PERINATAL NEUROSCIENCE
Breastfeeding the Neonate

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INK
Scientific American, December 2011

CORTISOL
HISTONE MODIFICATION
DNA METHYLATION
MICRO-RNA

The Neuroscience of Birth & Breastfeeding
The DNA
EPIDEMIOLOGY
The Brain
NEURODEVELOPMENT
EVOLUTIONARY BIOLOGY
ENVIRONMENT
ADAPTATION
EXPERIENCE
REPRODUCTIVE FITNESS

Genetics vs. Epigenetics
Many new insights into mental illness have come from studying epigenetic modifications of genes, which differ from genetic mutations (i.e., both kinds of alterations can disrupt the functioning of the brain and other tissues).

Epigenetic Changes After Activity

GENETIC MUTATIONS OFTEN ALTER MEANING
A gene mutation will only be passed on to the next generation if a somatic mutation occurs in the sperm or egg. Similarly, environmental factors can alter the expression of genes by changing the level of epigenetic modifications, such as DNA methylation or histone acetylation.

CORTISOL
HISTONE MODIFICATION
DNA METHYLATION
MICRO-RNA
**EPIGENES...**
controls on the DNA/gene
“switches in the mind”

$G \times E$

“Phenotype” – specimen
resulting from
gene - environment interaction

*Pencil*

200000 new nerve cells/min
Hammarberg 1896  Caviness 2008

**The brain is not a computer,**
it is a jungle

*G Edelman*

**The Neuroscience of Birth & Breastfeeding**

<table>
<thead>
<tr>
<th>The DNA</th>
<th>The Brain</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPIGENETICS</td>
<td>NEURODEVELOPMENT</td>
<td>EVOLUTIONARY BIOLOGY</td>
</tr>
</tbody>
</table>

**ENVIRONMENT**  ADAPTATION  EXPERIENCE  REPRODUCTIVE FITNESS

**Making of the neural tube**

Neuronal migration

**The Brain**

Evolutionary Biology

The Neuroscience of Birth & Breastfeeding

The DNA

Epigenetics

Neurodevelopment

Evolutionary Biology

Environment

Adaptation

Experience

Reproductive Fitness

200000 new nerve cells/min

Hammarberg 1896  Caviness 2008

Neuronal migration

The brain is not a computer,
it is a jungle

*G Edelman*
fetal REM sleep
(or active sleep) seems to be particularly important to the developing organism

... spontaneous synchronous firing

Marks et al 1995

“Neurons that fire together wire together while those which don’t won’t”
Hebb/Carla Shatz

Early wiring phase
Pruning of excess
Adult stage (efficient)
Optimal neural pathways are selected - J-P Changeux

Panksepp 1998
Siegel 2005
In adult: sleep pertains to memory  
In child: neurodevelopment (brain wiring)  
1st 1000 days
Brain Architecture and Skills are Built in a Hierarchical “Bottom-Up” Sequence

- Neural circuits that process basic information are wired earlier than those that process more complex information.
- Higher circuits build on lower circuits, and skill development at higher levels is more difficult if lower level circuits are not wired properly.

Slide by: Jack P. Shonkoff, M.D.

Reflections for practice

Sleep organization should guide care

Table 1. Definition of phases and behaviors identified

<table>
<thead>
<tr>
<th>Phases</th>
<th>Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth cry</td>
<td>Intense crying just after birth</td>
</tr>
<tr>
<td>Relaxation phase</td>
<td>Infant resting, recovering. No activity of mouth, head, arms, legs or body</td>
</tr>
<tr>
<td>Awakening phase</td>
<td>Infant begins to show signs of activity. Small-throats of head; up, down, from side-to-side. Small movements of limbs and shoulders</td>
</tr>
<tr>
<td>Active phase</td>
<td>Infant moves limbs and head, is more determined in movements. Rooting activity, ‘pushing’ with limbs without shifting body</td>
</tr>
<tr>
<td>Crawling phase</td>
<td>‘Pushing’ which results in shifting body</td>
</tr>
<tr>
<td>Resting phase</td>
<td>Infant rests, with some activity, such as mouth activity, sucks on hand</td>
</tr>
<tr>
<td>Familiarization</td>
<td>Infant has reached hands/ nipple with mouth positioned to brush and lack nipple/nipple</td>
</tr>
<tr>
<td>Sucking phase</td>
<td>Infant has taken nipple in mouth and continues sucking</td>
</tr>
<tr>
<td>Sleeping phase</td>
<td>The baby has closed its eyes</td>
</tr>
</tbody>
</table>
AT BIRTH, the brain has TWO CRITICAL SENSORY NEEDS: SMELL & CONTACT

... these data indicate that pups have a unique learning circuit relying on the olfactory bulb for neural plasticity and on the hyperfunctioning noradrenergic locus coeruleus flooding the olfactory bulb with norepinephrine to support the neural changes.

APPROACH RESPONSE learned prenatally, reinforced both during the birth process and repeatedly throughout the postnatal period, supported by a unique neural framework ... a system that ensures rapid and robust maternal odor learning

This was confirmed by demonstration of a statistically significant negative correlation between changes in $[HbO_2]$ and postnatal age ($r = -0.64, p < 0.001$ with 95% confidence interval) (Fig. 4). Those babies showing the greatest increase in $[HbO_2]$ were between 6 and 24 h old at testing

Those babies showing the greatest increase in $[HbO_2]$ were between 6 and 24 h old at testing

In the 14 babies older than 24 h there was no significant difference between the changes in $[HbO_2]$ during control and colostrum exposure

The first hours after birth are a CRITICAL PERIOD
“Skin-to-skin contact” is the salient stimulus for infant-parent behavior. “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

<table>
<thead>
<tr>
<th></th>
<th>SSC</th>
<th>Cot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood glucose (1 hr)</td>
<td>3.17</td>
<td>2.56</td>
</tr>
<tr>
<td>Base excess drop</td>
<td>3.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

(Christenson 1992)

**REGULATION**

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

(Alberts 1994)
Through “hidden maternal regulators”...

We concluded from these surprising results that warmth provided by the mother normally maintained the pup's activity level and that her milk maintained her pup's heart rate. Maternal

warmth → activity level
milk → heart rate

"physiological set points"
internal working models
scripts - templates

a mother precisely controls every element of her infant's physiology, from its heart rate to its release of hormones from its appetite to the intensity of its activity

(Gallagher 1992)

The Neuroscience of Birth & Breastfeeding

The Brain
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EVOLUTIONARY BIOLOGY

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BABY
BONDING

When does the infant become conscious?

Scientific American 1986
Scientific American Mind 2009

Noradrenergic neurons from LOCUS COERULEUS may activate the whole brain during wakefulness

Scientific American Mind 2009

Awake at birth

Scientific American Mind 2009
You can never reach the same high levels of catecholamine levels during your whole life as at birth.

Reduced catecholamine surge after C-section compared to vaginal delivery and elective C-section.

Riccardo Pfister

Reduced catecholamine surge after C-section required to activate (epithelial sodium channel) pump to get lung liquid clearance.

MODE OF DELIVERY AFFECTS FETAL LUNG LIQUID CHANGES THAT RELATE TO CLINICAL ADAPTATION

Conclusion: Clinical and experimental evidence suggests that pre-labour birth not only results in relative prematurity, but additionally entails the extent of lung liquid clearance that occurs in a normal vaginal delivery at term. Although methods can be used to improve maturaion of the pulmonary gas exchange “maturation”, the active expulsion of lung liquid via the airway appears to refer to the occurrence of uterine contractions, while the normal trigger for trans-epithelial liquid absorption in the amniotic and postnatal lung depends on a labour induced adrenal surge.
Reduced catecholamine surge after C-section

Why?

Vaginal delivery  Elective C-section

The newborn brain consumes 50% of all the blood glucose - In the adult 20%

Scientific American 2010

The infant brain is not blank! Resting activity - “stream of consciousness”

AT BIRTH, the brain has TWO CRITICAL SENSORY NEEDS:

SMELL & CONTACT connect direct to the amygdala

AT BIRTH, the brain has TWO CRITICAL SENSORY NEEDS:

SMELL & CONTACT connect direct to the amygdala

THE NEWBORN BRAIN SKIN-TO-SKIN CONTACT fires and wires

the amygdala-prefronto-orbital cortical pathway (PFOC)

SOCIAL and EMOTIONAL INTELLIGENCE

Prefrontal cortex Executive function

AMYGDALA: Emotional Processing Unit

SOCIAL and EMOTIONAL INTELLIGENCE

Prefrontal cortex Executive function

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SOCIAL and EMOTIONAL INTELLIGENCE

Prefrontal cortex Executive function

AMYGDALA: Emotional Processing Unit

SOCIAL and EMOTIONAL INTELLIGENCE

Behavioinal activation system reward-based (dopamine)
In humans, oxytocin increases gaze to the eye region of human faces and enhances interpersonal trust and the ability to infer the emotions of others from facial cues.
Here we demonstrate that in 2- to 3-month-old infants, the language-related neural substrate is fully active in both hemispheres with a preponderance in the right auditory cortex.

... although the brain responds to spoken language already at birth, thereby providing a strong biological basis to acquire language, progressive maturation of intrahemispheric functional connectivity is yet to be established with language exposure as the brain develops.

Neural language networks at birth

Fransson 2007
The BOND is made up of the sensory inputs from the parent to the infant.

REGULATION

Through “hidden maternal regulators”...

- warmth → activity level
- milk → heart rate

“physiological set points”

internal working models

scripts - templates

...a mother precisely controls every element of her infant’s physiology, from its heart rate to its release of hormones from its appetite to the intensity of its activity.

(Gallagher 1992)

Psychobiological Roots of Early Attachment

SEPARATION DYSREGULATES CORTISOL

SEPARATION

Detachment

Regulation

Loss of Regulatory Interactions

WHY IS EARLY MATERNAL SEPARATION STRESSFUL?

Fig. 1. Schematic representation of the dynamics of early-separation responses based on the concept of an attachment bond as described by John Bowlby (Bowlby, 1982).

Fig. 2. Schematic representation of the dynamics of early-separation responses resulting from the loss of regulatory interactions within the mother-infant relationship.
Maternal absence causes neonatal instability.

Components (e.g., nutrient, thermal/metabolic, or sensorimotor) of the infant's previous interaction with its mother and that the complex response to separation was due to the withdrawal of all these components at once.

PROTEST - DESPAIR is accompanied by DYSREGULATION

The impact of separation from the mother is quite profound in the infant primate and is well-documented in infant monkeys. They typically display a biphasic response characterised by an initial stage ('protest') of hyperactivity associated with distress vocalisations, followed by a depressive stage ('despair') marked by social withdrawal, a decrease in play, and the development of a typical sloshed posture (Minaka and Sooma, 1976; Capitanio, 1986). This is accompanied by physiological disturbances in the regulation of heart rate, body temperature, sleep patterns, cortisol secretion and the immune system (Landrnelger et al.,

EPIGENES ...
controls on the DNA/gene "switches in the mind"

G x E
"Phenotype" - specimen resulting from gene - environment interaction

MICHAELE MEANEY
epigenetics

Early stress alters gene expression, with health impact across lifespan.

Unsafe environment activates HPA axis (autonomic nervous system, ANS).
This maternal care was NOT abusive, just sub-standard.

This care is basically skin-to-skin contact.

Earliest care at birth matters

Same gene → switched
Earliest care at birth matters

Same gene switched

The Place FITNESS EXPERIENCE ADAPTATION

OXYTOCIN

Primate separation studies

Amygdala Gene Expression Correlates of Social Behavior in Monkeys Experiencing Maternal Separation

Children exposed to early parental loss from death or separation carry a greater risk for developing later psychiatric illnesses, such as anxiety and depression. Maternal separation paradigms in animals (e.g., infant monkeys) have shown that early-life stress can affect behavior in adulthood, such as increased anxiety and depression. These studies suggest that early-life stress can have long-lasting effects on the brain and behavior.

Maternal Separation Paradigm

0w 1w 2w 3w 4w 5w 6w → 12w
n 4 Mat MNS → group reared no mother

Gene specific for the AMYgdALA (GUYCIA3)

Separated at 1 week:
LOW gene expression:

Increased self soothing → Anxiety
Decreased sociality → Depression

Repeated short separations:
LOW gene expression:

Correlate to human adult depression

Primate Early Life Stress Leads to Long-Term Mild Hippocampal Decreases in Corticosterone Receptor Expression

Depression is predicted by prior early life stress (ELS), such as parent-infant/child neglect or abuse (1,2), but mediating mechanisms and processes are not well-understood. Maternal separation paradigms in animals (e.g., infant monkeys) have shown that early-life stress can affect behavior in adulthood, such as increased anxiety and depression. These studies suggest that early-life stress can have long-lasting effects on the brain and behavior.

Maternal Separation Paradigm

Early Deprivation (ED) vs control (CON)

ED n 11 Mat 0d 2d → 28d → 48w

CON n 4 Mat 0d → 30 min daily → 48w

Prolonged institutional rearing is associated with atypically large amygdala volume and difficulties in emotion regulation
Adults with depression, suicides:
LOW gene expression
smaller hippocampal volume
reduced expression frontal lobe

These findings translate previous results from rats / monkeys to humans

Epigenetic regulation of the glucocorticoid receptor in human brain associated with childhood abuse

Adults with depression, suicides:
LOW gene expression
smaller hippocampal volume
reduced expression frontal lobe

Increased methylation of glucocorticoid receptor gene (NR3C1) in adults with a history of childhood maltreatment: a link with the severity and type of trauma

Maternal support in early childhood predicts larger hippocampal volumes at school age

Hippocampus volume by preschool depression severity and maternal support.

These findings translate previous results from rats / monkeys to humans

Epigenetic regulation of the glucocorticoid receptor in human brain associated with childhood abuse

Adults with depression, suicides:
LOW gene expression
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reduced expression frontal lobe
The Neuroscience of Birth & Breastfeeding

Nelson & Panksepp 1998

SAFE    UNSAFE

The DNA
Behaviour
EVOLUTIONARY  BIOLOGY
ENVIRONMENT
BABY
REPRODUCTIVE  FITNESS
BIRTH
BONDING
SEPARATION

Integrative-Emotional System for Social Affect

The Brain
NEURODEVELOPMENT
ADAPTATION
EXPERIENCE

MATERNAL DEPENDENCE

HABITAT
MATERNAL MOTHER
OTHER
ALTERNATE

THE "OLD" BRAIN HAS
3 PROGRAMMES
DEFENCE
NUTRITION
REPRODUCTION

SKIN-TO-SKIN CONTACT

FROM BIRTH
COMPARSED TO CONVENTIONAL INCUBATOR CARE

Research funded by THRASHER RESEARCH FUND, U.S.A.

Admin and stats by MEDICAL RESEARCH COUNCIL, R.S.A.

The Neuroscience of Birth & Breastfeeding

Nelson & Panksepp 1998

SAFE    UNSAFE

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THE PLACE MODEL

SKIN-TO-SKIN CONTACT

Breastfeeding (PSNS) Growth

Other

Protest, Stress, Survival or Despair

Reference

RCT of skin-to-skin contact from birth versus conventional incubator care for physiological stabilisation in 1200- and 2199-gram newborns.

Bergman NJ, Linley LL, Fawcus SR. Acta Paediatrica 2004 Vol 93(6); 779-785
Primary hypothesis

SSC (skin-to-skin contact) from birth is superior to incubator care for low birthweight infants

ONLY HABITAT DIFFERS

Results

Minimisation technique ensured groups balanced for confounders.

<table>
<thead>
<tr>
<th></th>
<th>KMC</th>
<th>CMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean weight</td>
<td>1813g</td>
<td>1866g</td>
</tr>
<tr>
<td>Mean GA</td>
<td>34.2w</td>
<td>35.3w</td>
</tr>
<tr>
<td>Approp GA</td>
<td>65%</td>
<td>64%</td>
</tr>
<tr>
<td>Male</td>
<td>60%</td>
<td>60%</td>
</tr>
</tbody>
</table>

(n = 34)

Control

Intervention

Mean weight 1813g    1866g
Mean GA 34.2w    35.3w
Approp GA 65%      64%
Male 60%      60%

(p 765)

Research hypotheses

<table>
<thead>
<tr>
<th></th>
<th>Stabilising DURING 6h</th>
<th>Stabilised AT 6 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAILOUT</td>
<td>H1a</td>
<td>H1b</td>
</tr>
<tr>
<td>SCRIP</td>
<td>H2a</td>
<td>H2b</td>
</tr>
</tbody>
</table>

BAILOUT points

"physiological parameters exceeding normal limits, requiring medical assessment and or intervention"

1 Skin temp consistently <35.5°C
2 Heart rate <100; or > 180 bpm
3 Apnoea longer than 20 seconds
4 O₂ sats below 89% (x2), (CPAP/60% O₂)
5 Blood glucose < 2.6mmol/l, (laboratory)

H1b (SPECIFIC)

Doctor summoned:

INCUBATOR: 92% 8%
SKIN-TO-SKIN: 17% 83%

THE PLACE MODEL

SKIN-TO-SKIN CONTACT

MOTHER

INCUBATOR: 83% “STABLE”
SKIN-TO-SKIN: 8% “STABLE”

Bergman et al 2004
**STABILITY**

- Heart rate
- Oxygen saturation
- Respiratory rate

**SCRIP**

- **Heart rate**: Regular
- **Deceleration**: to 80-100 bpm
- **Rate >200 bpm**: Apnoea <10s or periodic breathing
- **Apnoea >10s**: Tachypnoea >80 pm
- **Oxygen saturation**: Regular >87%
- **Any fall to 80-87%**: Any fall below 80%

*Score allocated for a five minute period of continuous observation, maximum six for period* **Fischer et al, 1988**

### “100% SCRIP STABILITY”

<table>
<thead>
<tr>
<th>Weight Range</th>
<th>1st-6th Hour</th>
<th>6th Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200g to 2200 g</td>
<td>56% 11%</td>
<td>100% 46%</td>
</tr>
<tr>
<td>1200g to 1800g</td>
<td>44% 0%</td>
<td>100% 25%</td>
</tr>
</tbody>
</table>

### Stabilization 1200g - 1800g

- **Skin-to-skin**
- **Incubator**

*Hourly average of SCRIP score, 2nd to 6th hour*

### INCUBATORS DE-STABILISE NEWBORNS

- **SKIN-TO-SKIN**

*BERGMAN et al 2004*

### Stabilization

- **Breastfeeding**
- **Mother Feeding**
- **Other**
- **PROTEST-DESPAIR (SNS)**

*SEPARATION CORTISOL*

*Bergman et al 2004*

**PROTEST - DESPAIR causes**

9.4.1. Separation of infants:
The impact of separation from the mother is more profound in the infant primate and is well-documented in infant macaques. They typically display a biphasic response characterised by an initial stage ("protest") of hyperactivity associated with distress vocalisations, followed by a depressive stage ("despair") featuring social withdrawal, a decrease in play, and the development of a typical sloth posture (Miner and Sonni, 1974; Capistrano, 1986). This is accompanied by physiological disturbances in the regulation of heart rate, body temperature, sleep patterns, cortisol secretion, and the immune system (Luchshneider et al.,

**DYSREGULATION**

**WHY IS EARLY MATERNAL SEPARATION STRESSFUL?**

**REGULATION vs STIMULATION**

- Expected vs Unexpected
- Ecologic salience vs Potential threat
- Resource growth vs Threat readiness

- **OXYTOCIN vs CORTISOL**
- **HOMEORHESIS vs HOMEOSTASIS**
- **MOTHER vs OTHER**
Maternal absence causes neonatal instability.

![Diagram](image)

Maternal presence (SSC) regulates preterm physiology.

(Alberts 1994)

"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 lifetime."
**BONDING components**

- Emotional
- Social
- Physical

**SENSATIONS THAT WIRE BRAIN**

- SEES Mum’s eyes
- SMELLS Mum’s milk
- TASTES Mum’s milk
- Touches Mum’s skin
- Hand TOUCH Mum’s skin
- Skin-to-skin CONTACT
- Back FEELS Mum’s arm
- Ear HEARS Mum’s voice
- MOVES with Mum
- WARMED on Mum’s front

**The Neuroscience of Birth & Breastfeeding**

- The DNA
- EPIGENETICS
- BEHAVIOUR
- NEURODEVELOPMENT
- EVOLUTIONARY BIOLOGY

**The Brain**

- Environment
- Adaptation
- Experience
- Reproductive Fitness

**Psychobiological Roots of Early Attachment**

**BONDING consequence**

- **Adult**: Attachment Anxiety to partner
- **Child**: Insecure attachment

- **CORTISOL**
  - Adult: Higher CORTISOL and lower immunity (CD4 cells)

- **ANS**
  - Emotional

- **Physical**

**John Bowlby**

Secure attachment: "a safe base from which to explore the world".

- Safe Haven
- Secure base
- Proximity maintenance
- Separation distress

---

**a kind of invisible hothouse**

**BREAST - FEEDING = BRAIN - WIRING**

---

**Jaremka 2013**
The Neuroscience of Birth & Breastfeeding

**Critical period concept:**

"Windows of opportunity in early life when a child's brain is exquisitely primed to receive sensory input in order to develop more advanced neural systems."

A mother's brain...  
SENSITIZATION

Dose of SCC first 24 hours correlates  
Maternal behaviour Q Sort  
Predicts attachment security

Dose of SCC first 24 hours correlates  
NCATS (Nursing Child Assessment Teaching Scale)  
Predicts cognitive outcome  
SENSITIZATION
The Neuroscience of Birth & Breastfeeding

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REPRODUCTIVE FITNESS

BIRTH
BABY
MOTHER

LOVING
Sensitization

BREASTFEEDING
Sleep / Sleep Cycling

Secure Attachment
Attuned parenting

Resilience

RESILIENCE
(= STRESS RESISTANCE)

“capacity to maintain healthy emotional functioning in the aftermath of stressful experiences”

RESISTANCE / SENSITIVITY

ALLOSTASIS

ANY STRESS:
Psychological
Neurological
Endocrine
Immune

STRESS → RESPONSE

health

ALLOSTATIC LOAD

elevated activity of mediators, with return to baseline and no impact on health.

elevated activity sustained over time, or severe ...
→ changes the “set points” for homeostasis (e.g. increasing blood pressure, change in cholesterol level)

ALLOSTASIS

ANY STRESS:
Psychological
Neurological
Endocrine
Immune

PERCEPTIONS
“NEUROCEPTION”

STRESS → RESPONSE

PERCEPTIONS
“NEUROCEPTION”

Severity of stress uniquely determined by individual.

ALLOSTASIS

ANY STRESS:
Psychological
Neurological
Endocrine
Immune

STRESS → RESPONSE

PERCEPTIONS
“NEUROCEPTION”

Health

ALLOSTASIS

ANY STRESS:
Psychological
Neurological
Endocrine
Immune

PERCEPTIONS
“NEUROCEPTION”

STRESS → RESPONSE

ALLOSTATIC STATE

Health
CORTISOL

Allostasis & Allostatic Load

http://www.imr.no/copewell/work_packages/wp3/en

CORTISOL

ALLOSTASIS
ANY STRESS: Psychological Neurological Endocrine Immune PERCEPTIONS “NEUROCEPTION”

STRESS \rightarrow RESPONSE

\leftarrow RESISTANCE \rightarrow SENSITIVITY

ALLOSTATIC STATE

ALLOSTATIC LOAD

ALLOSTATIC OVERLOAD

HEALTH

ALLOSTATIC LOAD

ALLOSTATIC OVERLOAD

HEALTH

VULNERABILITY

WELL-BEING \rightarrow SUSCEPTIBILITY \rightarrow MORBIDITY \rightarrow MORTALITY

RESILIENCE

=" STRESS RESISTANCE"

“capacity to maintain healthy emotional functioning in the aftermath of stressful experiences”
Awake at birth

Noradrenergic neurons from LOCUS COERULEUS may activate the whole brain during wakefulness.

Fransson 2007

A primary visual areas,
B somatosensory motor cortex
C primary auditory cortex
D parietal cortex & cerebellum
E m l anterior prefrontal cortex

EMOTION CONTROL CENTRE

FACE RECOGNITION CENTRE

SOCIAL CONTROL CENTRE

REWARD CONTROL CENTRE

FEAR CONTROL CENTRE

DOPAMINE

CORTISOL

OXYTOCIN

RESILIENCE (= STRESS RESISTANCE)

“capacity to maintain healthy emotional functioning in the aftermath of stressful experiences”

OXYTOCIN

CORTISOL
... there is considerable overlap in the brain structures associated with these neural mechanisms ... functional interactions among the circuits.

An overly responsive fear circuit ... may negatively influence functioning of the reward system.

... a properly functioning reward circuit may be necessary for ... positive social behaviors.

Maternal separation produces lasting changes in cortisol and behavior in these offspring. 

RESILIENCE: “capacity to maintain healthy emotional functioning in the aftermath of stressful experiences”

Plasma CORTISOL response to STRESS (2y)

RESILIENCE (= STRESS RESISTANCE)

“capacity to maintain healthy emotional functioning in the aftermath of stressful experiences”

The Neuroscience of Birth & Breastfeeding

The Brain

EPIGENETICS

BEYOND

BABY

MOTHER

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NEURODEVELOPMENT

RESILIENCE

DISEASE

RESISTANCE

CORTISOL

OXYTOCIN

Plasma CORTISOL response to STRESS (2y)

DISEASE

RESISTANCE

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EXPERIENCE

ADAPTATION

NEURODEVELOPMENT

RESILIENCE

DISEASE

RESISTANCE

CORTISOL

OXYTOCIN
The basic science of pediatrics.

Shonkoff J P et al.
Pediatrics 2012; 129:e232-e246

The Neurosciences of Birth & Breastfeeding

The DNA
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Neurodevelopment
Evolutionary Biology
Environment
Adaptation
Experience
Reproductive Fitness

Positive Stress

• Moderate, short-lived stress responses, such as brief increases in heart rate or mild changes in stress hormone levels.

Slide by: Jack P. Shonkoff, M.D.

Tolerable Stress

• Stress responses that could disrupt brain architecture, but are buffered by supportive relationships that facilitate adaptive coping.

• Generally occurs within a time-limited period, which gives the brain an opportunity to recover from potentially damaging effects.

Slide by: Jack P. Shonkoff, M.D.
Toxic Stress

• Strong and prolonged activation of the body’s stress management systems in the absence of the buffering protection of adult support.

• Disrupts brain architecture and leads to stress management systems that respond at relatively lower thresholds, thereby increasing the risk of stress-related physical and mental illness.

“Non-pharmacological reduction of hypercortisolaemia in preterm infants”

Moder & Glover 1998, Mooncey et al 1997

Preterm infants experience prolonged severe stress with tenfold increases in stress hormones.
Stress hormones at such levels are neurotoxic.

RCT on methods to reduce stress (at one hour):

- Cortisol
- Endorphin
- Massage: slightly lower
- Soft music: no change
- Skin-to-skin: 66% lower 74% lower

“Of a good beginning cometh a good end”

John Heywood, Proverbs (1546)

When is the beginning?

BERGMAN COMMENTARY — NEWBORN

Early years = early hours & days “FIRST 1000 MINUTES”

Learning Behavior Physical well being Mental well being
Bergman Commentary - Newborn

Maternal absence is toxic stress.

Toxic stress occurs when there is strong and prolonged activation of the body's stress management systems in the absence of the buffering protection of adult support.

Reducing toxic stress is very easy.

The neuroscience of birth & breastfeeding:

- The DNA
- The brain
- Epigenetics
- Neurodevelopment
- Behaviour
- Evolutionary biology

Environment: Adaptation → Experience → Reproductive fitness

Birth:
- Bonding
- Maternal
- Separation

Beyond breastfeeding:
- Secure attachment
- Disordered attachment
- Vulnerability

Resilience
- Cortisol
- Oxytocin
- Cessation
- Sleep cycling

Massive cost $$$

Reduction of toxic stress leads to healthier lifestyles, chronic diseases, and health disparities.
**The Neuroscience of Birth & Breastfeeding**

<table>
<thead>
<tr>
<th>Environment</th>
<th>Adaptation</th>
<th>Experience</th>
<th>Reproductive Fitness</th>
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</thead>
</table>

**Birth**
- Bonding
- Sensitization
- Breastfeeding
  - Feeding & Sleep Cycling

**Beyond**
- Secure Attachment
- Attuned Parenting
- Disordered Attachment
- Resilience
- Vulnerability

**Health**

**Disease**

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**Gastrointestinal function development and microbiota**

Gut microbial colonisation in premature neonates predicts neonatal sepsis

Juliette C. Midan,1 Richard Cowper-Salari,2 Olego Sauven,3 Lisa Davidson,4

Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns

María G. Domínguez-Bello,1,³ Elizabeth K. Costello,1,³ Monica Centorieri,1,³ Mapila Mejía,1,⁵ gift Hidalgo,1,⁵ Health Physio,1,³ and Bob Knight1,³

The "Perfect Storm" for Type 1 Diabetes

The Complex Interplay Between Intestinal Microbiota, Gut Permeability, and Mucosal Immunity

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The Neuroscience of Birth & Breastfeeding

**MOTHER**

is the key to neurodevelopment ... ... because she is the **RIGHT PLACE!!**

A mother and baby

**IT MATTERS**

**HOW WE ARE BORN**

SEPARATION

**ZERO SEPARATION**

the innate agenda of mother and baby

DISEASE

**IT MATTERS**

HOW WE ARE BORN

**SEPARATION**

VIOLATES the innate agenda of mother and baby

DISEASE
The neuroscience of birth – and the case for Zero Separation

Innovative strategies ... ... reduce toxic stress
Creative new strategies
“compelling need for bold new strategies”
An ecobiodevelopmental framework for early childhood policies and programs.

Attachment

Bonding

Skin-to-Skin Contact

Breastfeeding

Skin-to-Skin Contact

Breastfeeding

BERGMAN COMMENTARY - NEWBORN
Reducing toxic stress IS VERY EASY!!

PERINATAL NEUROSCIENCE and SKIN-TO-SKIN CONTACT

INTRODUCTION
“It is easier to build strong children than to repair broken men.”
Frederick Douglass (1817–1895)

www.skintoskincontact.com

ZERO SEPARATION
“It is easier to build strong children than to repair broken men.”