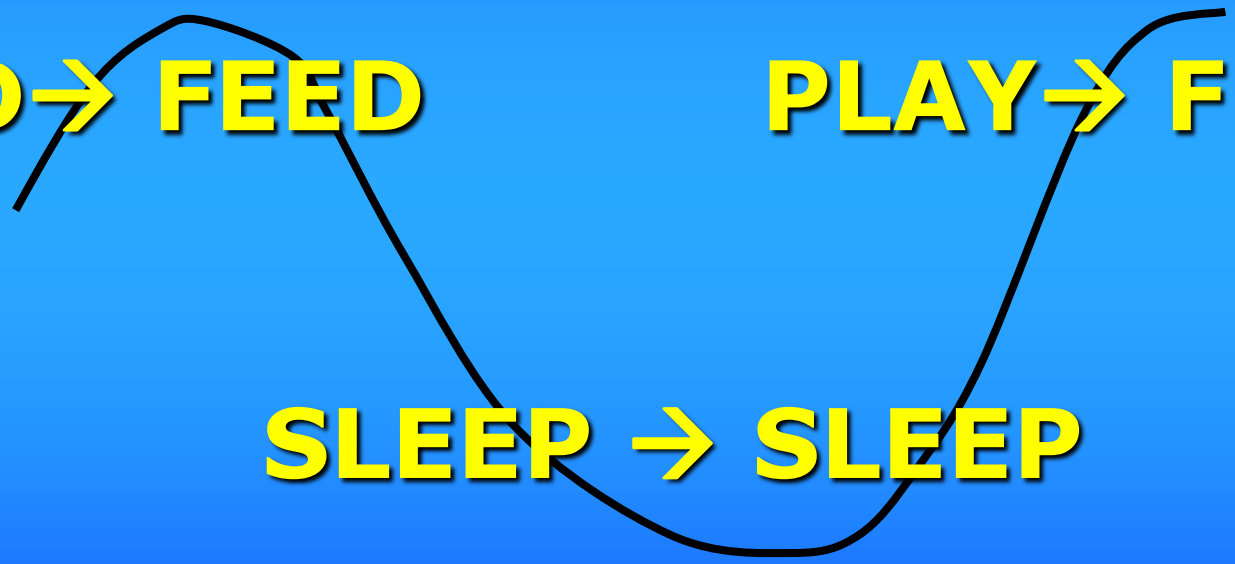
approx **60 min.**

BRAIN CYCLING



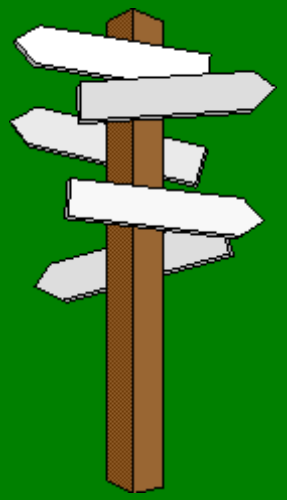
Normal physiology of the Enteric Nervous System

The "niche" (occupation) of a neonate (Alberts)



"Small and frequent feeds, according to the sleep cycle"

INFANT FEEDING FREQUENCY: available evidence & neuroscience



OVERVIEW:

Neuroscience
Anatomy & physiology
Available evidence
Proposal feeding frequency
Implications

Zangen S et al
Rapid maturation of gastric relaxation in newborns

A balloon in stomach can fill to 76 mls

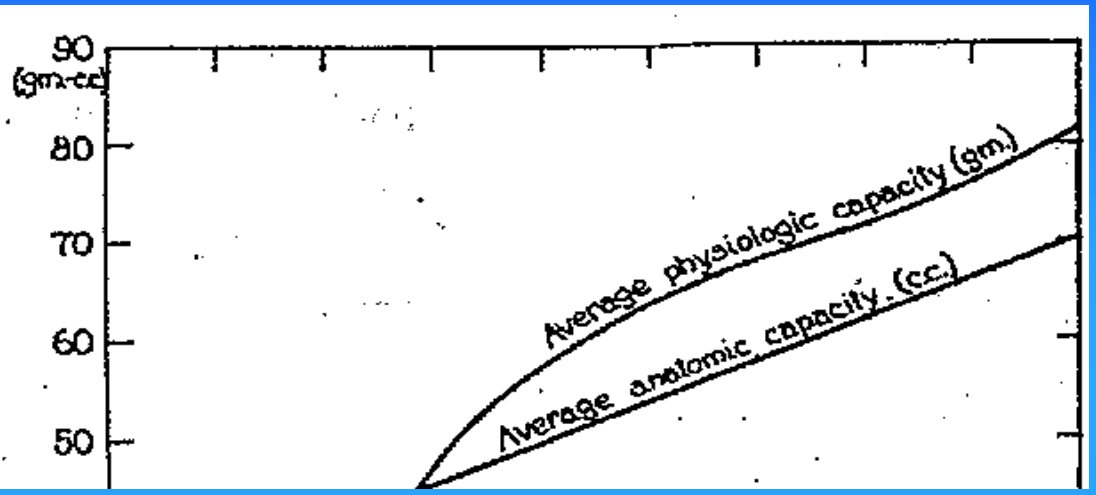
What does the stomach –
without a balloon –
do to 76 mls?

REFLUX !!!

PRESUME: each feed approximately 75 mls

Zangen 2001

WHERE IS THE MILK?

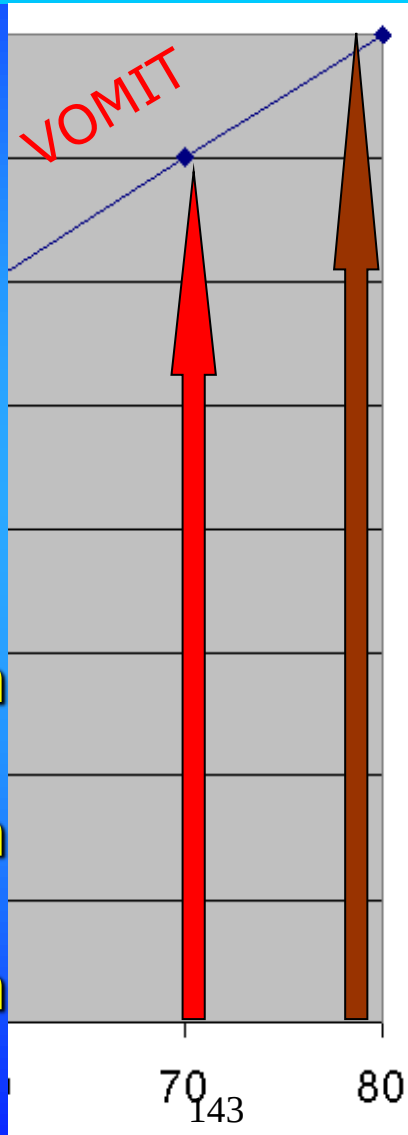


This volume is not in the stomach

Stomach

Stomach

Stomach



WHERE IS THE MILK?

How To Do Just About Everything

How to Burp a Baby

Burping a baby can reduce spitting up and relieve bloating caused by swallowed air. Here are some tried-and-true methods.

Mother's shoulder

Oesophagus

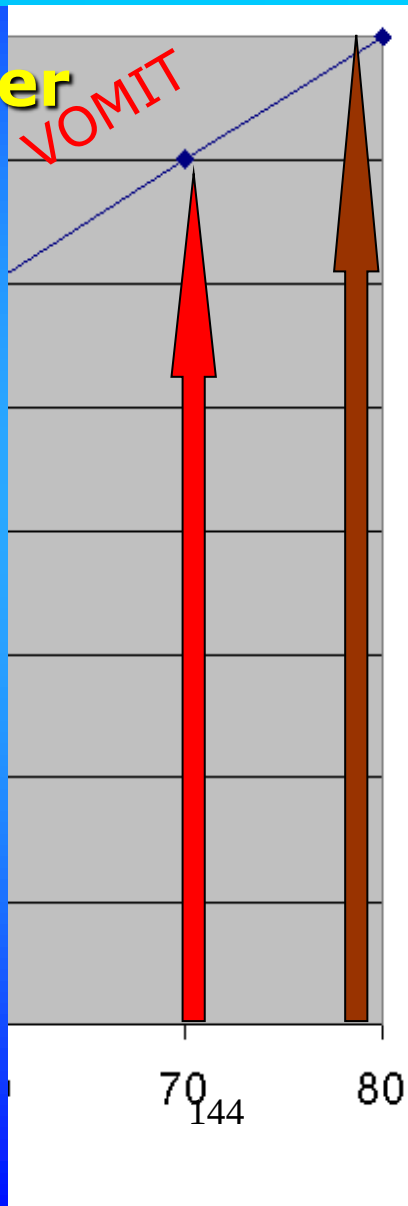
Duodenum

Duodenum

Stomach

Stomach

Stomach



WHERE IS THE MILK?

What happens when my baby spits up?

Babies spit up when they've eaten too much or when they're burped. It can also happen when your baby is drooling.

Spitting up is not vomiting.

Babies usually don't notice when they spit up, while vomiting is forceful and painful. Spitting up is a common occurrence for most babies.

How To Do Just About Everything

How to Burp a Baby

Burping a baby can reduce spitting up and relieve bloating caused by swallowed air. Here are some tried-and-true methods.

Copyright © 1996-2007 American Academy of Family Physicians

http://familydoctor.org/online/famdocen/home/children/parents/infants/218.html

WHERE IS THE MILK?

What happens when my baby spits up?

Babies spit up when they've eaten too much or when they're burped. It can also happen when your baby is drooling.

Spitting up is not vomiting.

Spitting up is REFLUX.

Nils Bergman, 2011

Blood sugar may fall …
after 90 minutes …

"There is a
reason behind
everything
in nature" Aristotle

Would nature allow this?

HYPOGLYCAEMIA

A babies stomach empties in **60 minutes.**

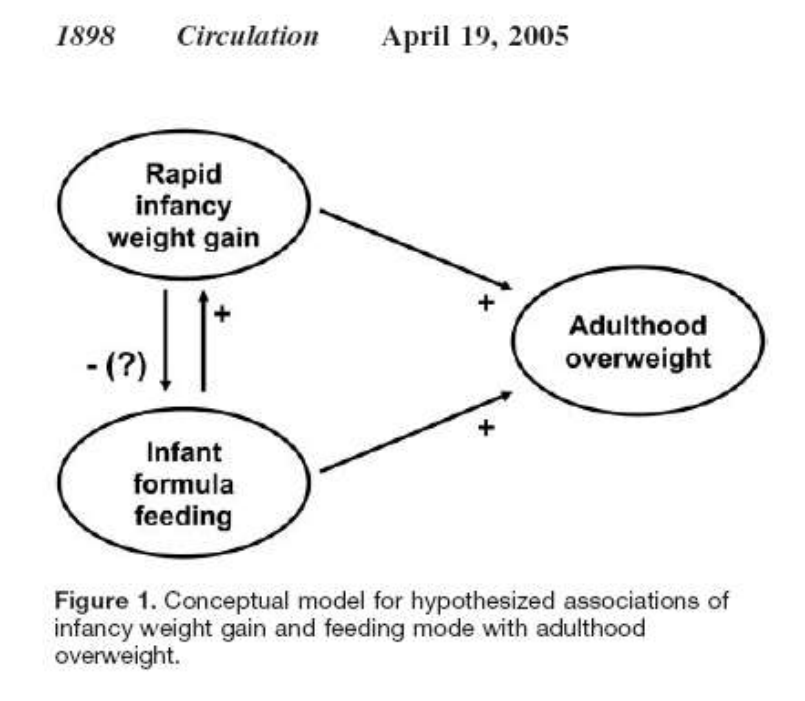
Blood sugar may fall …

after 90 minutes …

Option?

HOURLY FEEDING.

Stettler et al
Weight Gain in the First Week of Life and Overweight in Adulthood:
A Cohort Study of European American Subjects Fed Infant Formula



Large volume feeds stretched stomach=

doubled absorptive capacity as adult

Stettler 2005

Stettler et al
Weight Gain in the First Week of Life and Overweight in Adulthood:
A Cohort Study of European American Subjects Fed Infant Formula

This finding is important, not so much to predict which infants are at risk for becoming overweight adults, but more to understand the importance of the human physiology of programming during short early-life periods on the development of chronic disease over the life course.

Gastric overfilling syndrome?

Excessive volumes

reflux, aspiration, colic

Excessive time interval

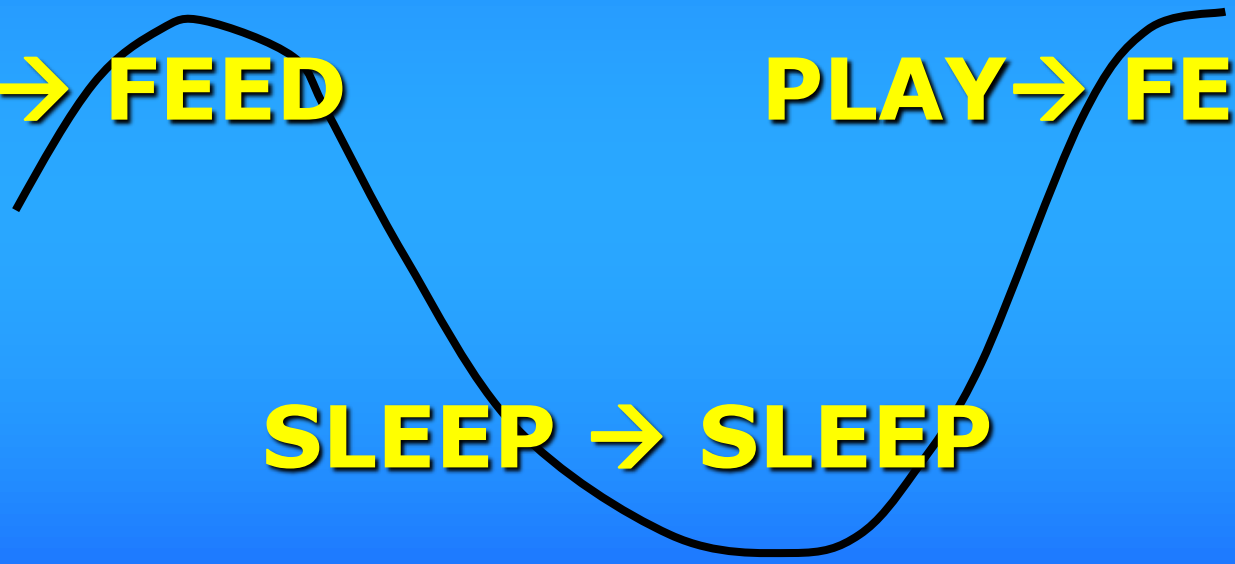
hypoglycaemia

Adaptations

diabetic diathesis, obesity

Developmental Care of the Enteric Nervous System

The "niche" (occupation) of a neonate (Alberts)



"Small and frequent feeds, according to the sleep cycle"

WHAT IS THE STOMACH VOLUME OF THE PREMATURE ??

Assume low resilience

Assume proportionality →

The CAPACITY of a low birthweight prem from 20ml / 3000g

= 0.007 x BWt (g)

1kg x 0.007 = 7mls

2kg x 0.007 = 14mls

evidence) (*270*, *282*). These studies indicated that feeding regimens such as 4-hourly feeds for infants >2000 g, 3-hourly for infants 1500–2000 g, 2-hourly for infants 1000–1500 g, and hourly in infants <1000 g were well tolerated, promoted biochemical stability, and produced minimal gastric aspirates.

Standardised from 20ml capacity for 3kg baby (x 0.007)

Baby weight; freq; req'd size → actual

2kg baby: 4hrly

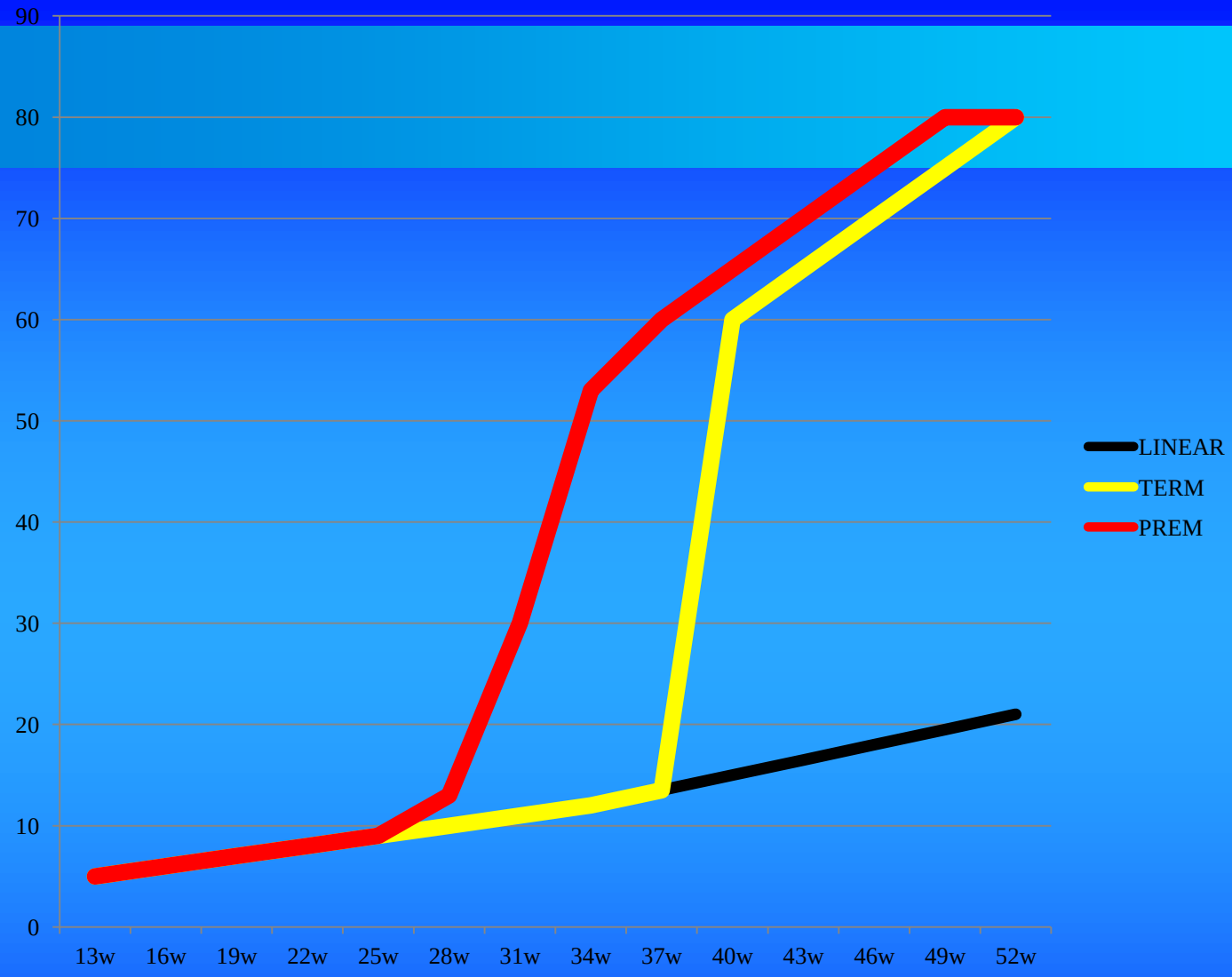
~ 320 ml/6 = 53ml → 14ml

1,5 baby: 3hrly

~ 240 ml/8 = 30ml → 10ml

1,0 baby: 2hrly

~ 160 ml/12 = 13ml → 7ml


90
80
70
60
50
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30
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37w
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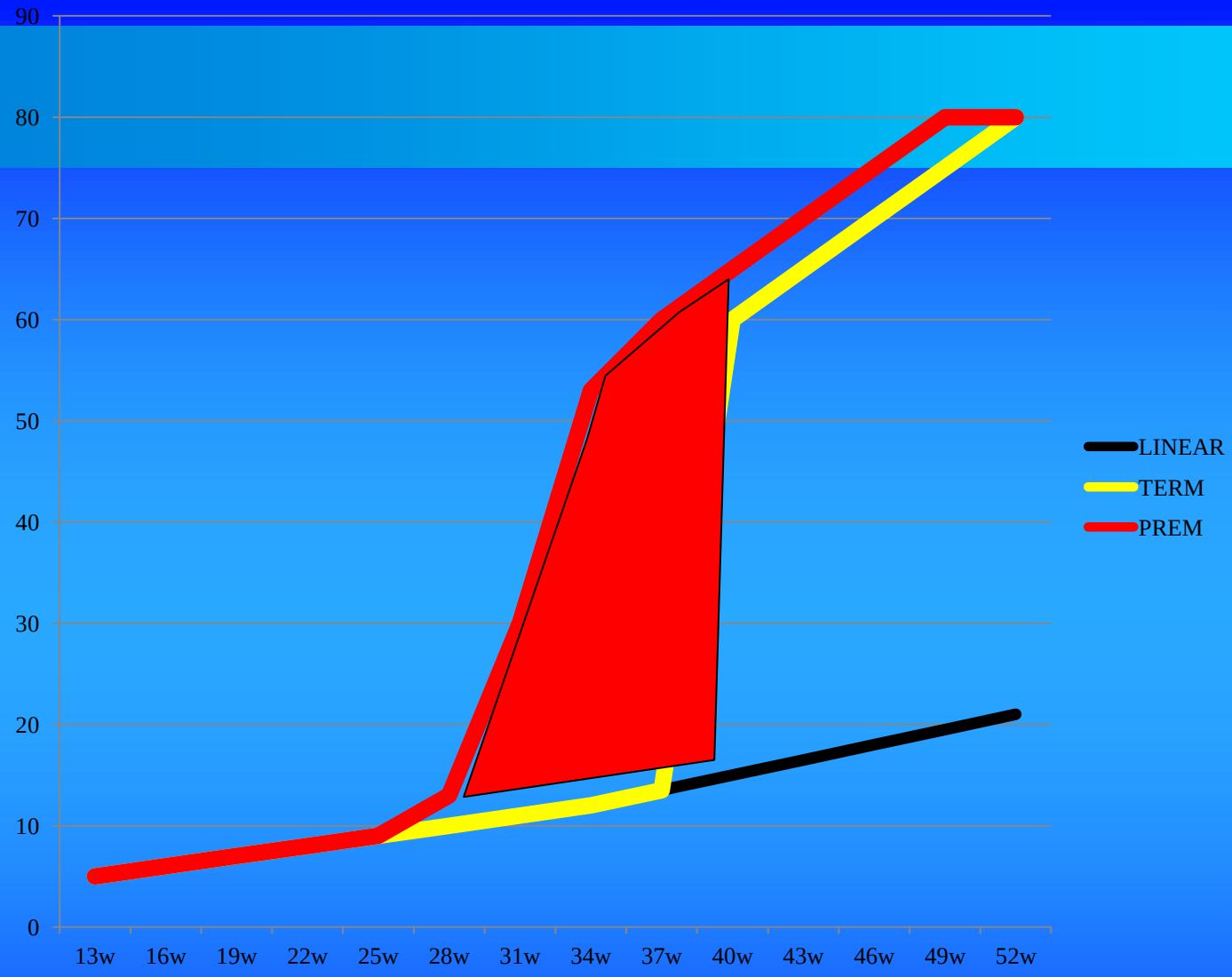
49w
52w
LINEAR
TERM
PREM


90
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31w
34w
37w
40w
43w
46w
49w
52w
LINEAR
TERM
PREM

Proposed Management →

Babies should be fed EVERY TIME THEY WAKE !!

Proposed Management →

All babies should be fed at least once an hour !!

Proposed Management →

All babies should be fed at least once an hour !!

The first Milk Ejection Reflex (MER)

elicited in < 2 minutes
works quickly
swallowed 1 minute

Feeding time (max)
3 minutes

Repeat every 1 hour

The “normal” or usual and common breastfeed

takes 15 minutes
discomfort after
burping time 5 minutes

Feeding time <u>20 min</u>

Repeat every 3 hours

3 minute 20ml feeds x 24/d = 72 minutes

20 minute 60ml feeds x 8/d = 160 minutes

SMALL AND FREQUENT FEEDS ARE EFFICIENT !!!!

FEWER NURSES NEEDED !!!

The calculated daily requirement for a 3kg baby can be given without increase in pressure ....
→ MINIMAL RISK

20 mls x 24 feeds
= 480mls / day

PARENTS CAN DO
SAFELY !

All babies should be fed at least once an hour !!

First two days: **COLOSTRUM**

15 mls / day (Paula Meier)

"one teaspoon,
three times a day"

From third day: **MILK**

small frequent feeds
(on demand)
between sleeps

Available from Geddes Productions

Infant feeding frequency: Proposal based on available evidence and neuroscience

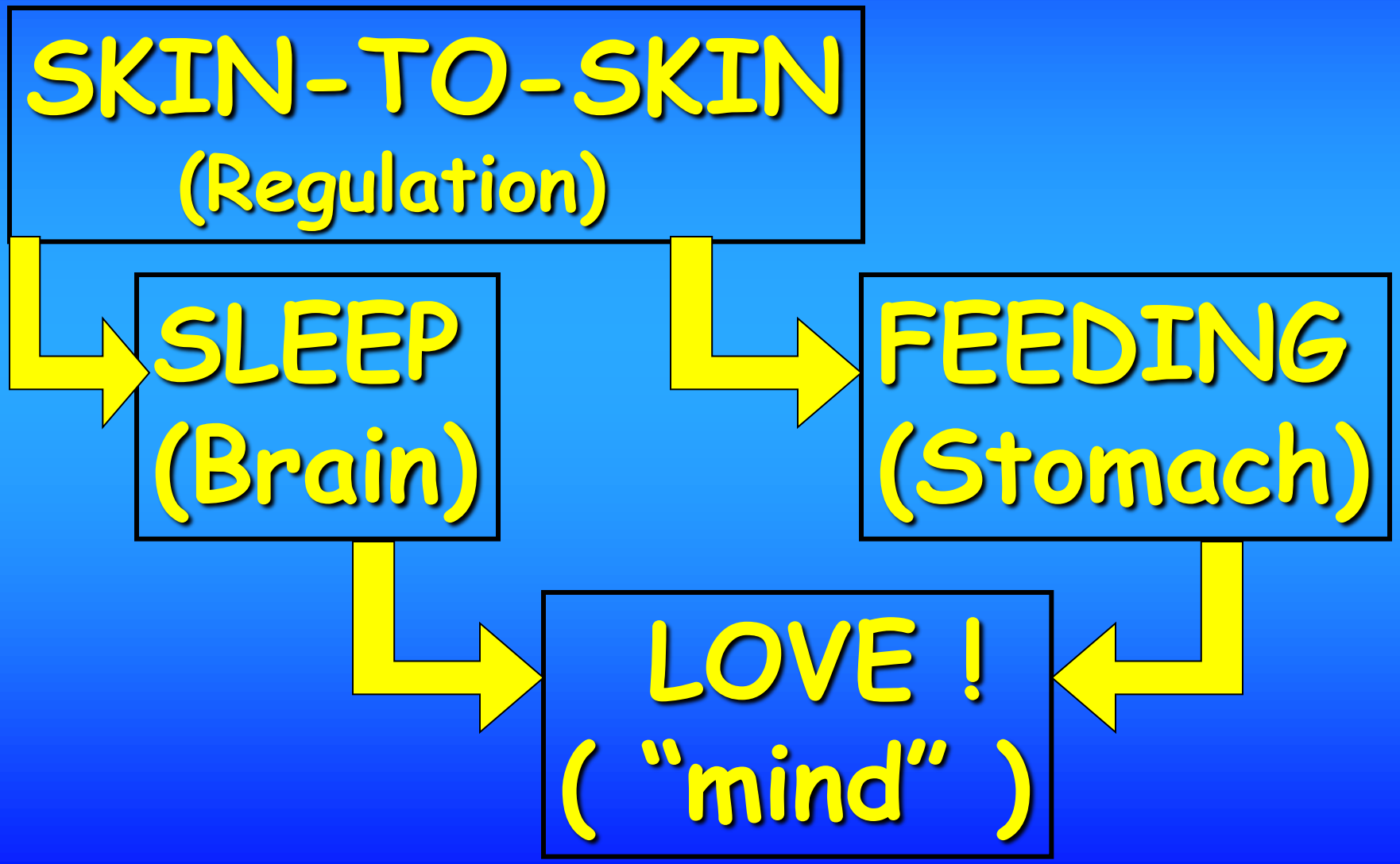
"Small and frequent feeds, adjusted to the sleep cycle"

In the past, whether
to breastfeed or not
was a lifestyle choice.

Our new knowledge of the brain
makes breastfeeding
a public health issue.

(Gail Storr, Fredericton, NB)

SUMMARY !!


SKIN-TO-SKIN
(Regulation)
SLEEP
(Brain)
FEEDING
(Stomach)
LOVE !
("mind")