The Urban Child Institute

Because We Care About Our Children

www.TheUrbanChildInstitute.org

Hank Herrod, MD

Optimizing Early Brain Development:

Can It Make a Difference in Memphis?

We Believe The Answer Is Yes!!

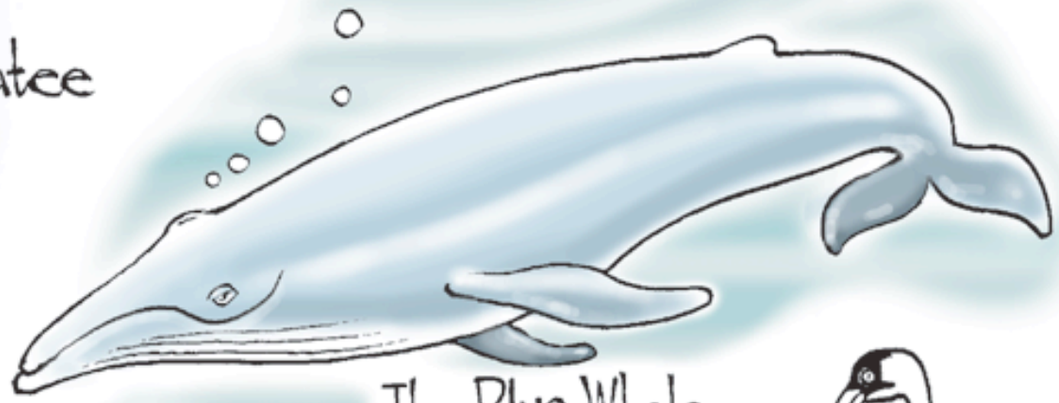
Why Is a Healthy Early Childhood So Important?

- The healthy development of children provides a strong foundation for healthy and competent adulthood, responsible citizenship, economic productivity, strong communities, and a sustainable society.
  Source: J. Shonkoff Harvard's Center on the Developing Child

- Converging evidence from biology, economics, sociology, psychology, support the concept of the importance of brain development in early childhood as crucial to ultimate adult outcomes.

A BRIEF LIST OF ENDANGERED SPECIES

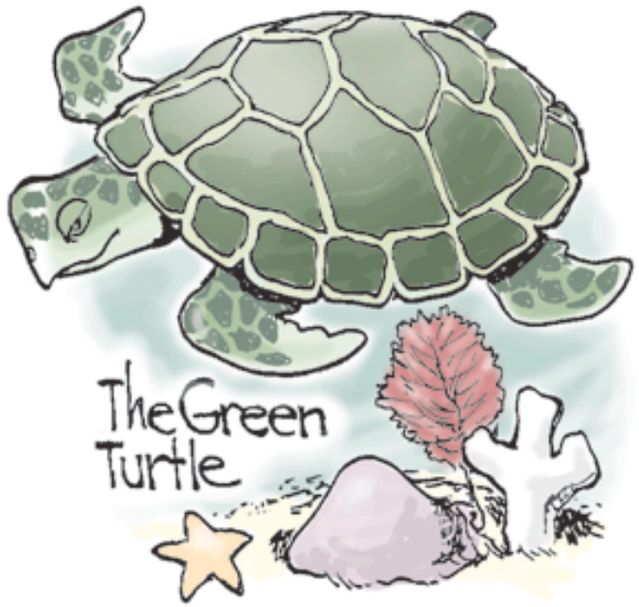
The Manatee



The Blue Whale

The Golden-Cheeked Warbler

The Spotted Owl



The Green Turtle

The Whooping Crane

The Urban Child

The Urban Child Institute: Mission

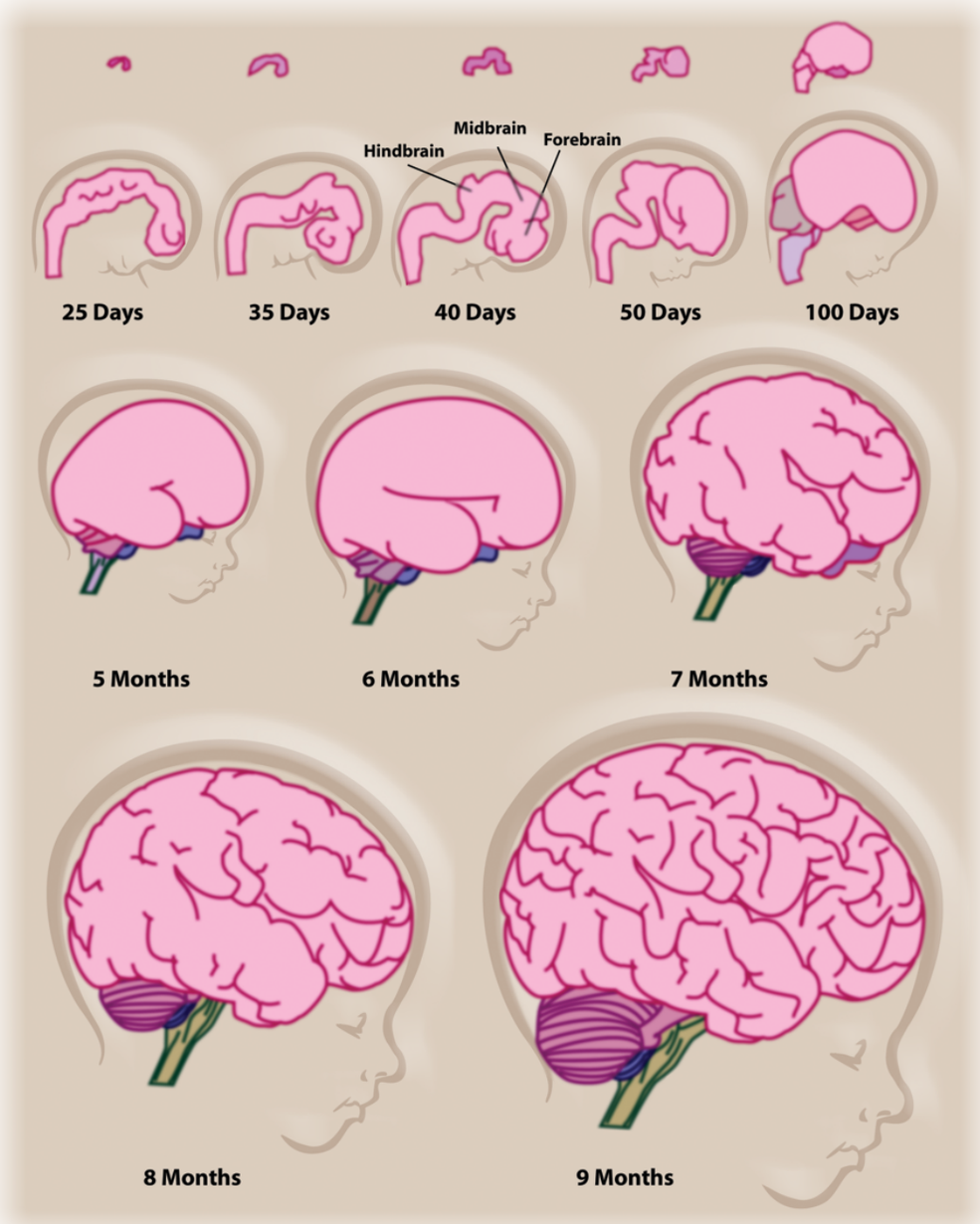
Our mission is to increase awareness of the importance of optimal brain development from conception to three years of age in Memphis and Shelby County.

TUCI Structure

- Emphasis on early brain development
- TUCI houses social scientists from UM, epidemiologists and bio-statisticians from UTHSC, employed staff
- Focus areas: Data ➡ Dissemination ➡ Policy
- Community-focused investments
  - Neighborhood Christian Center
  - Conditions affecting neurocognitive development and learning in early childhood (CANDLE) study

The Human Brain

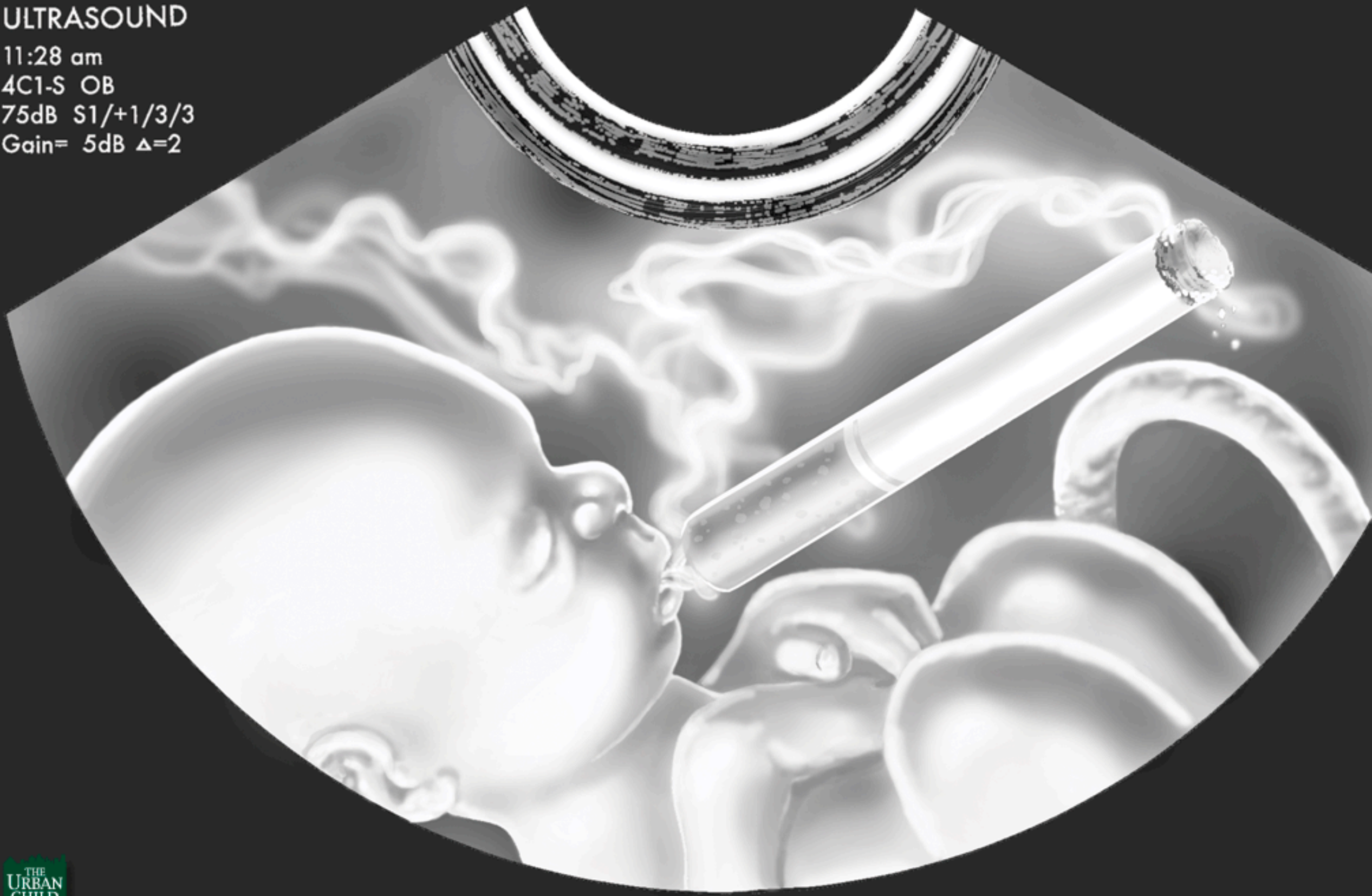
The Brain from Conception to Birth



How Does the Mother's Lifestyle Influence the Fetal Brain?

- Almost **anything** Mom does can affect the fetus both positively and negatively
- Examples
  - Environmental exposures
  - Substance abuse
  - Nutrition
  - **Stress**

UNIT 649399 LR
20F: MOTHER, SMOKER
ULTRASOUND
11:28 am
4C1-S OB
75dB S1/+1/3/3
Gain= 5dB ∆=2



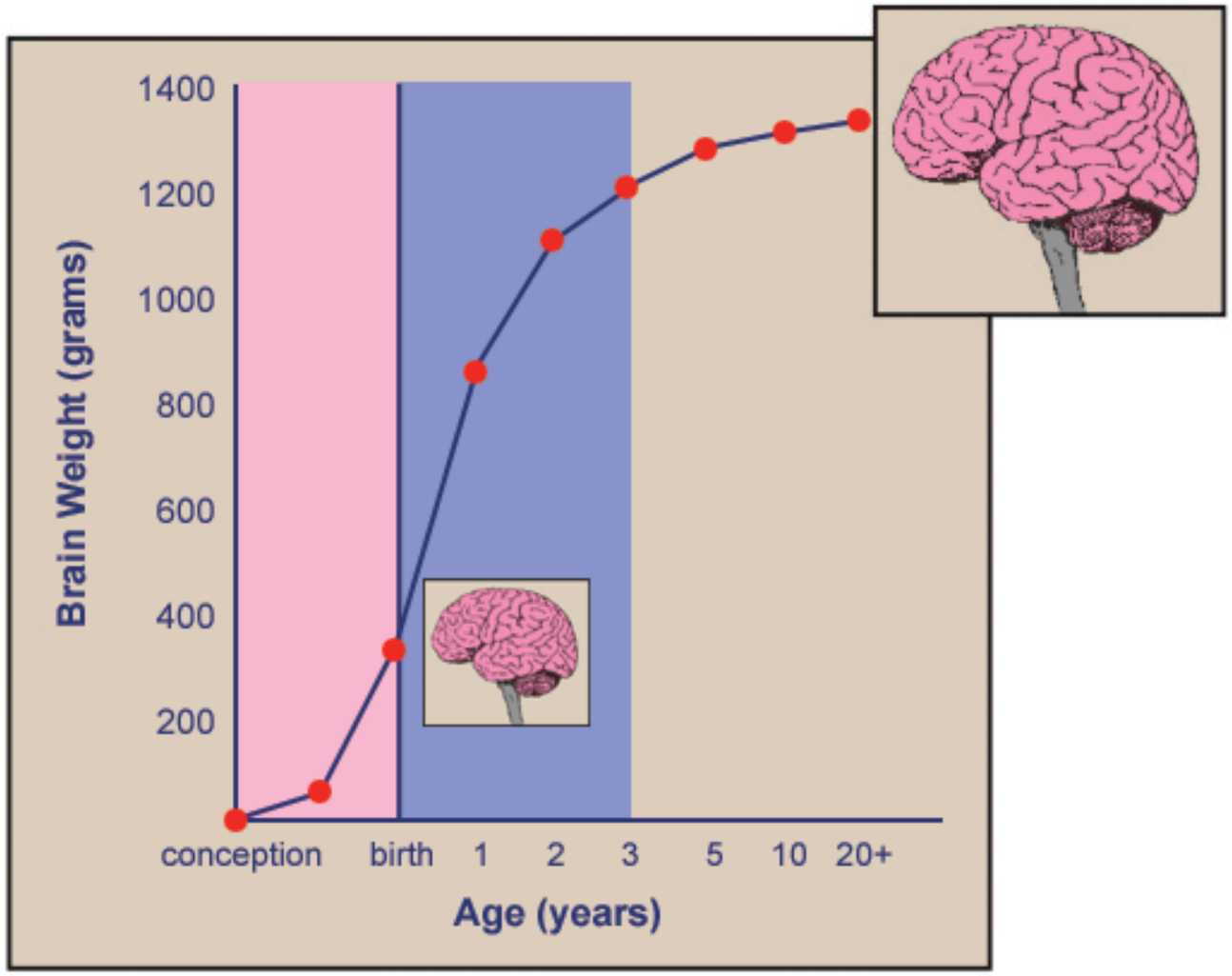
Normal Brain (L) and
Brain Exposed to Excessive Alcohol (R)

Maternal Nutrition: The Relationship Between Neural Tube Defects and Folic Acid

Status of the Brain at Birth

- 100 billion neurons present
- Each neuron can have up to 10,000 synapses
- The developing brain
  as an architectural project:
  Plans (blueprint – genes) and hardware (foundation, framing, exterior, interior – neurons, glial cells) are in place but connections (insulation, mechanics, making it work –synapses) not yet made
  - Quality building supplies (nutrition, nurturing, experiences)
  - Master carpenter (experiences)
- Use it or lose it
- Do it early – it's too expensive and difficult to fix it later

The Developing Brain: From Birth to Adolescence



Both **Nature** (Genes) and **Nurture** (Environment)
are important for optimal brain development

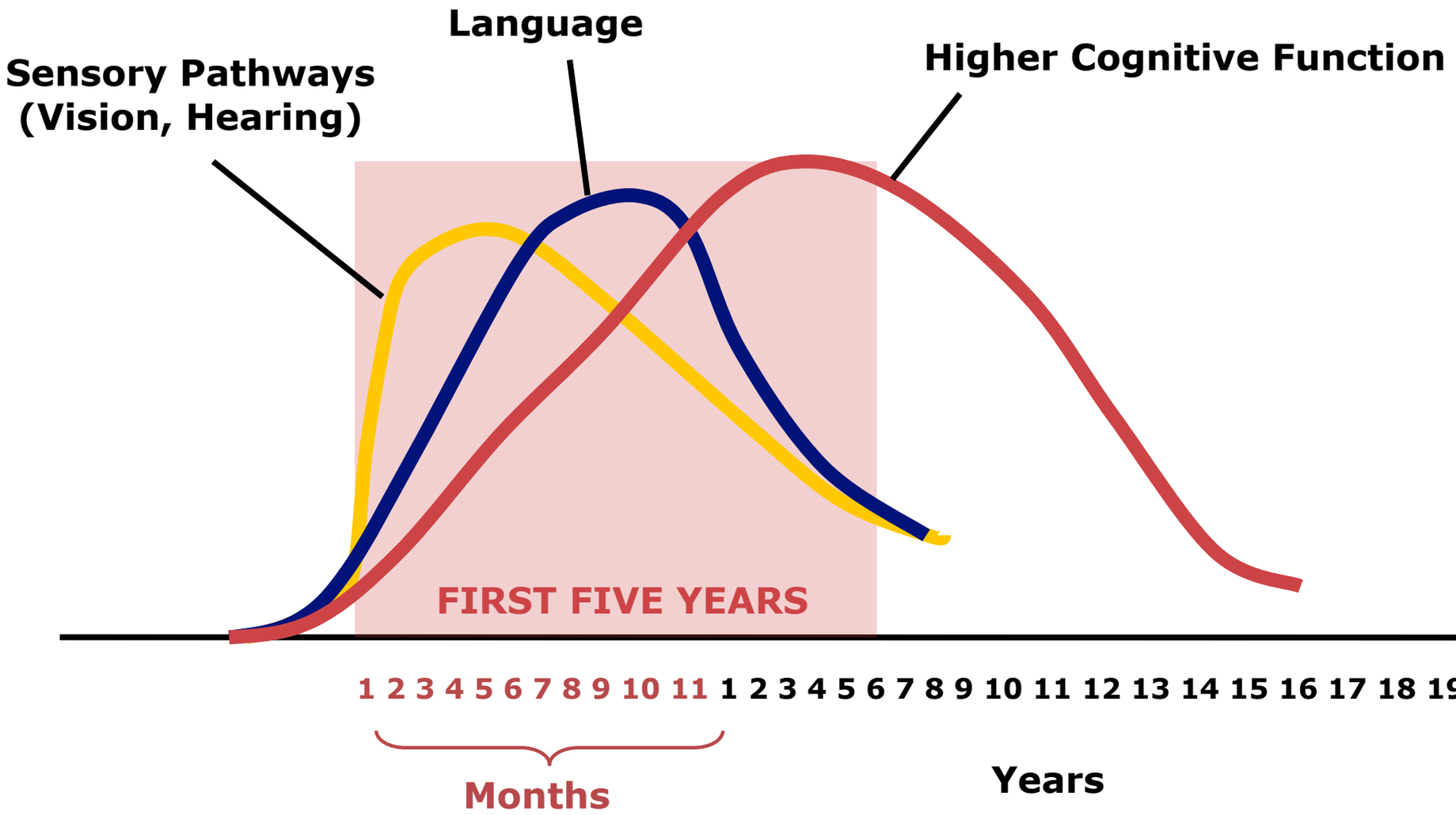
The Developing Brain Has Periods of Exceptional Sensitivity to the Effects of Experience and Environment

- Maturing neural circuits are influenced by molecular events that are triggered by external factors
  e.g., vision, hearing, language, responses to social cues

- Sensitive periods occur at different ages for different parts of the brain

Neural Circuits are Wired in a Bottom-Up Sequence

(700 synapses formed per second in the early years)



Source: C.A. Nelson (2000)

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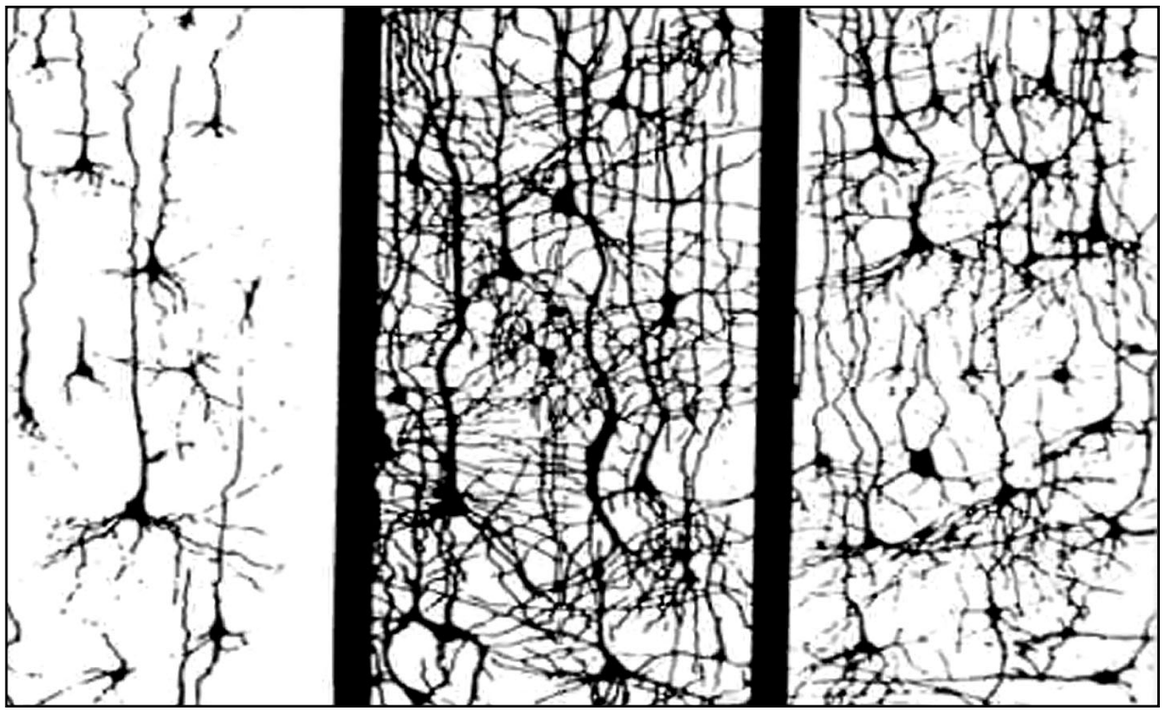
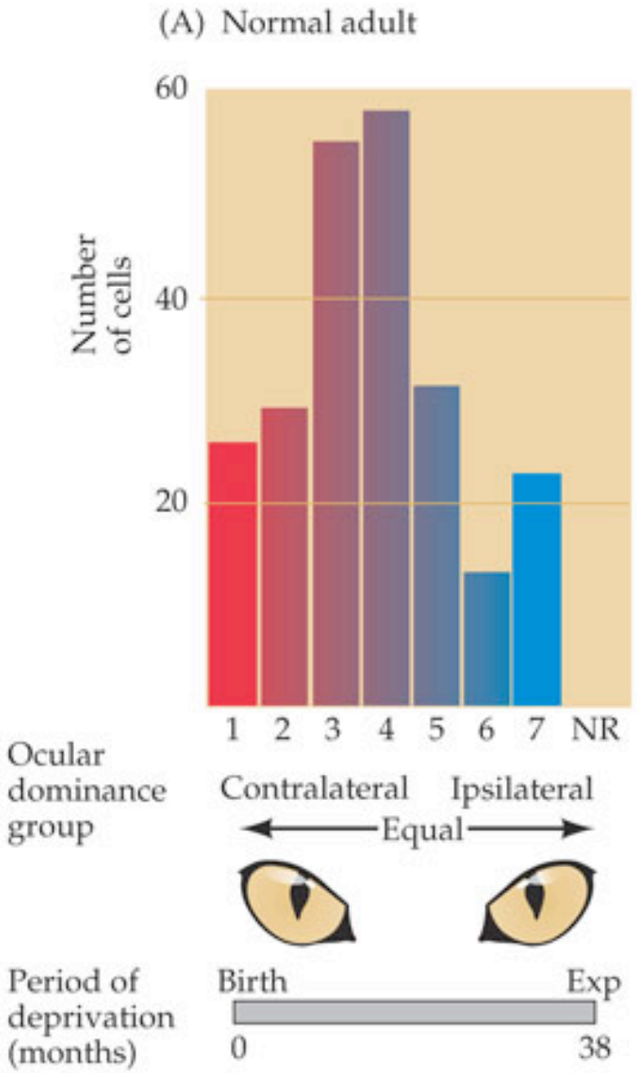
Pruning Effects, Neuron Density, and Synaptic Connections in Development: **Use It or Lose It**

3 mos 6 mos 14 yrs

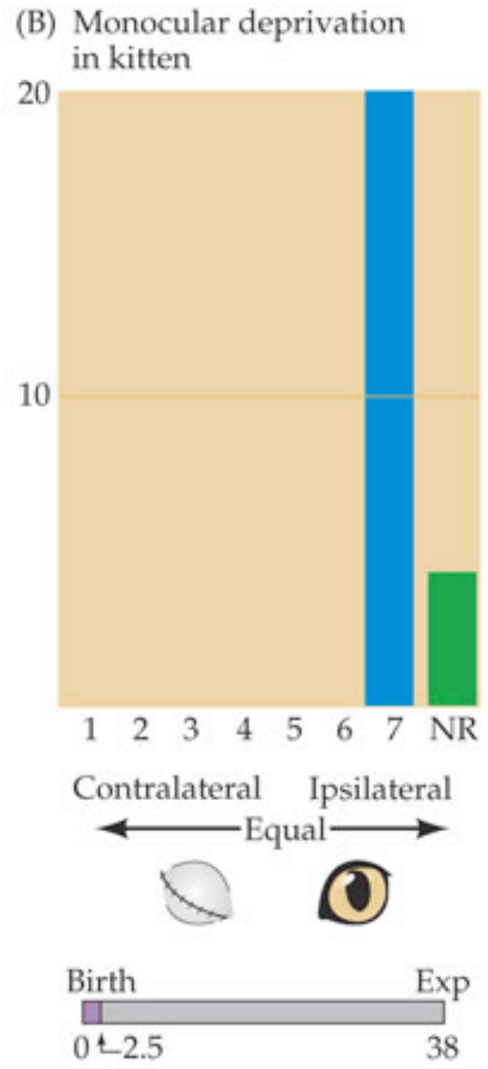


Source: H.T. Chugani
Wayne State University

Critical Period for Visual Development in Kittens: The Influence of Visual Stimulus



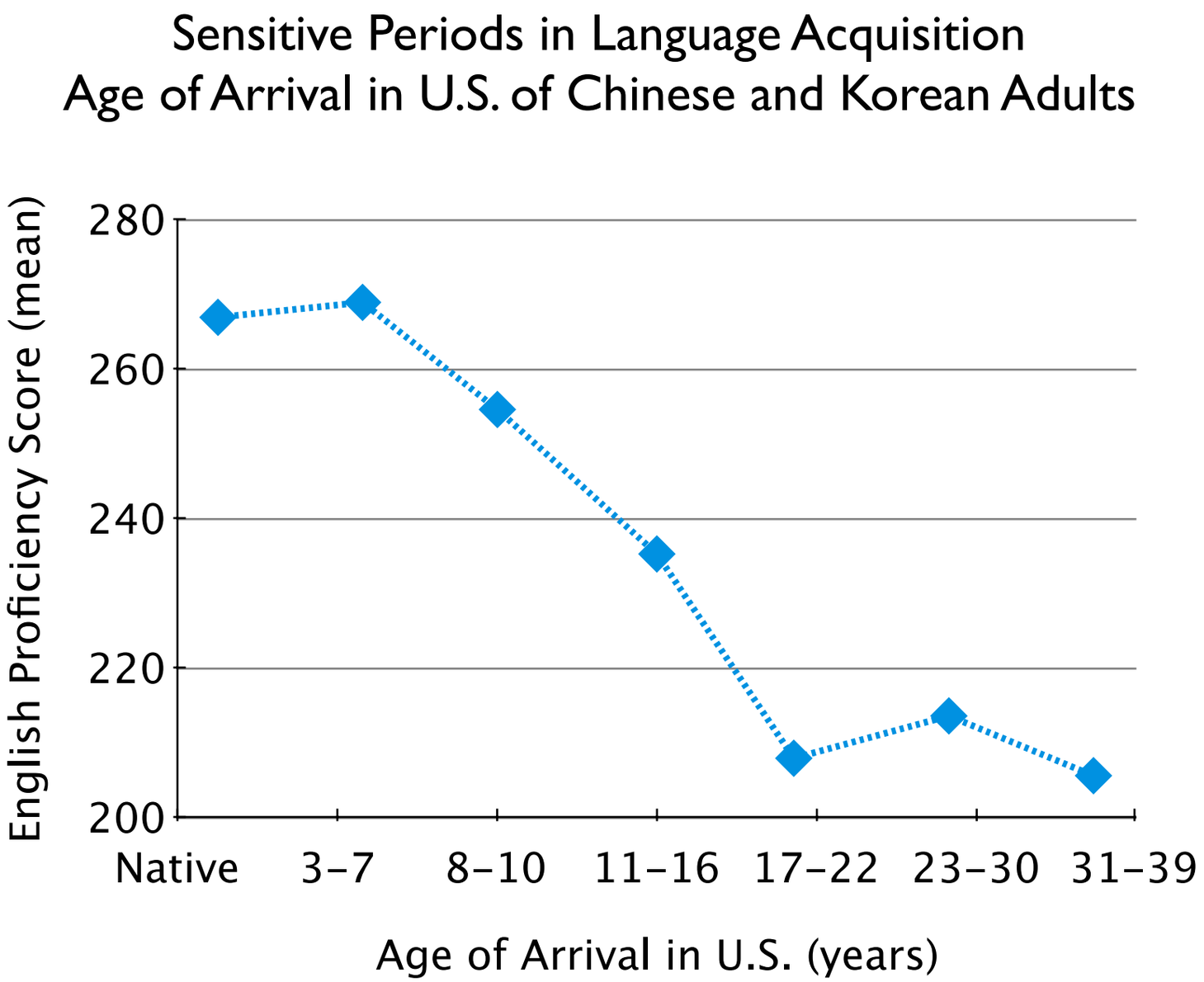
Normal response properties of brain cells.



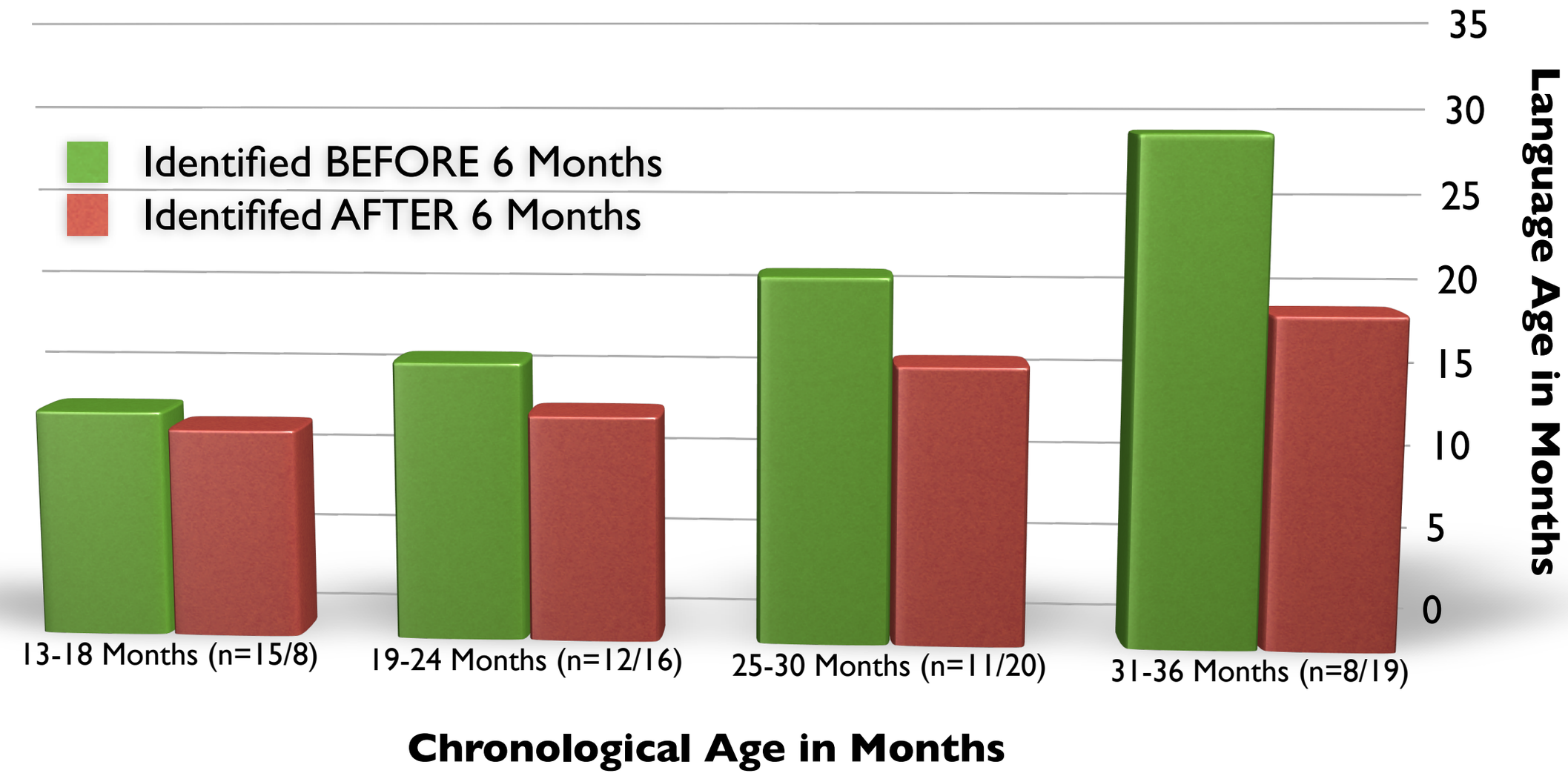
After visual deprivation of one eye: Majority of brain cells are driven by the non-deprived eye (shift in ocular dominance).

Source: NEUROSCIENCE, Third Edition, Figure 23.4 (Part 1) © 2004 Sereauer Associates, Inc.

Critical Periods for Language Development



Expressive Language Scores for Hearing Impaired Children Identified Before and After 6 Months of Age



The ACE Study

- The Adverse Childhood Experience (ACE) Study-A CDC, Kaiser Permanente Collaborative

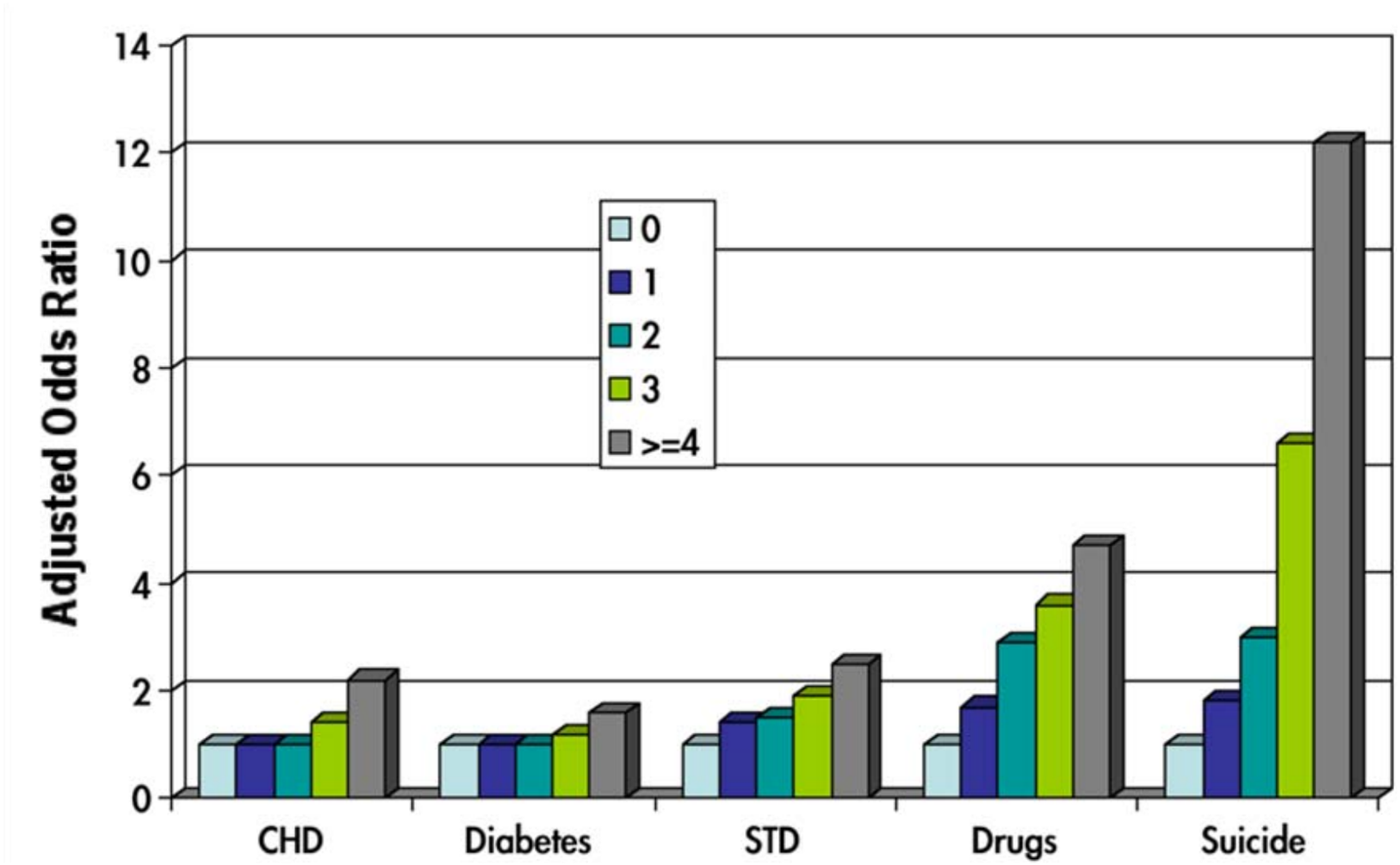
- 17,000 Middle Class Enrollees average age 57 years

- 10 ACE: Abuse, Neglect, Household Dysfunction

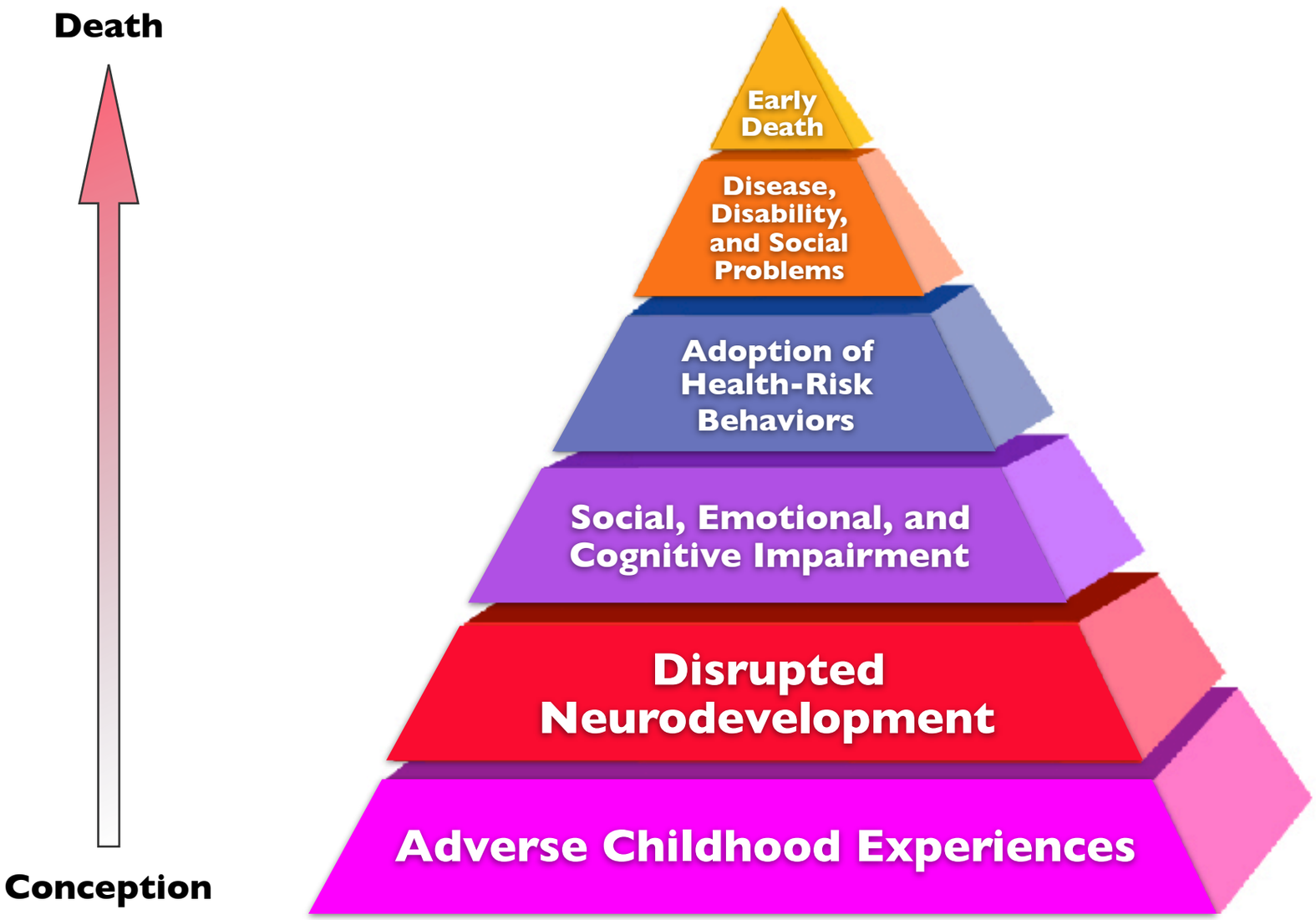
Adverse Childhood Experiences (ACE Study)

- Three types of abuse
  - Sexual
  - Physical
  - Emotional
- Two types of neglect
  - Physical
  - Emotional
- Five types of family dysfunction
  - Having a mother who was treated violently
  - Household member who's an alcoholic or drug user
  - Household member who's been imprisoned
  - Household member who's diagnosed with mental illness
  - Parents are separated or divorced

Negative Childhood Experiences Can Affect Adult Behavior



Adverse Childhood Experiences Can Last a Lifetime



Mechanisms by Which Adverse Childhood Experiences Influence health and Well-Being Throughout the Lifespan

Three Levels of Stress

Positive
Brief increases in heart rate,
mild elevations in stress hormone levels.

Tolerable
Serious, temporary stress responses,
buffered by supportive relationships.

Toxic
Prolonged activation of stress response systems
in the absence of protective relationships.

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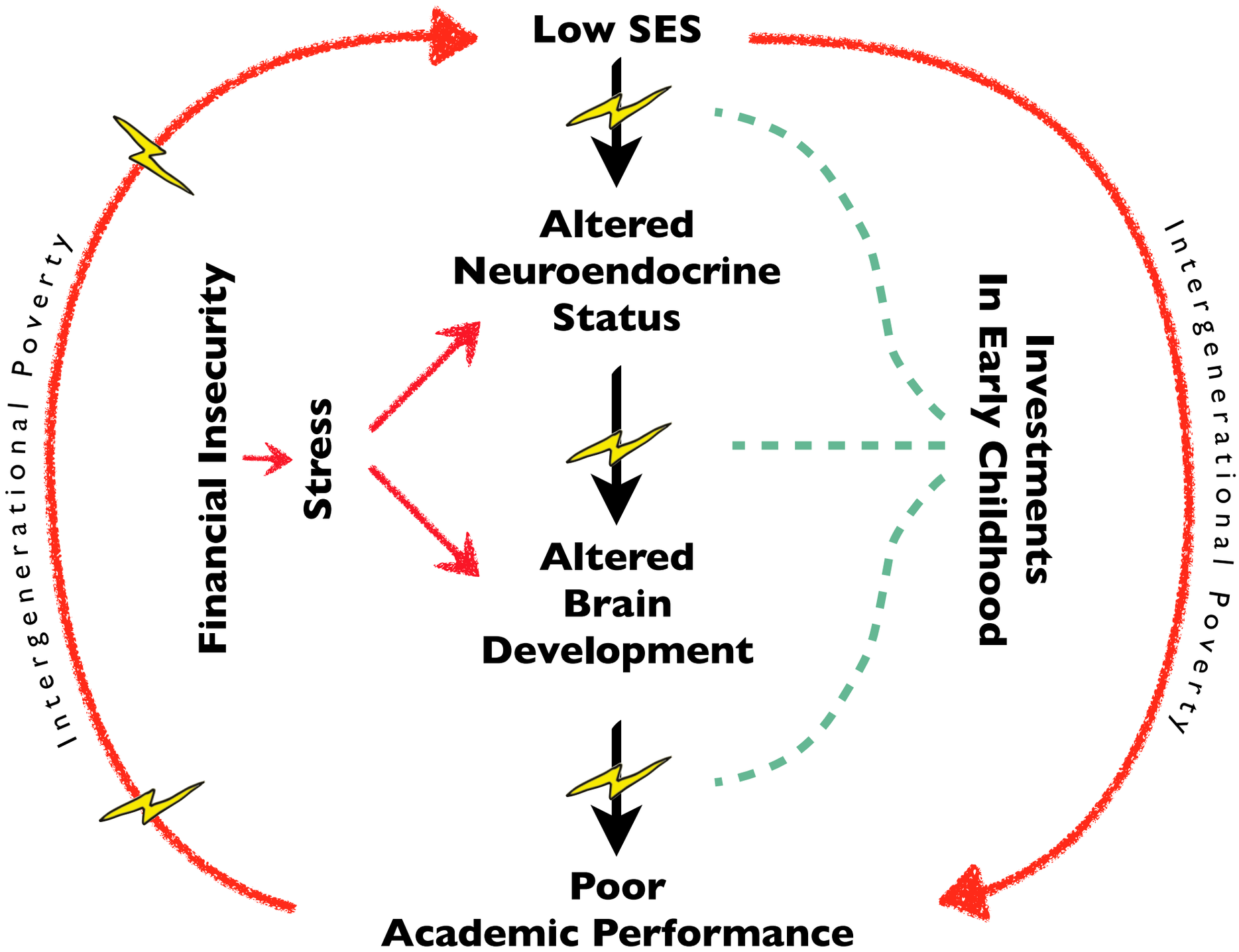
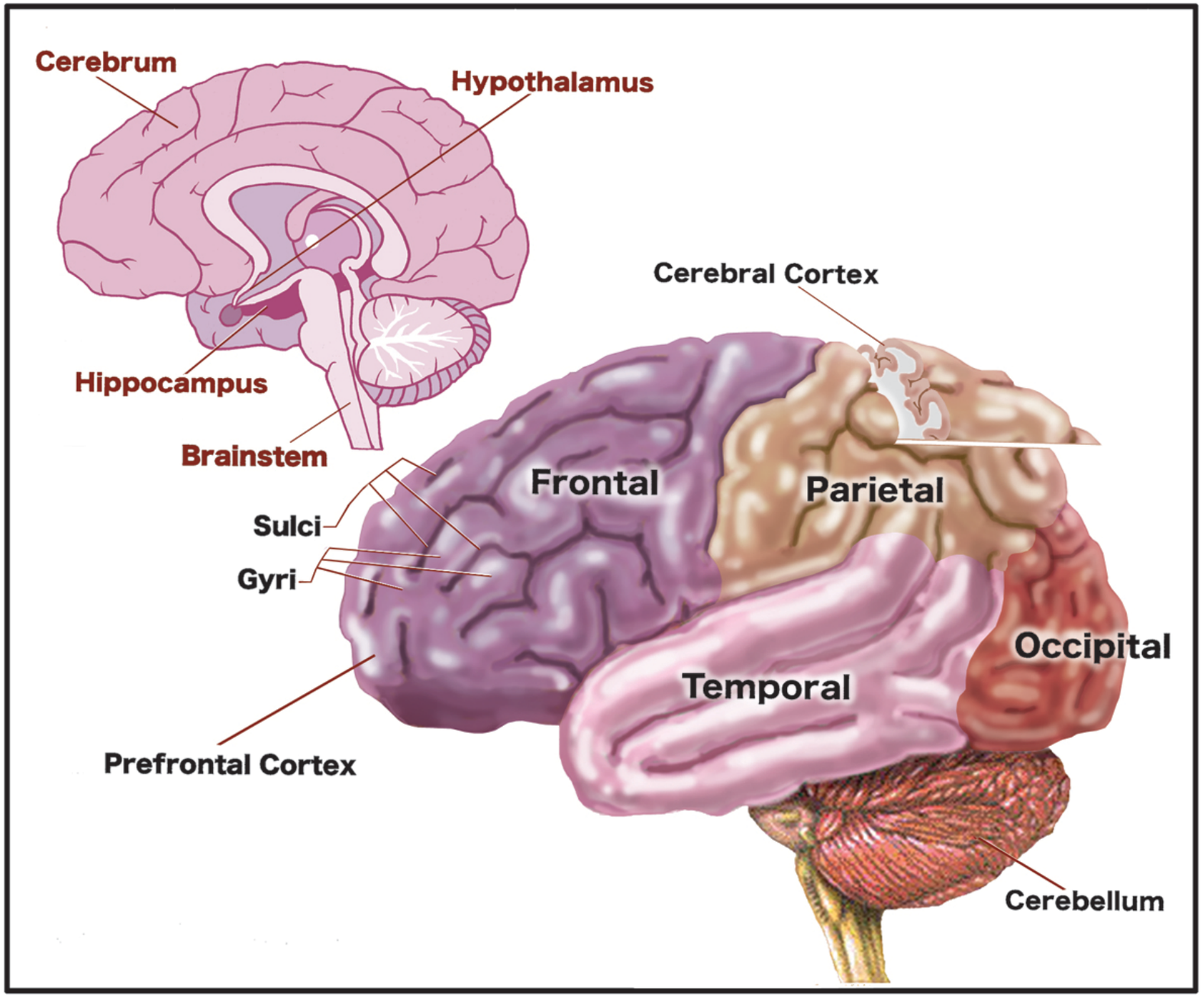
Breaking The Cycle of Poverty



Source: Hank Herrod, MD, The Urban Child Institute, 2010

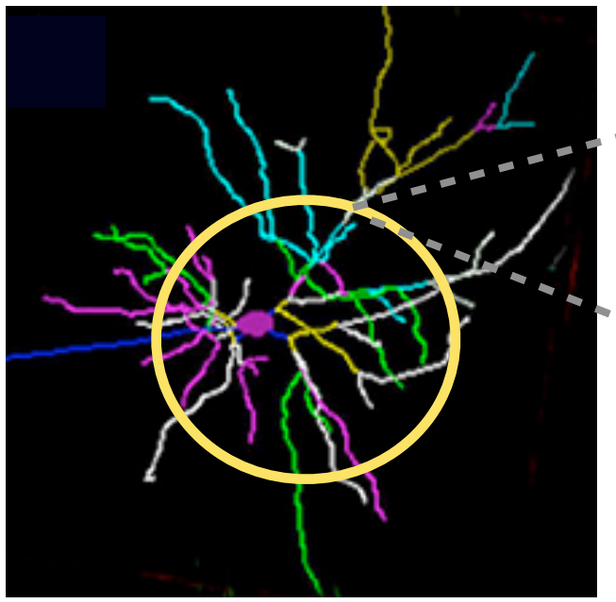
Medial View of the Human Brain



The Neuroscience of Stress

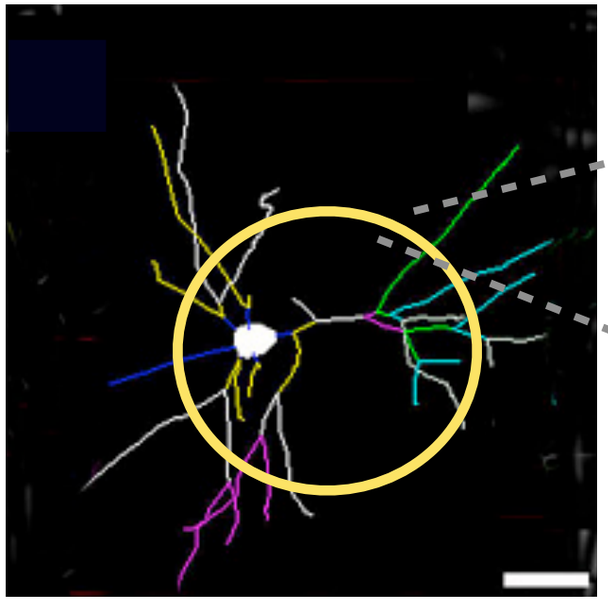
Toxic Stress Changes Brain Architecture

Normal



Typical neuron –
many connections

Toxic Stress



Damaged neuron –
fewer connections

Prefrontal Cortex and Hippocampus

Sources: Radley et al. (2004) Bock et al. (2005)

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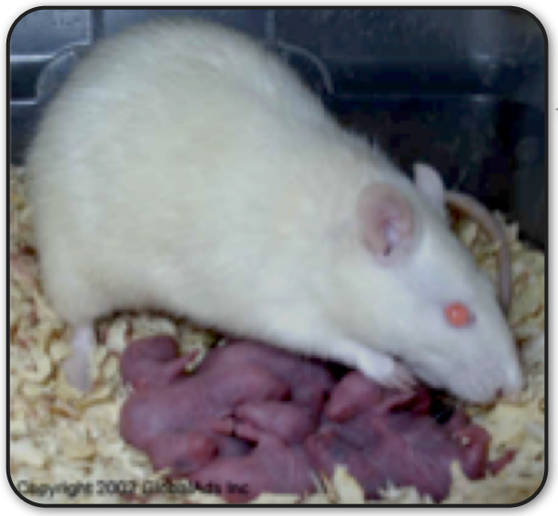
Tying It All Together

- Epigenetics- Describes changes in gene function that are not the result of changes in the underlying DNA sequences
- E.g. All cells in the human body have the same DNA but different cells do different things: neurons vs muscle
- Nature + Nurture can result in modification of gene expression such that your DNA genome is not necessarily your destiny
- In some situations changes in gene expression can be passed down at least one generation

- Cloud, J. Why Genes Aren't Destiny, Time Magazine Jan 18 2010, p 48-53.

Effect of Maternal Care (Nurturing, Environment) on Gene Expression (Nature) in the Rat

Bad Mom

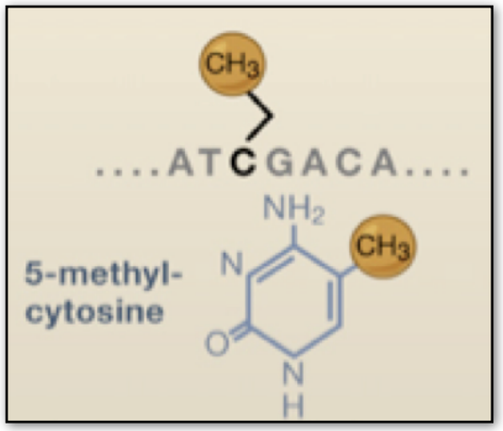


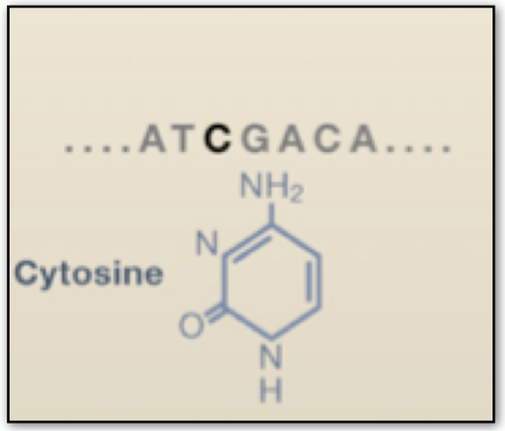
On the left, a mother nurses her offspring without arching her back, which may lead to increased cytosine methylation (diagrammed on bottom left) in a glucocorticoid receptor gene promoter, which will decrease glucocorticoid receptor gene expression.

On right, a mother engages in arched-back nursing, which allows for greater movement and access to nipples and is associated with more demethylated cytosine (diagrammed on bottom right) and more glucocorticoid gene expression.

Maternal behavior changes expression of an important stress response gene through methylating a gene promoter.

Good Mom





Source: *Stanford Center for Law and the Biosciences Blog, "Molecular Scars of Child Abuse"* by Kelly Lowenberg, 9/20/2009.

Environmental Signals Can Remodel Epigenetic Marks that Regulate Gene Expression

(MJ Meaney, Child Psych, 2010)

- Low LG pups have enhanced HPA responsiveness when faced with stress
- Low LG pups have decreased hippocampal glucocorticoid receptors
- Effects of maternal care on hippocampal GCR expression are associated with an epigenetic modification of a neuron specific GCR promoter
- High LG pups have increased GCR expression in hippocampal tissue and a muted HPA response to stress

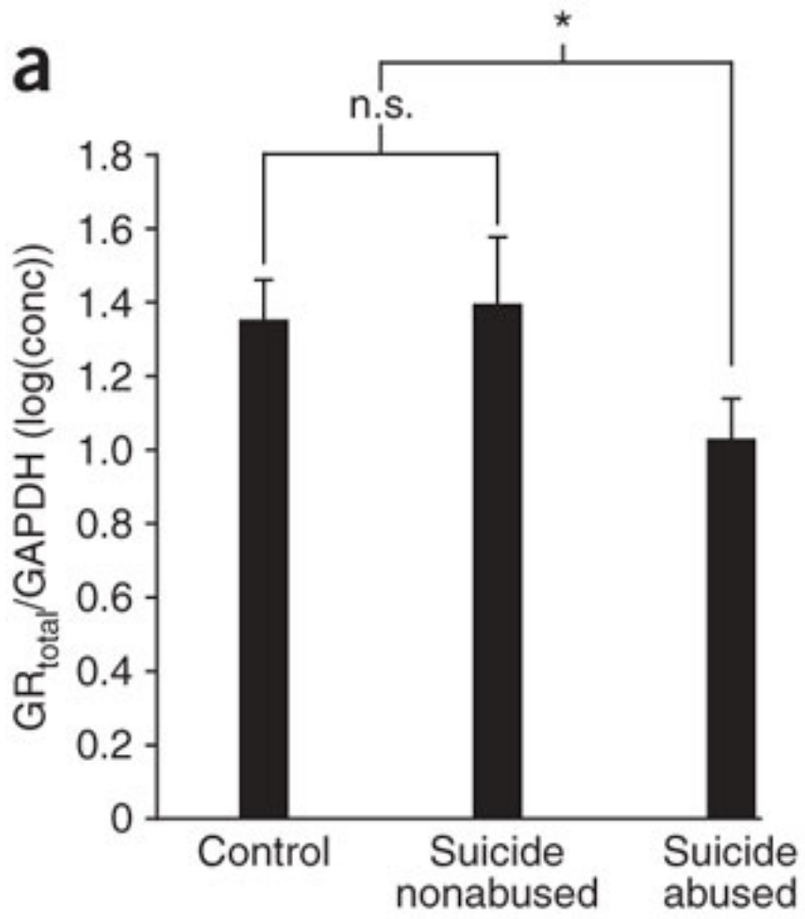
Epigenetic Regulation of GCR and Child Abuse

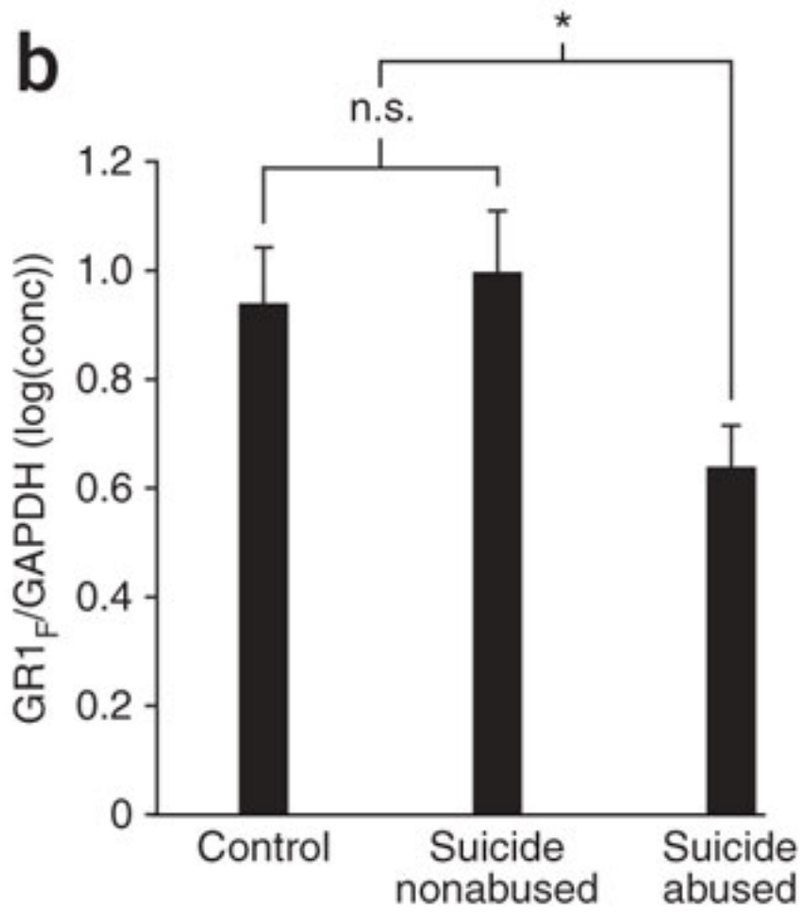
(McGowen et al. Nature Neuroscience 2009)

- 12 Accidental death controls
- 12 suicide victims who had a history of child abuse: decreased GCR in hippocampus, increased methylation of NR3C1 promoter
- 12 suicide victims without a history of child abuse: no significant difference from 12 acute accidental death controls.

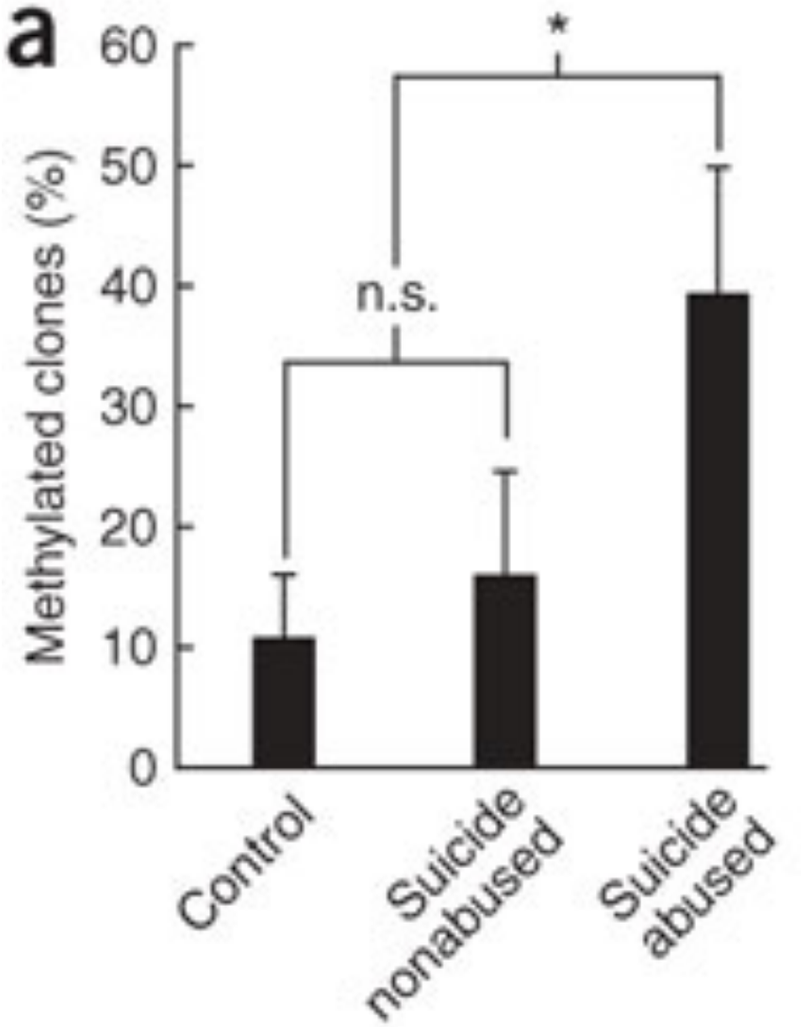
Hippocampal GCR expression in humans

a) GR mRNA b) GR receptor





Methylation of the NR3C1 Promoter in the Human Hippocampus



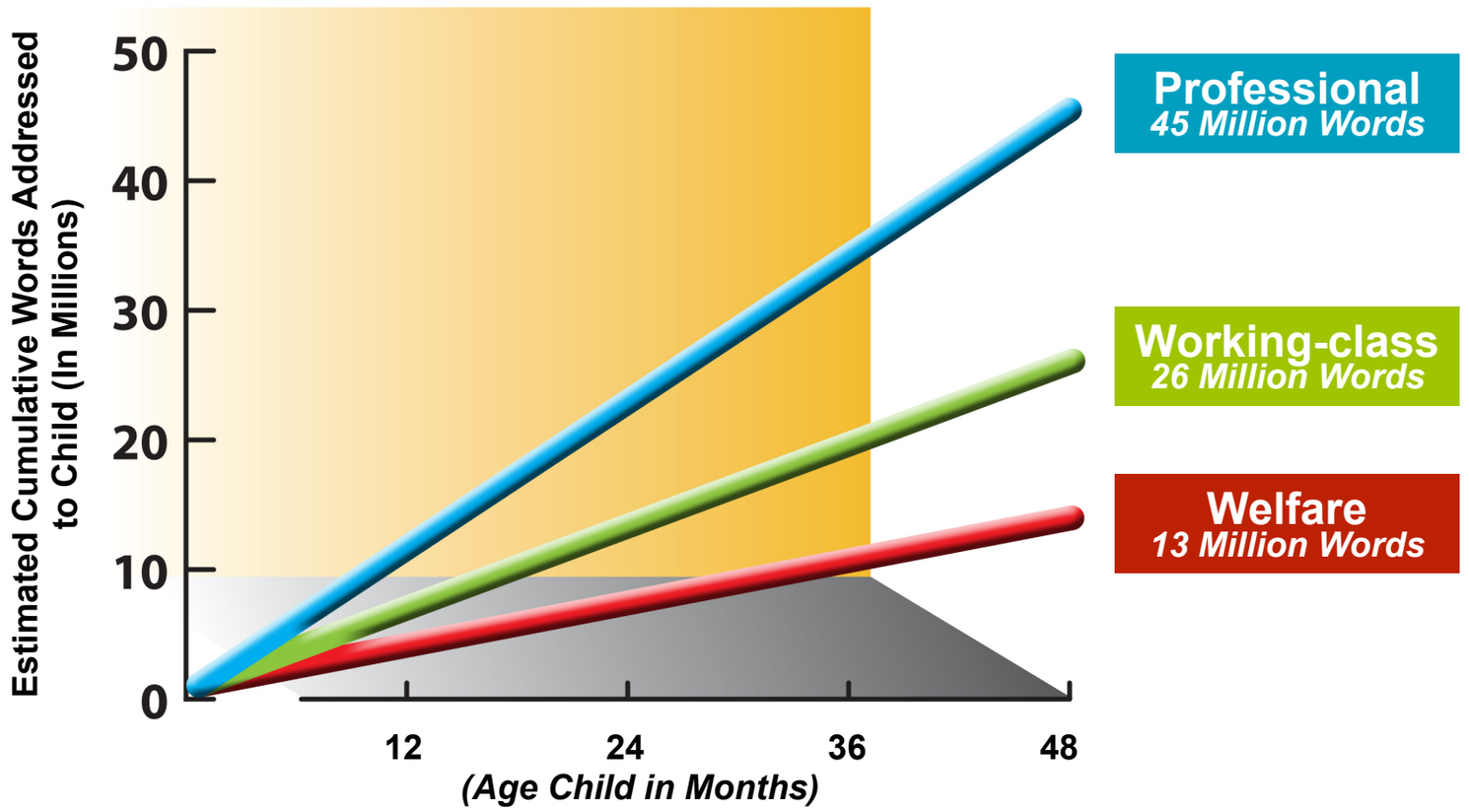
Toxic Stress.

Source: Bill Day, The Urban Child Institute, 2009

Optimizing a Baby's Brain Development

- Family and friends
- Structured Interventions
  - Home Visitation
  - Center Based Care

Language Experiences by SES Group

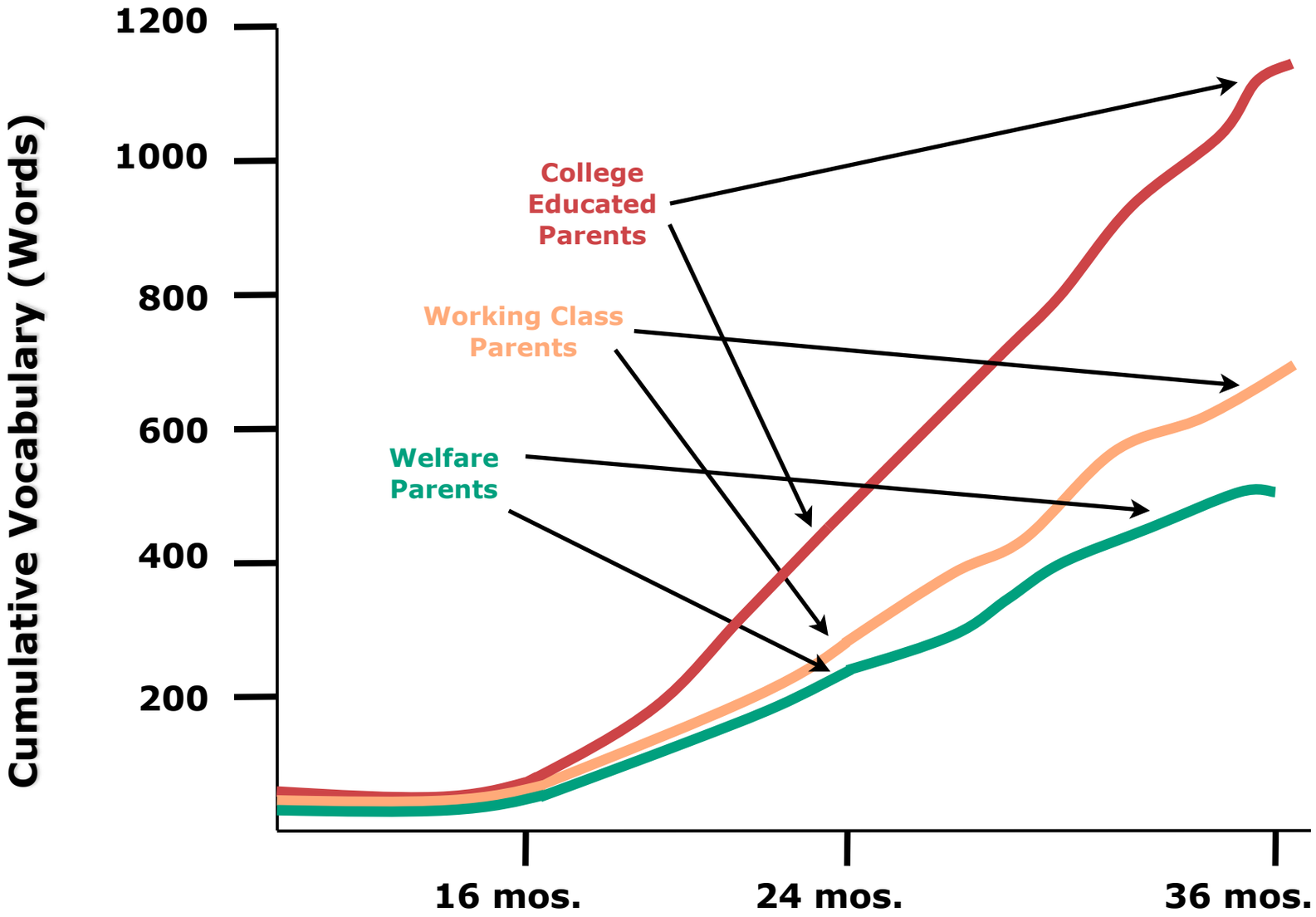


Source: *Meaningful Differences in the Everyday Experience of Young American Children* by Betty Hart & Todd R. Risley. Paul H. Brookes Publishing Co. (1995).

Source: Bill Day, The Urban Child Institute, 2009

“Motherese”

Barriers to Educational Achievement Emerge at a Very Young Age



Source: Hart & Risley (1995)

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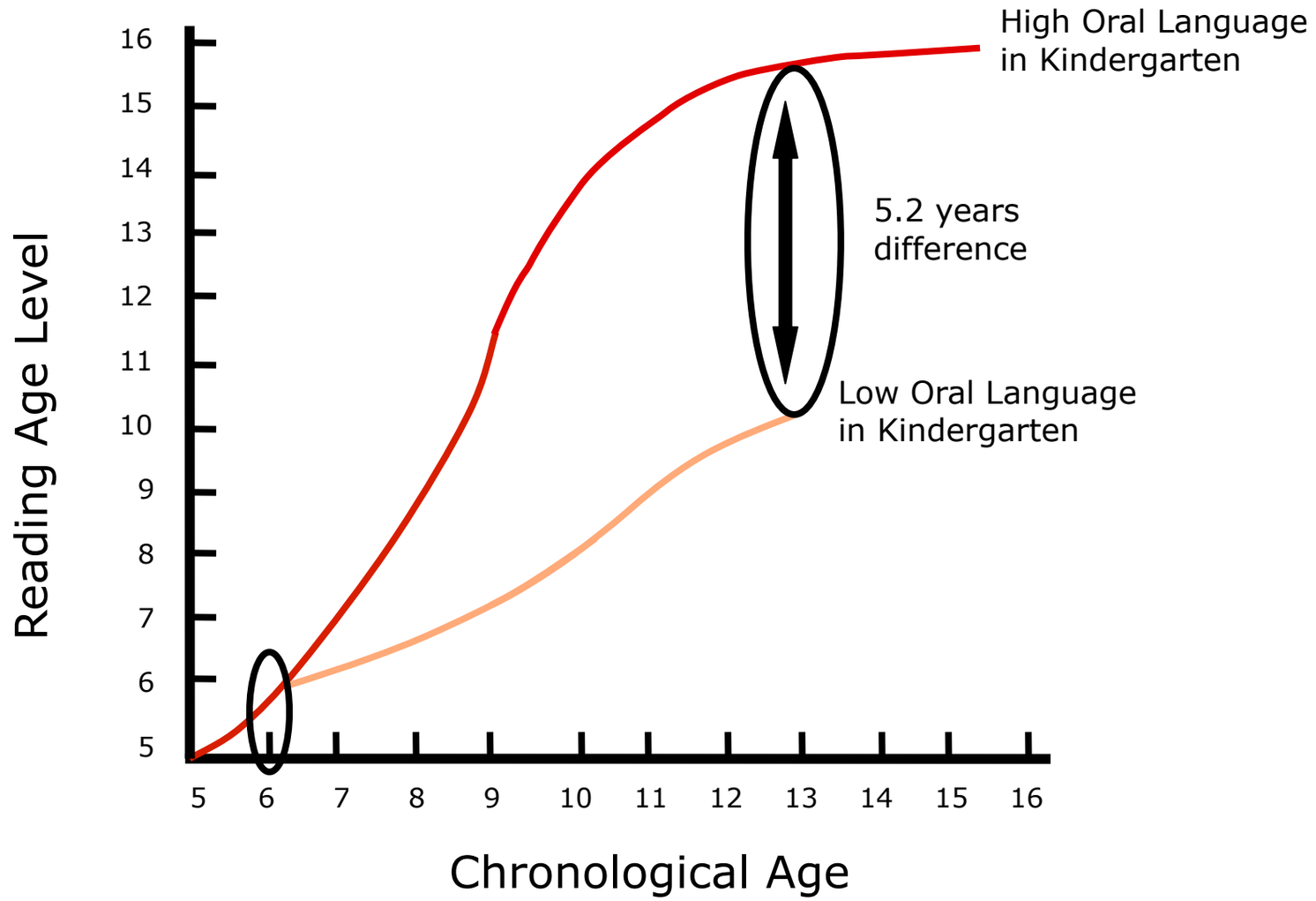
Effect of Oral Language on Reading Levels



The Memphis Nurse Family Partnership Program

(Olds et al Peds 2007 e 832-e845.)

- Enrollment Characteristics-AA, unmarried, low income, <12 grade education, unemployed
- Control Group-515 enrollees. Prenatal visits and developmental screenings at 6, 12, 18 mos.
- Intervention Group-228 enrollees. As above plus home visits while pregnant and for first two years of child's life

Effect of Memphis NFP on Mothers

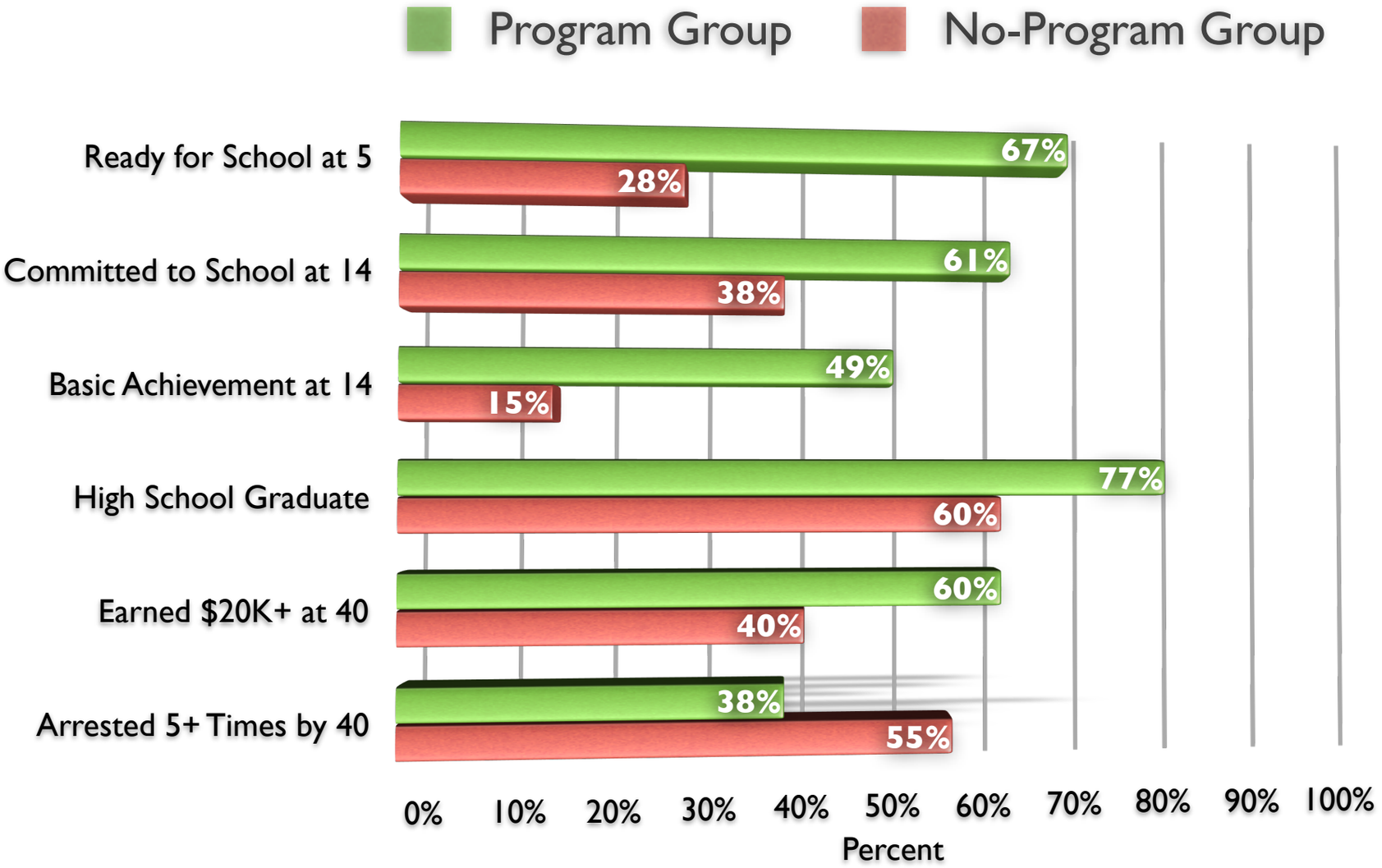
- Increased interval between births of first and second children
- Longer period with same partner
- Decrease in number of months on food stamps and other welfare programs
- Fewer subsequent low birth weight babies
- Less substance use

Effect of Memphis NFP Program on Children Through First Nine Years

- During the first 2 years of life fewer hospitalizations for accidents and injuries
- By 9 years of age improved grade point averages-lowest resource children (LRC)
- Improved achievement test scores-LRC
- Deaths: Control group 10 deaths (4 SIDS, 2 firearm deaths) Intervention group 1death (chromosomal abnormality)

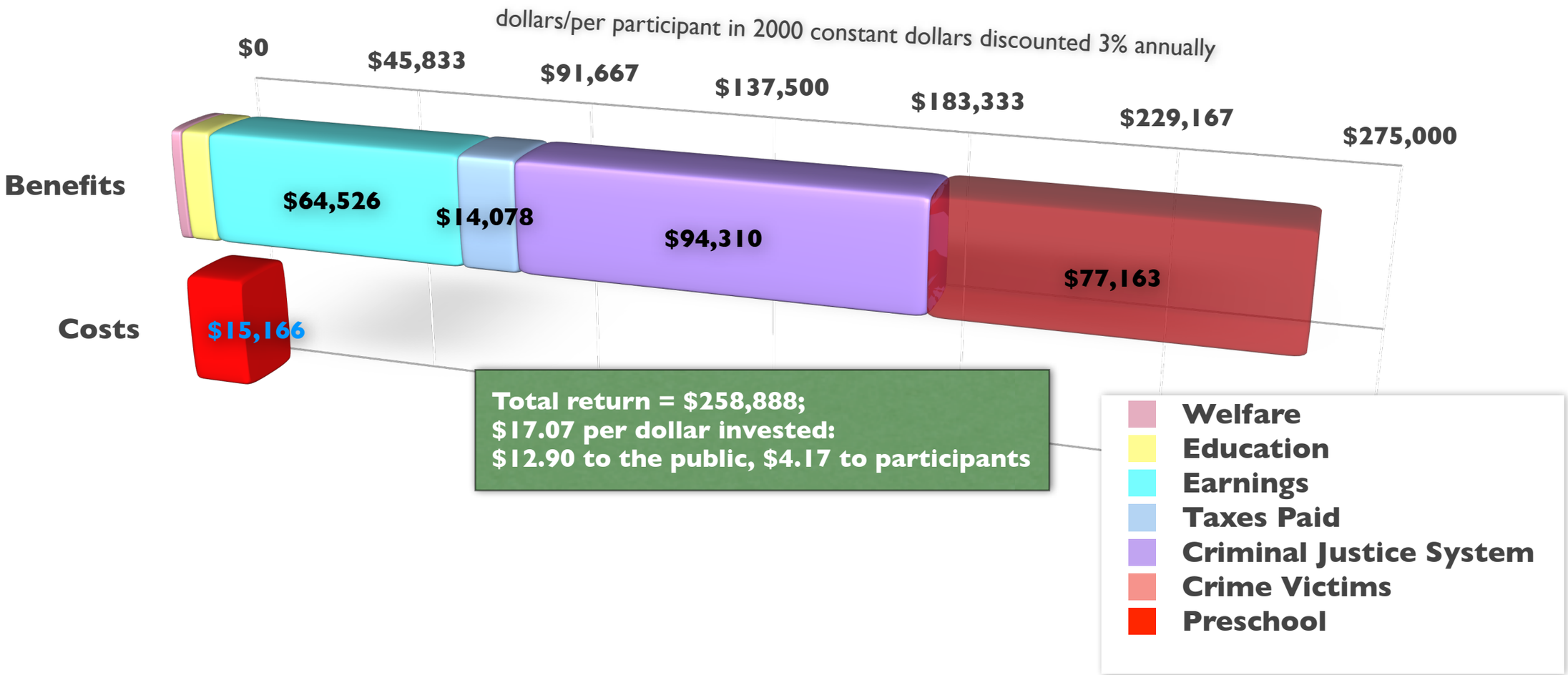
Source: Olds et al Peds 2007 e 832-e845.

Model Preschool Programs May Have Lifetime Effects



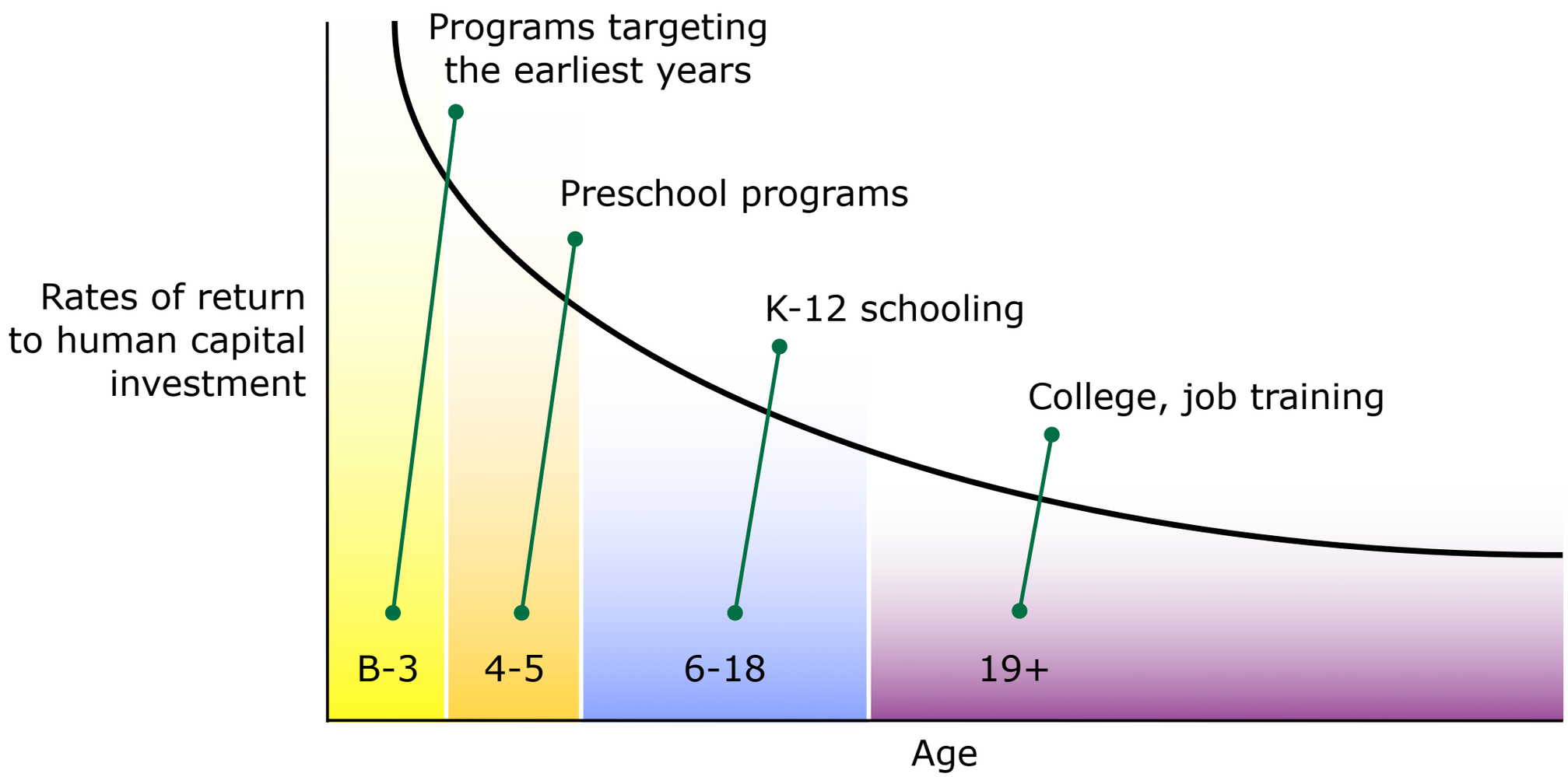
Source: High/Scope Perry Preschool Study

Model Preschool Programs Have Large Return on Investment



Source: High/Scope Perry Preschool Study

Preventive Intervention is More Efficient and Produces More Favorable Outcomes Than Later Remediation



Source: Heckman, J. (2007)