

Brain Architecture, Toxic Stress and Human Development

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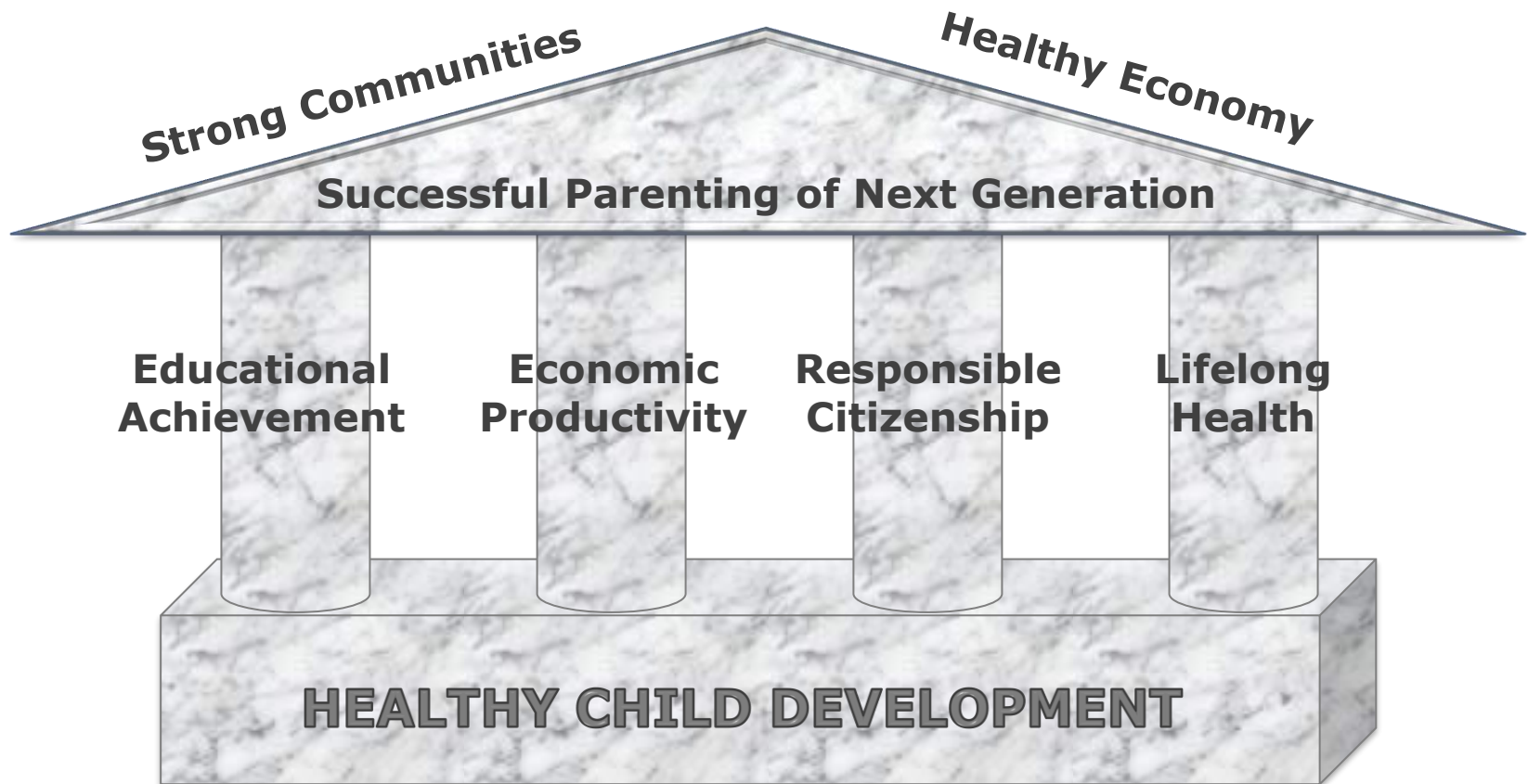
Member, National Academy of Sciences

Member, American Academy of Arts and Sciences

Institute of Child Development

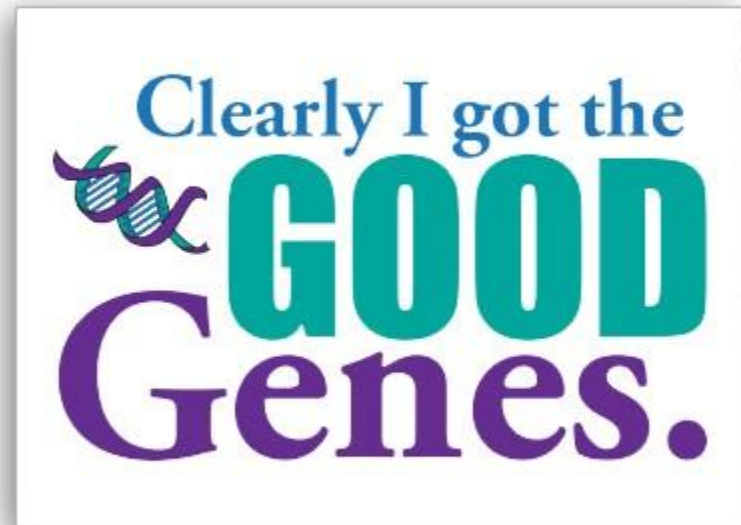
University of Minnesota

The Foundation of a Successful Society is Built in Early Childhood

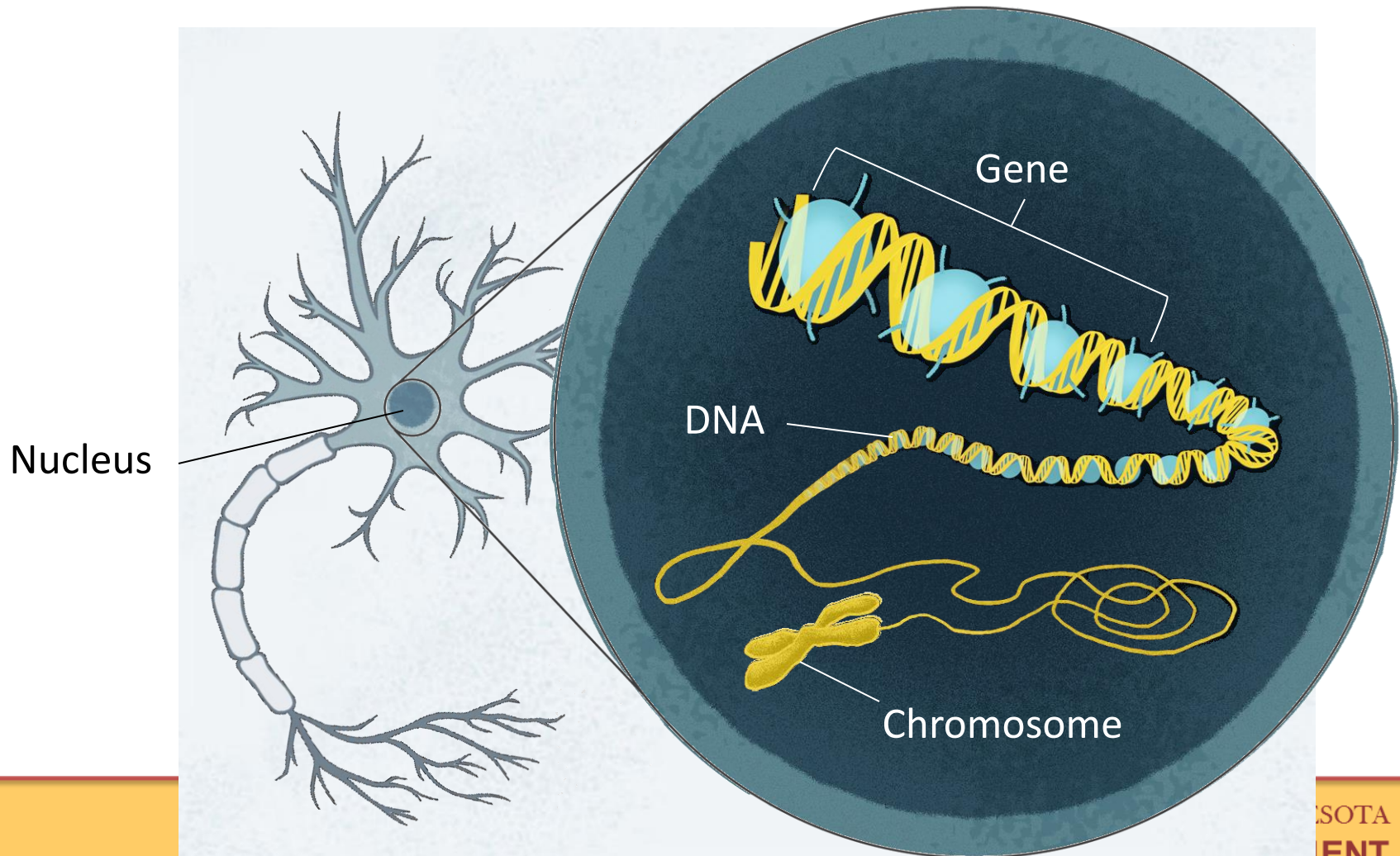


Building Healthy Brain Architecture – The Ingredients

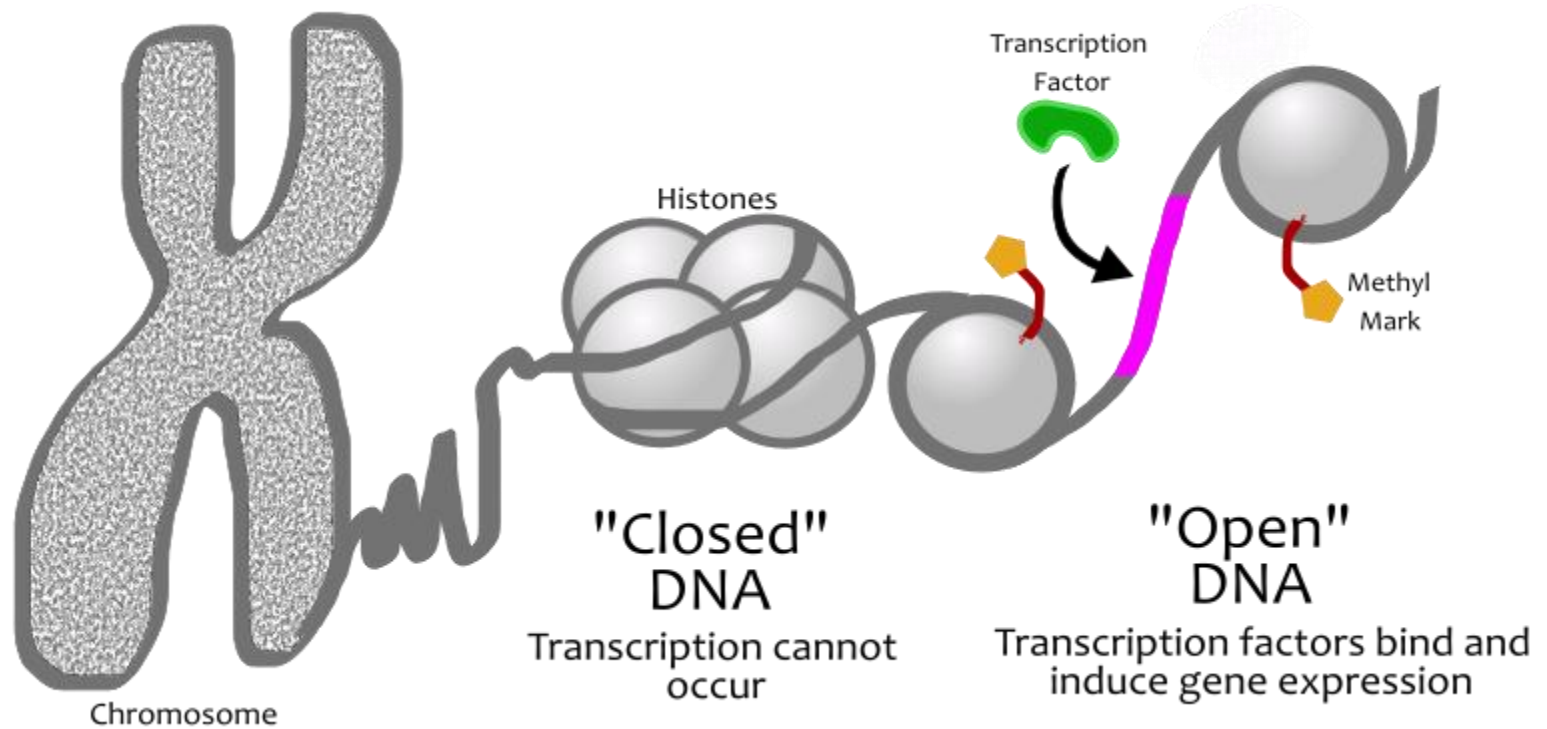
- Takes more than having the right genes
- Takes the right, supportive experiences
- Experience literally writes on our genes, determining how well our genes work



Genes Carry Instructions that Tell Our Bodies How to Work



Epigenetics



Environment Influences Regulation of Gene Expression Beginning Before Birth

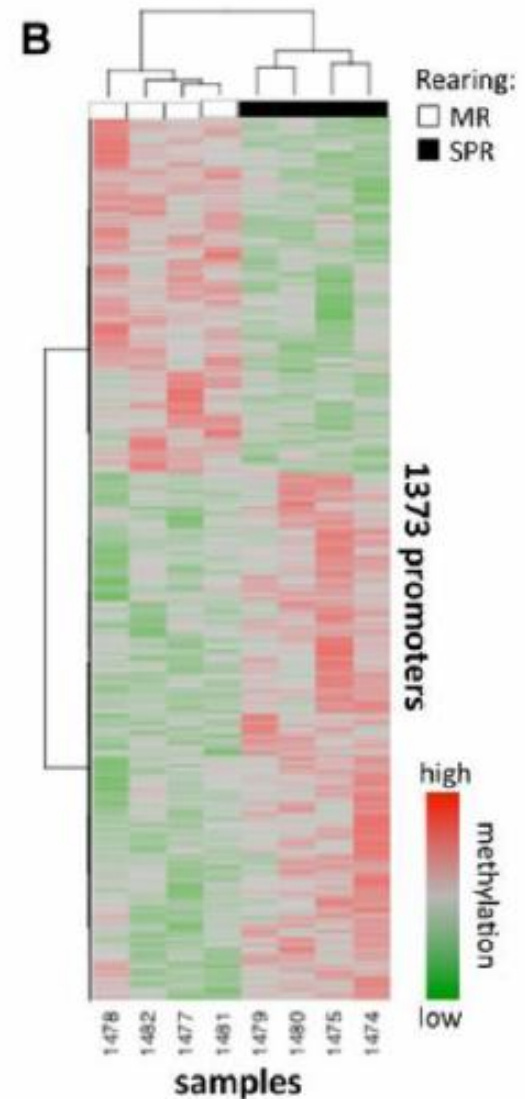


If we are going to build healthy brains, we cannot start at birth nor can we end at 4 yrs.

Early Adversity and DNA Methylation

- Monkeys reared with and without their moms
- Piece of the Prefrontal Cortex helps you control and guide your behavior
- Red=more methylated
- Green=less methylated
- Each row is a different gene; columns are different animals

Provencal et al., 2012

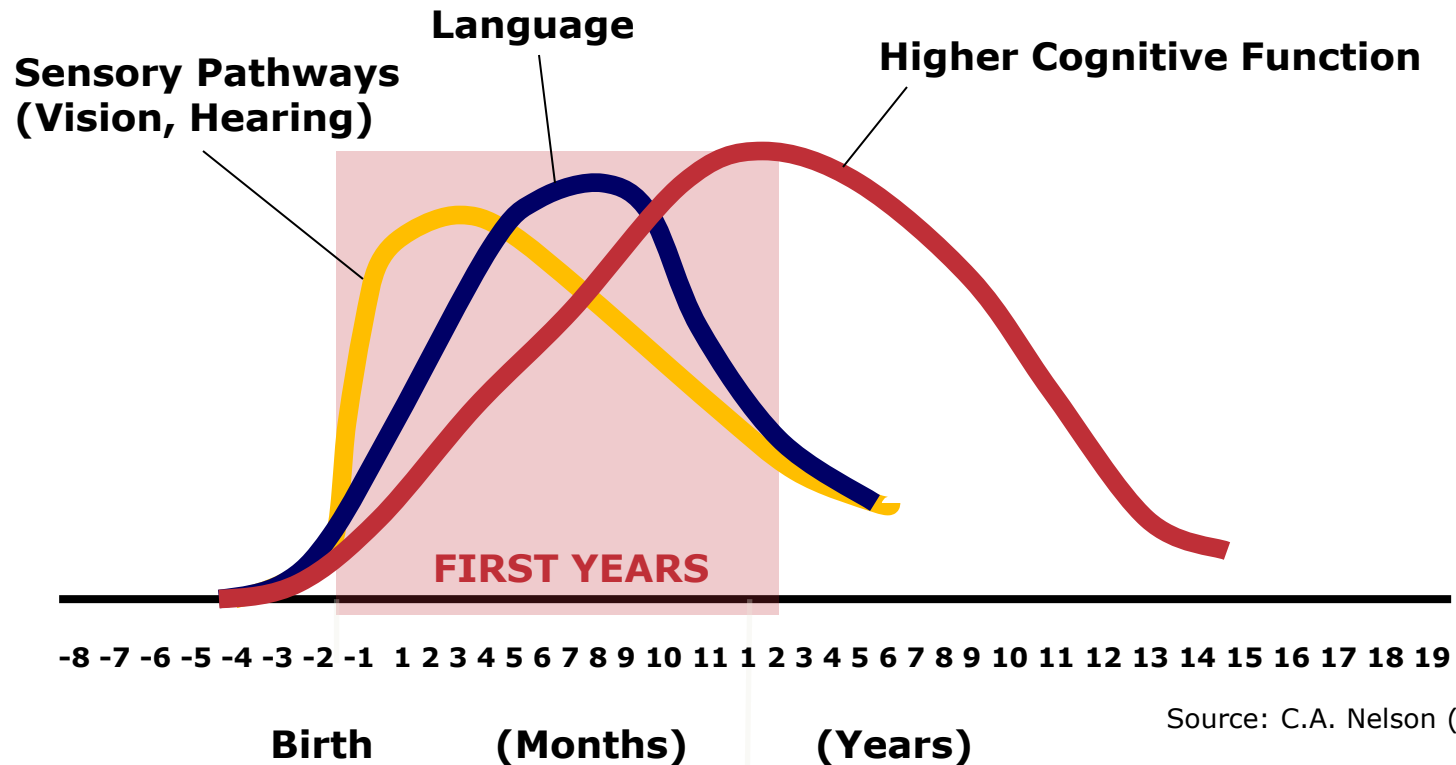


Experience Shapes Brain Architecture by Over-Production Followed by Pruning

(700 synapses formed per second in the early years)



Neural Circuits are Wired in a Bottom-Up Sequence



Source: C.A. Nelson (2000)

Stimulation is Needed
In Order for the Brain
To Develop

Human Infant is Unable to Provide
Itself Adequate Stimulation
for Normal Brain Development

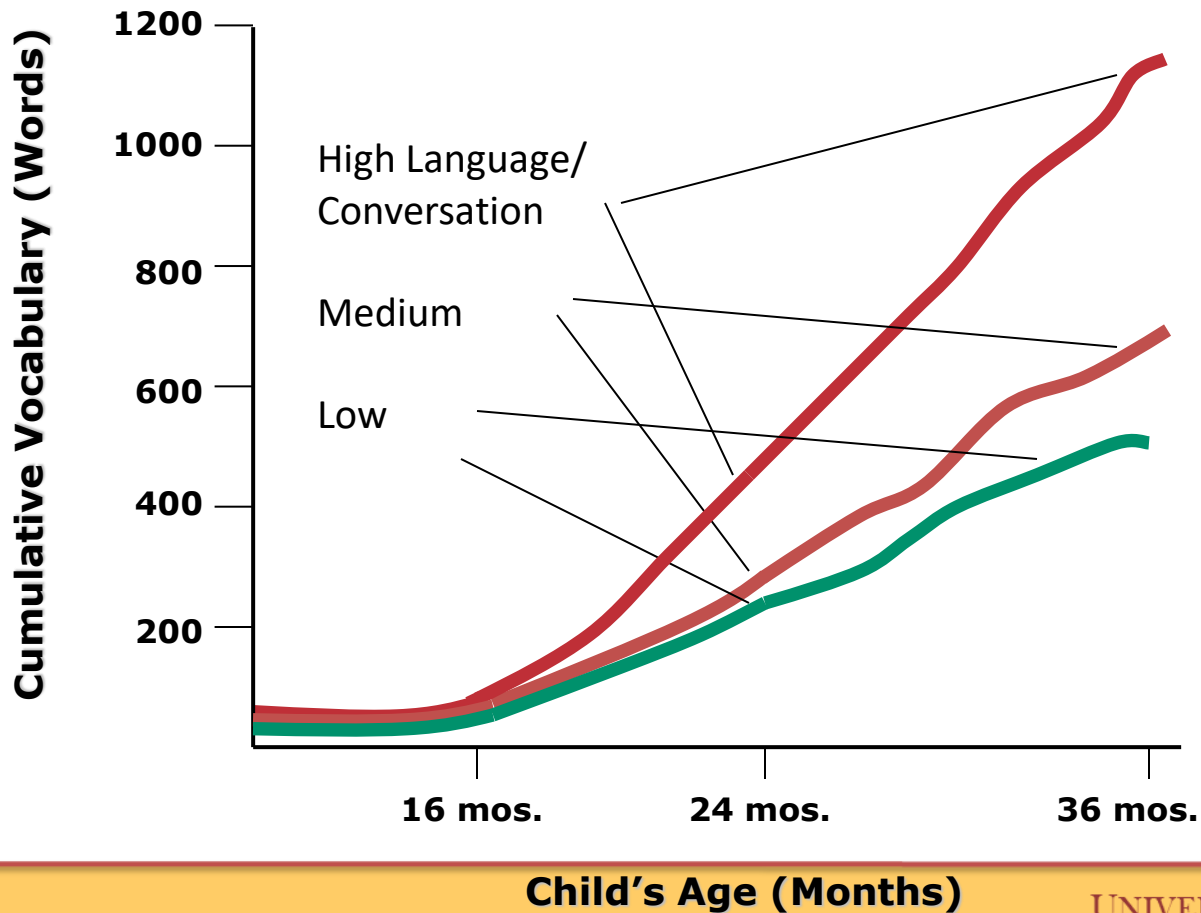
The Brain Develops in the Context of Relationships

Sensitive and Responsive Relationships

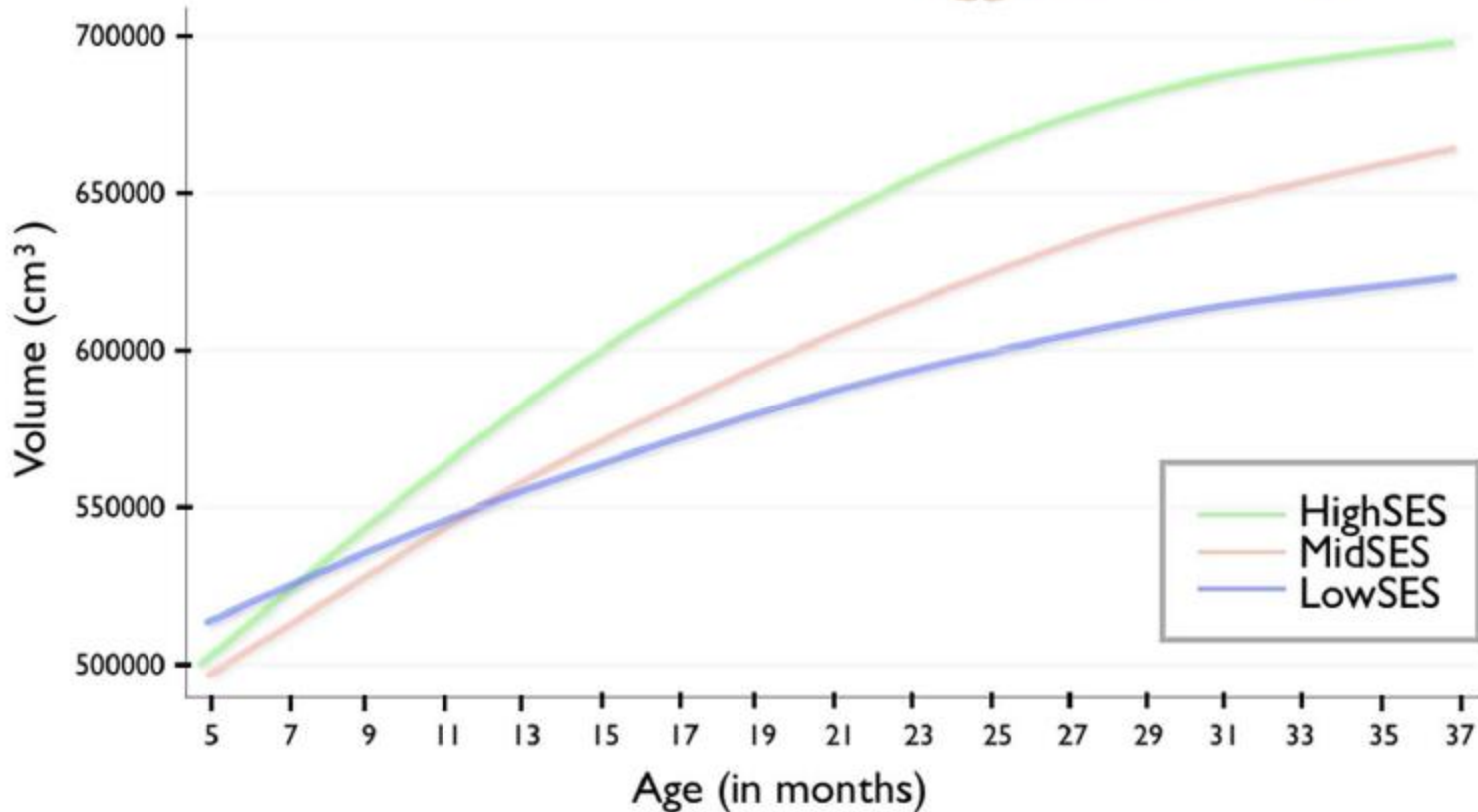
Sort of Like

Serve and Return/Call and Response

Barriers to Educational Achievement Emerge at a Very Young Age



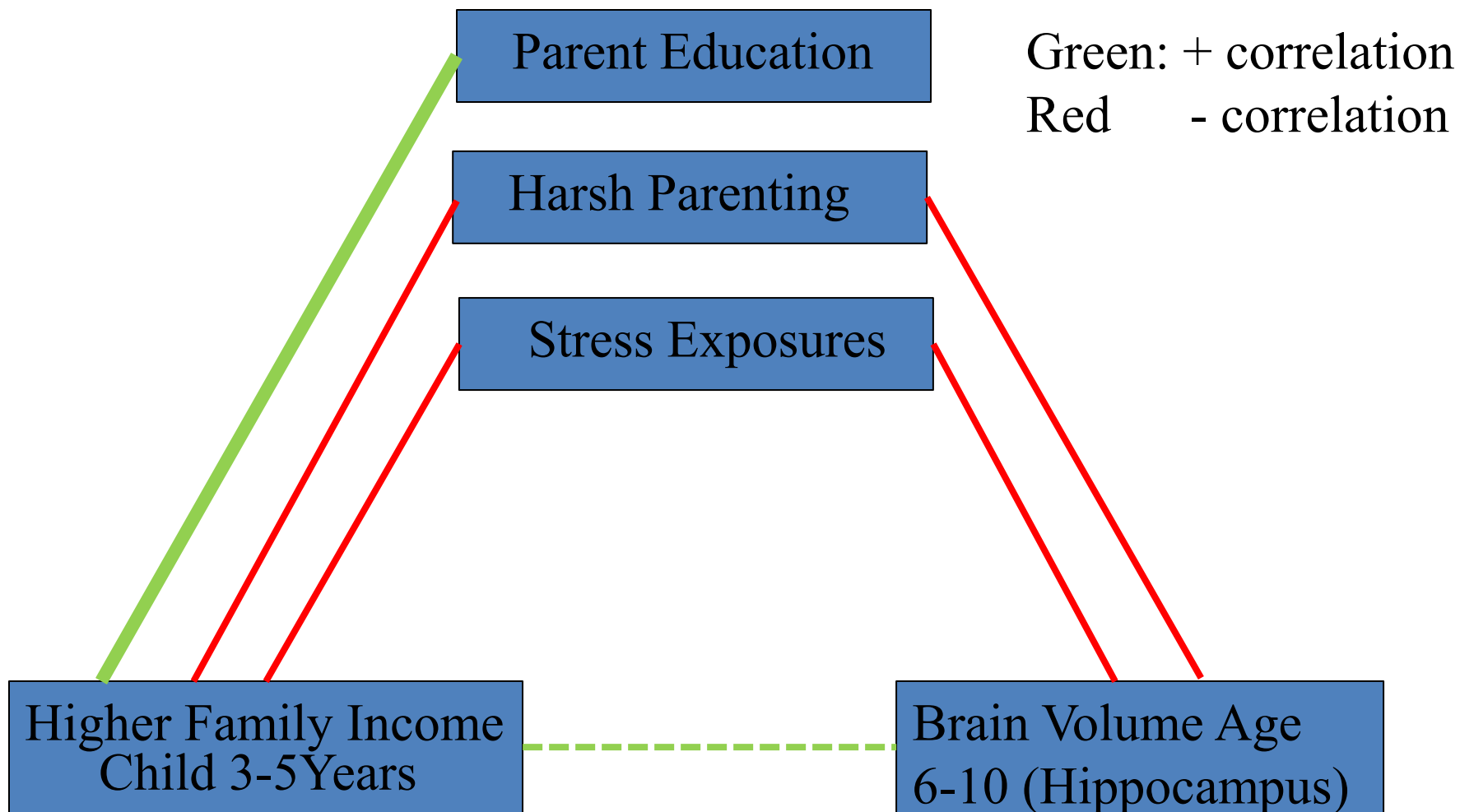
Total Gray Matter



Hanson et al., 2014

Enriching Experiences Support Healthy Brain Development

- Libraries, playgrounds, children's programs, museums, etc.
- Few parents can do it without help.
- Parents working several jobs to make ends meet need our help.
- High Quality Early Childhood Programs are needed
- Finding that care is hard and the pandemic has made it harder. Especially difficult in greater Minnesota.



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.

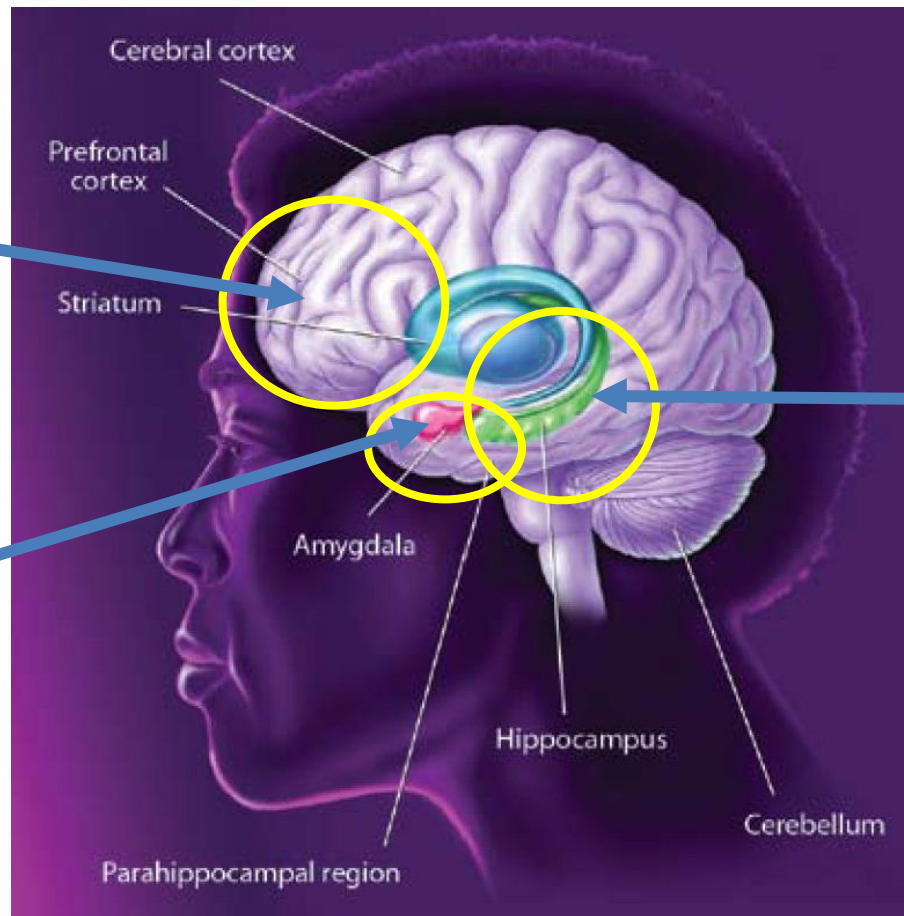
Toxic

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

Stress and Brain Functioning

Planning
Self-
Regulation

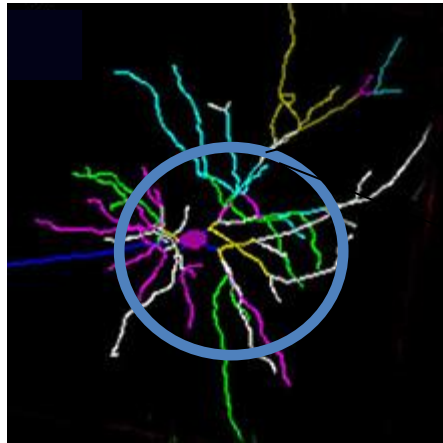
Fear
Learning



Memory &
Learning

Toxic Stress Changes Brain Architecture

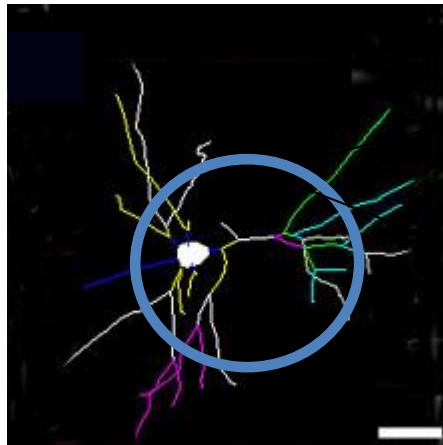
Normal



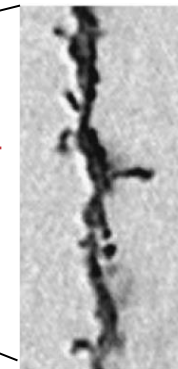
Typical neuron—
many connections



Toxic
stress



Damaged neuron—
fewer connections



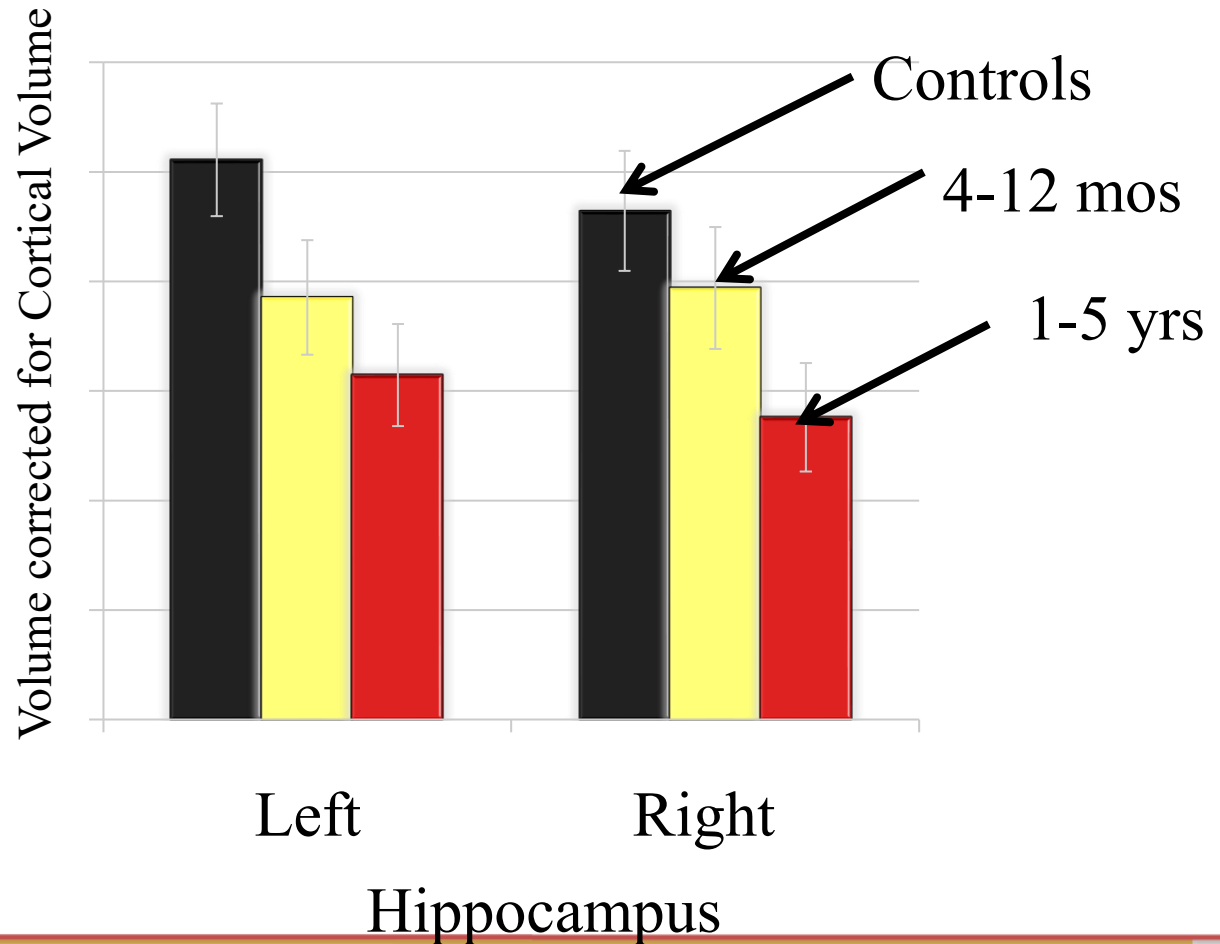
Prefrontal Cortex and
Hippocampus

UNIVERSITY OF MINNESOTA
INSTITUTE OF CHILD DEVELOPMENT

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



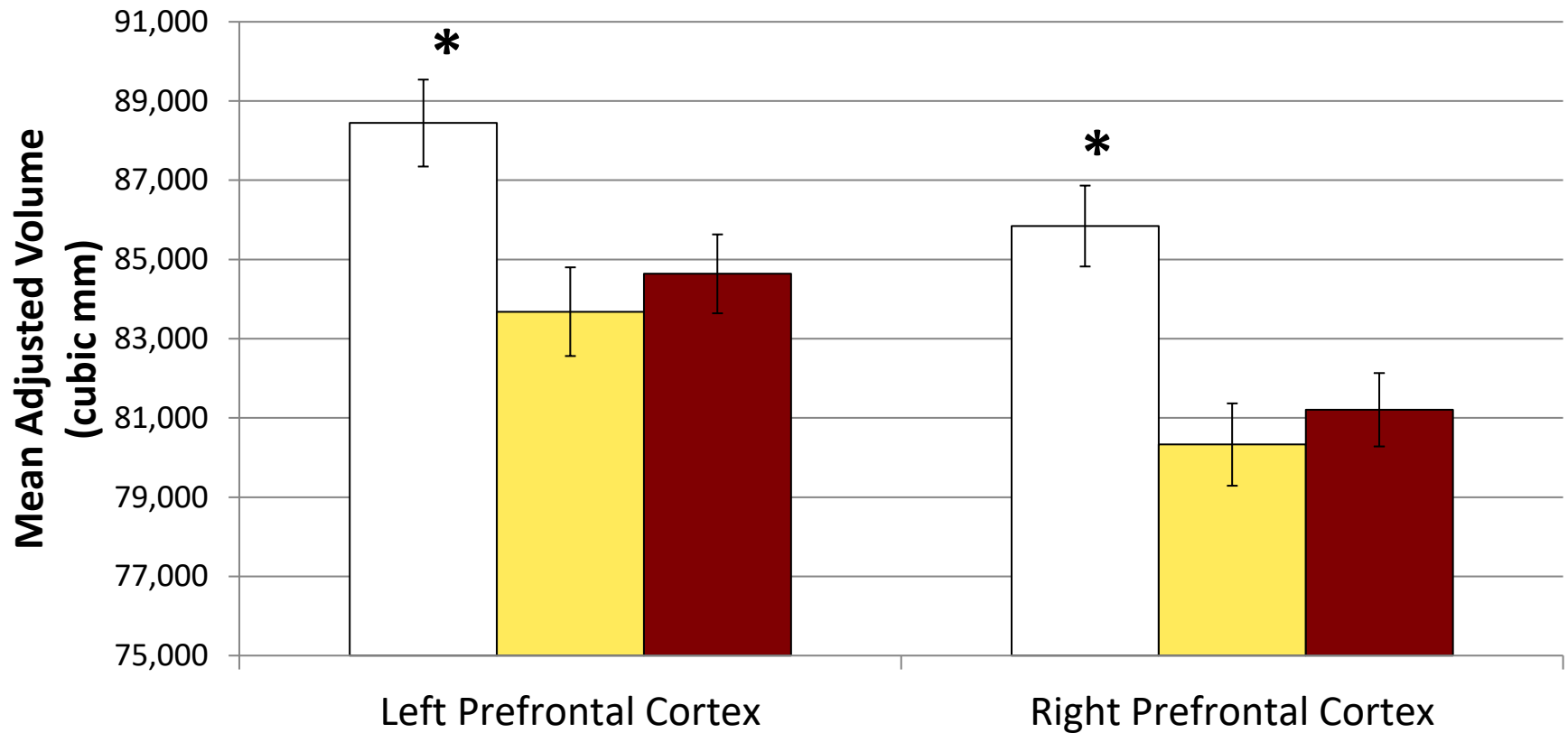
12 and 13 years at Scanning



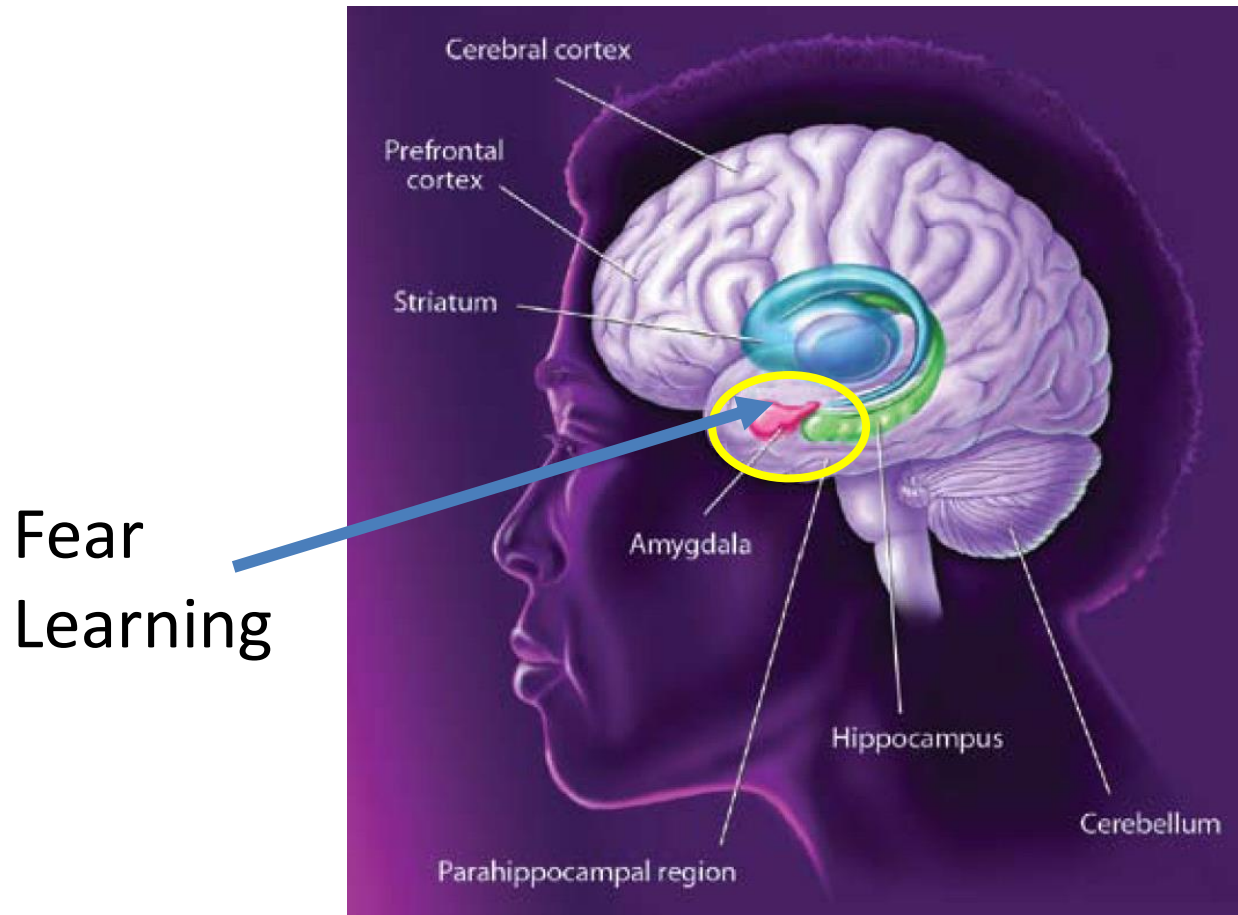
Hodel et al., 2015

Prefrontal Cortex Volume x Group

□ Minnesota Controls ■ Early Adopted (<= 12 months) ■ Late Adopted (> 12 months)



Stress and Brain Functioning



Fear
Learning

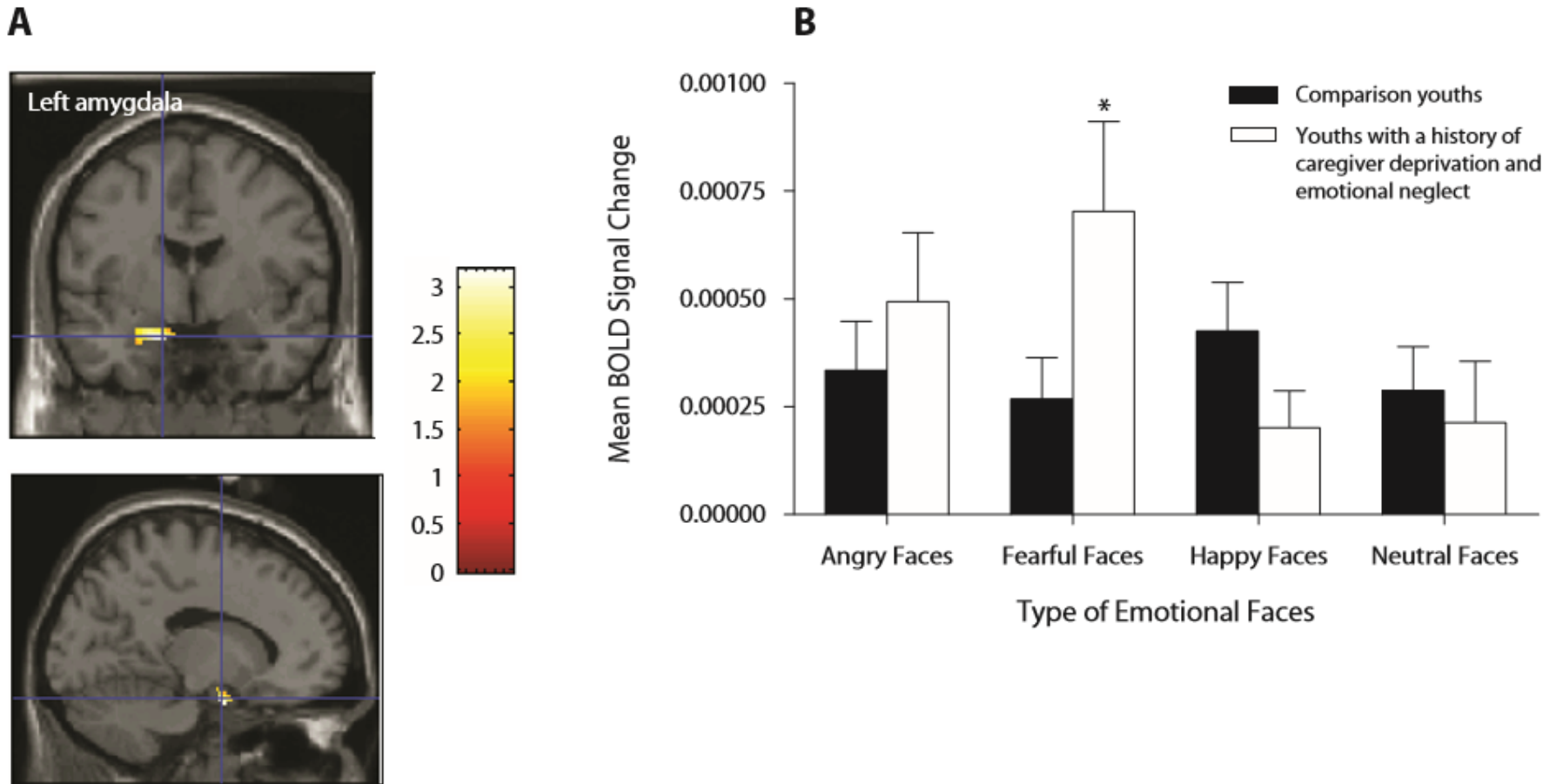


Figure 2. (A) Left amygdala activation among youths with a history of caregiver deprivation and emotional neglect ($N = 11$) and comparison youths ($N = 19$) in the contrast fearful versus neutral faces in the afraid attention state. (B) Mean BOLD signal changes extracted at the identified peak voxel during the viewing of fearful faces versus neutral faces (across all attention states). * $p = .039$.

Interim Summary

- The architecture of the brain is shaped by our experiences
- Skills beget skills, simpler skills support later developing skills
- A poor early foundation affects all that comes after
- Brain architecture develops in the context of relationships
- Serve and Return provides the experiences that literally build the brain and establishes secure relationships that protect the brain from stress.
- The brain becomes what the brain has to think about; enriching experiences support the development of a healthy brain that can learn!
- Toxic stress can literally shape an anxious/fearful brain that acts first and thinks later.
- The achievement and opportunity gap begins early in life

How Can We Act On the Science?

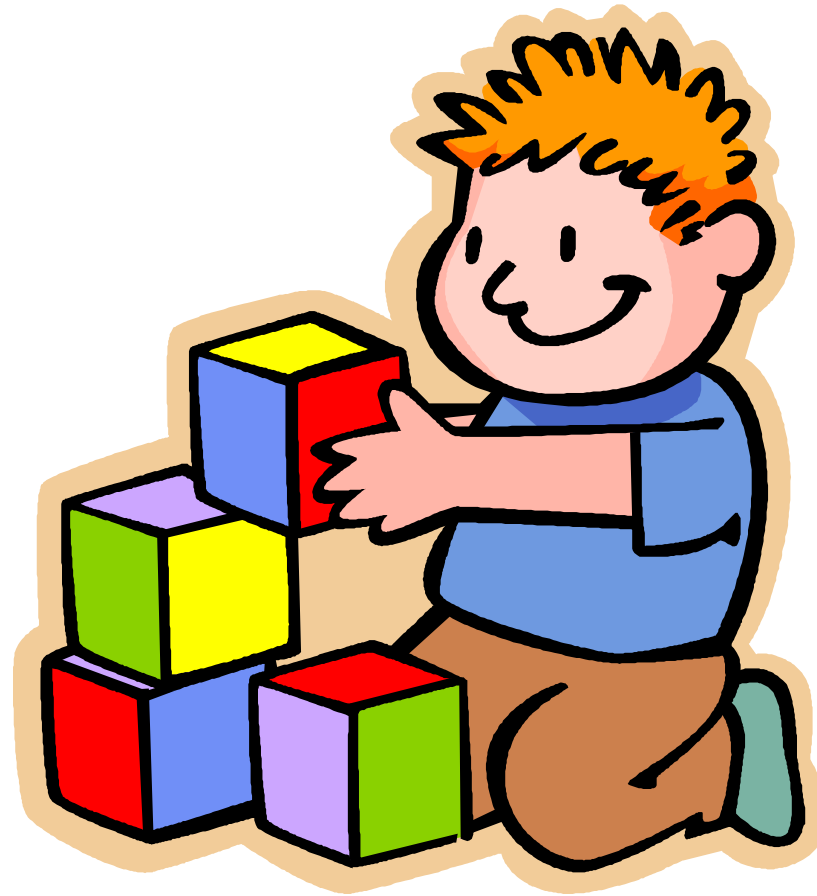
Get It Right the First Time

The basic principles of neuroscience indicate that creating the right conditions for early childhood development will be more effective and less costly than addressing problems at a later age.

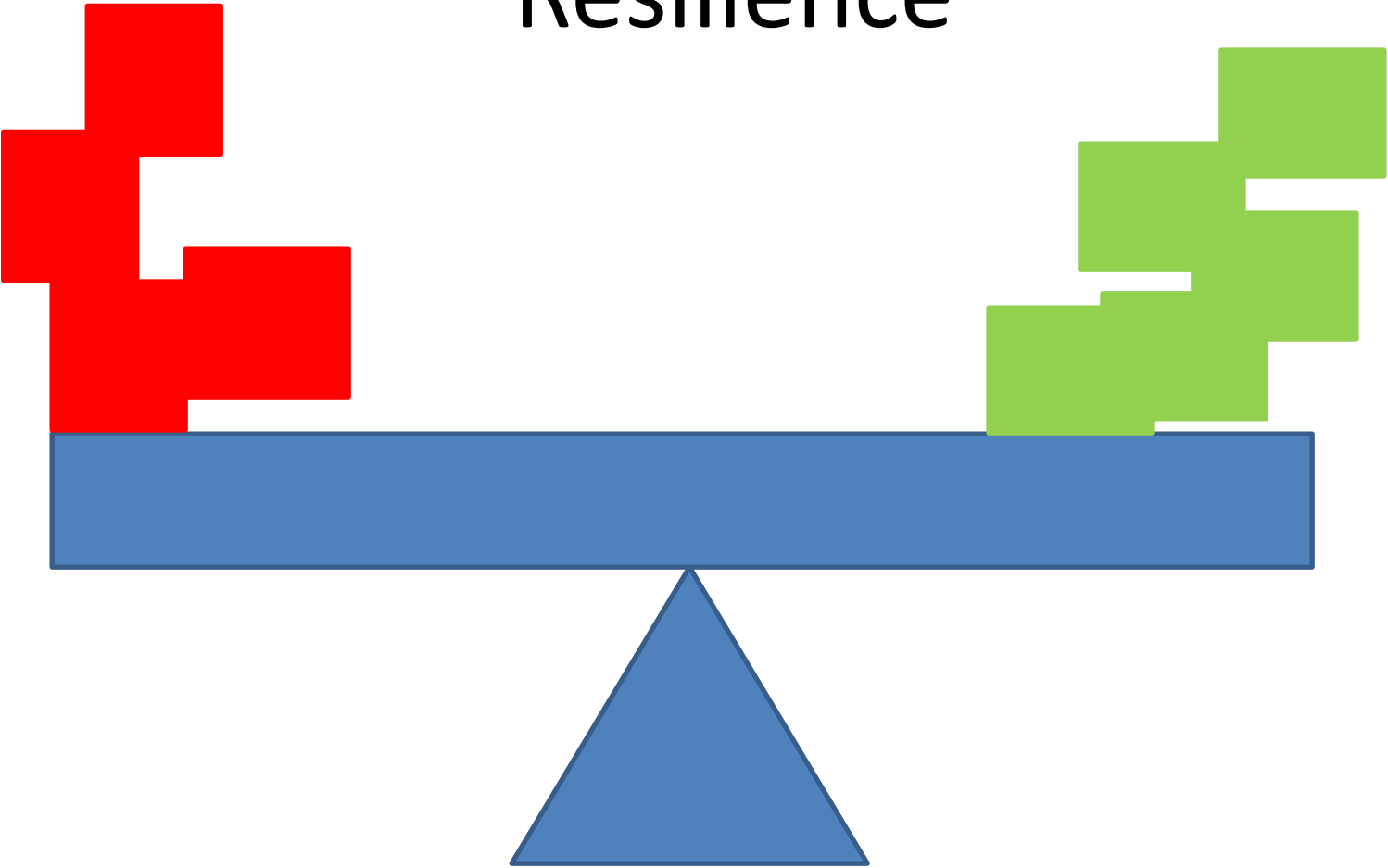
Brains: more physiological energy needed to compensate for poorly formed neural circuits.

Society: higher cost of remedial education, clinical treatment, crime.

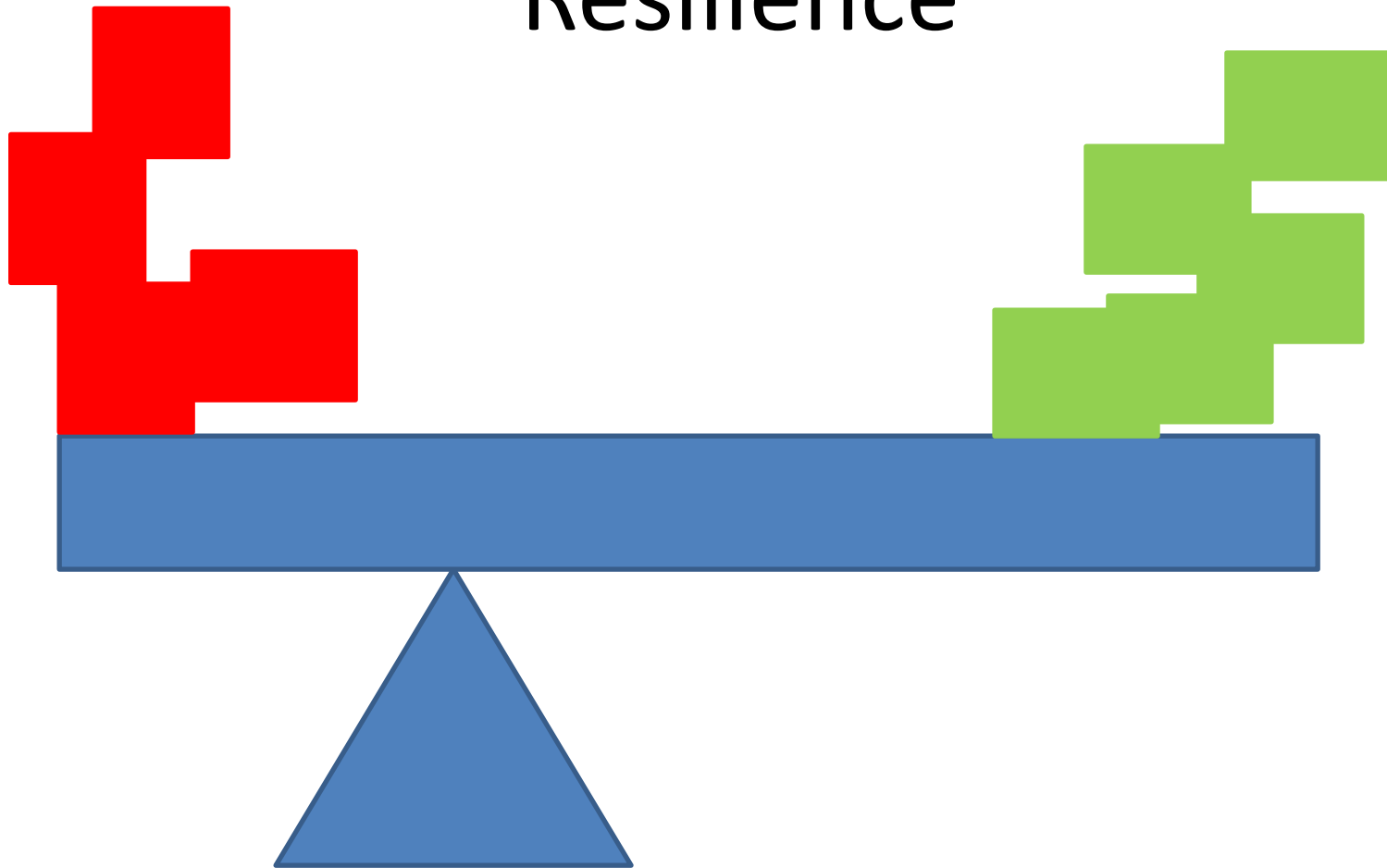
Help Children Build Resilience



Resilience



Resilience

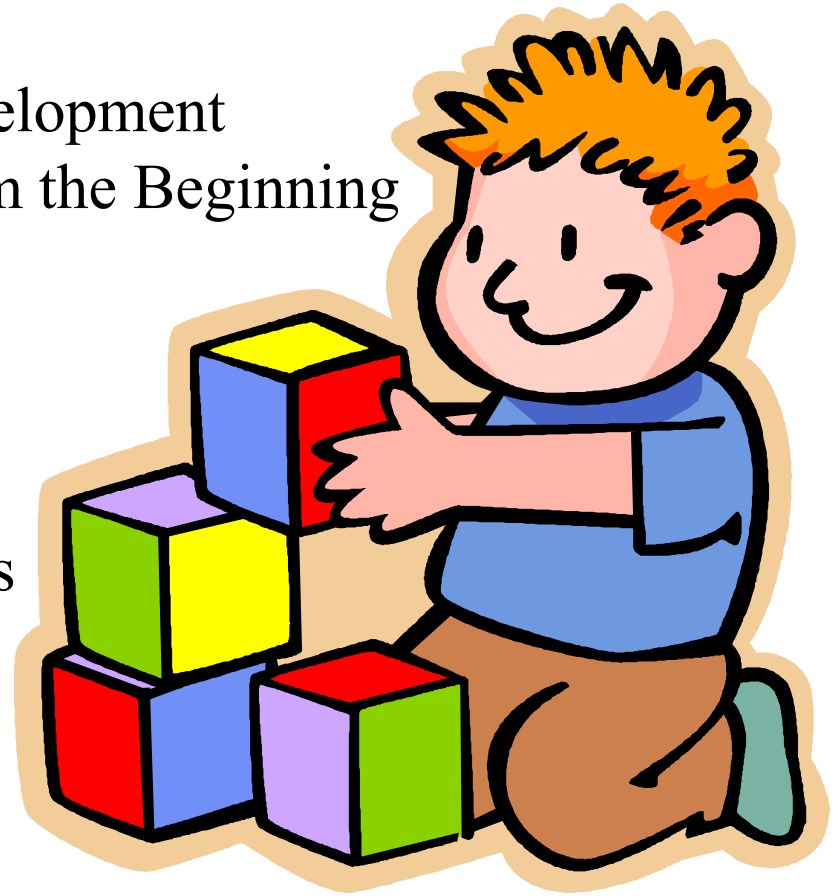


Recipe for Resilient Citizens

Adequate Stimulation for the Development
of Healthy Brain Architecture from the Beginning

Reduce/Eliminate Toxic Stress in
Childhood

Increase/Support Protective Factors
for Children and Families



Communities Building Resilience

- Early intervention for families at risk
- High quality early education programs beginning in infancy
- Laws and Policies that create stability not disruptions in families in need
- Mental health and substance abuse services available to all families in need
- High quality schools
- Good Libraries
- Safe Play Spaces
- After school programs
- Mentoring programs
- Highly Networked Neighborhoods

For More Information

<http://www.cehd.umn.edu/icd/>

<http://www.developingchild.net>

