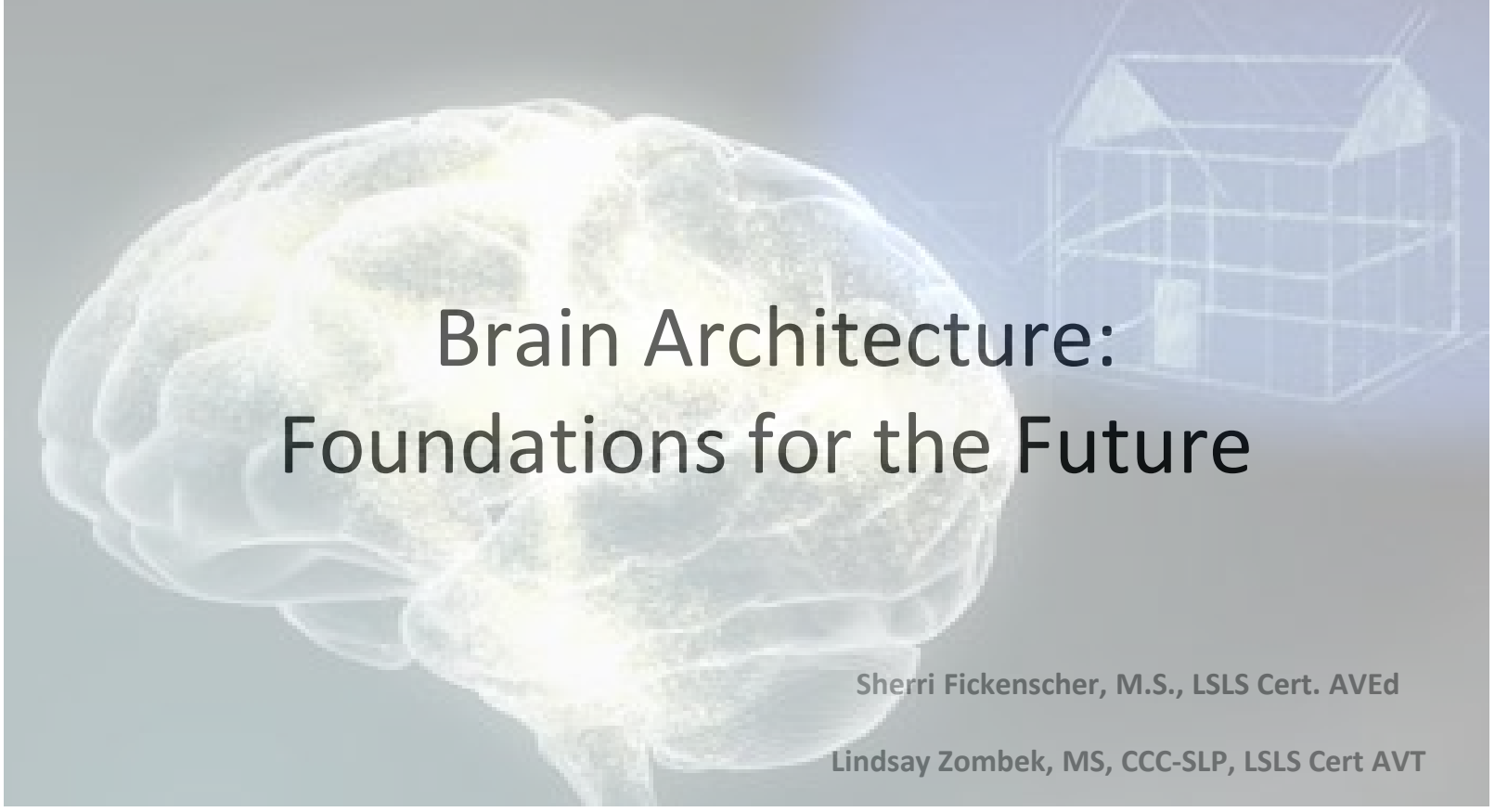

Brain Architecture: Foundations for the Future

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Learner Objectives

The learner will:

1. State how life experiences impact brain development and the expression of genes.

2. State reasons why children with hearing loss are at additional risk for negative impact on brain development

3. Identify strategies a practitioner uses to foster positive impact on brain development

WE DO NOT LISTEN WITH OUR EARS!

Hearing and ***Listening*** are different.

Hearing: the physiological process; the sound is brought to the brain

Listening: brain work and intentionality; processing the sounds to make them meaningful

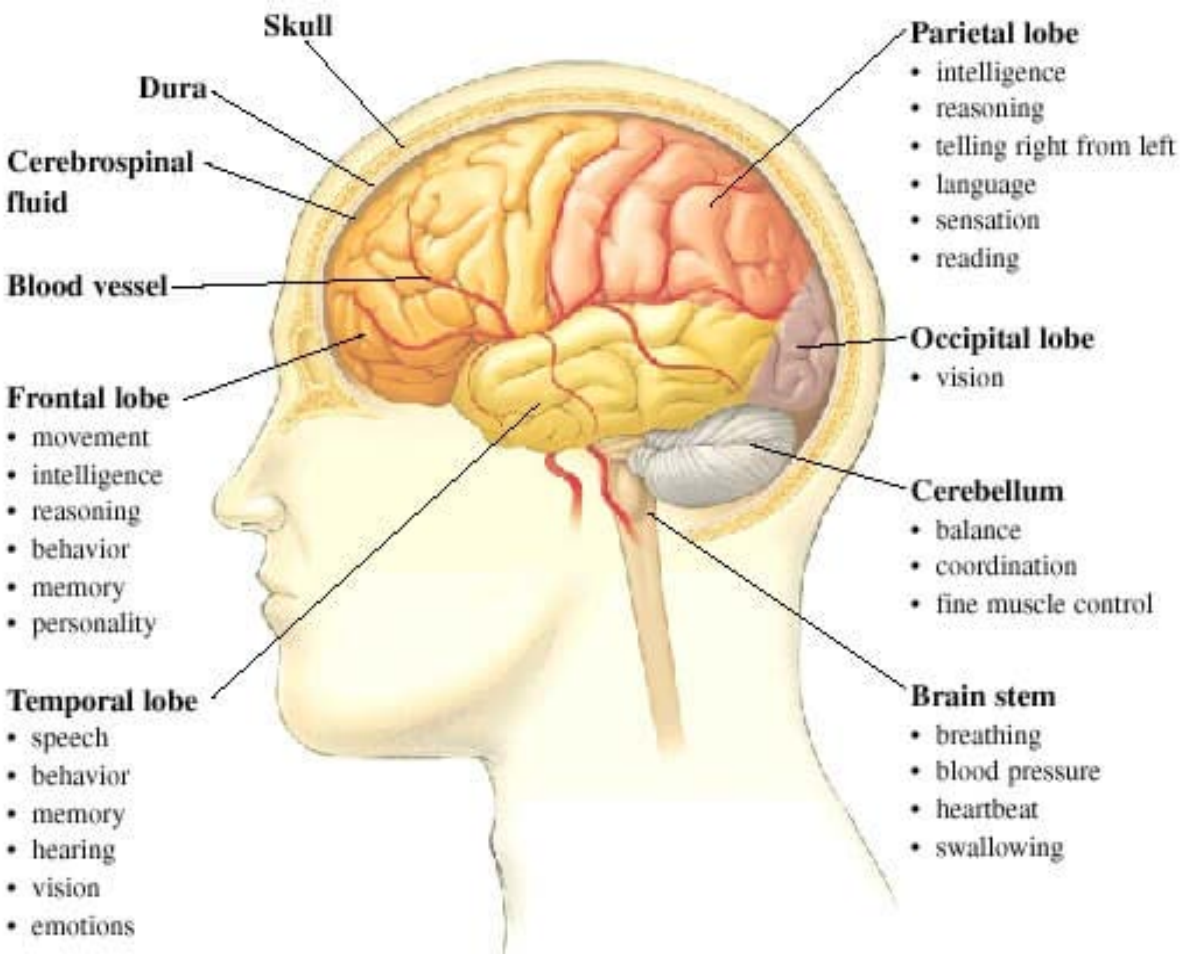
SO: What about brain development?

Some basic brain facts…..

The Size of the Brain

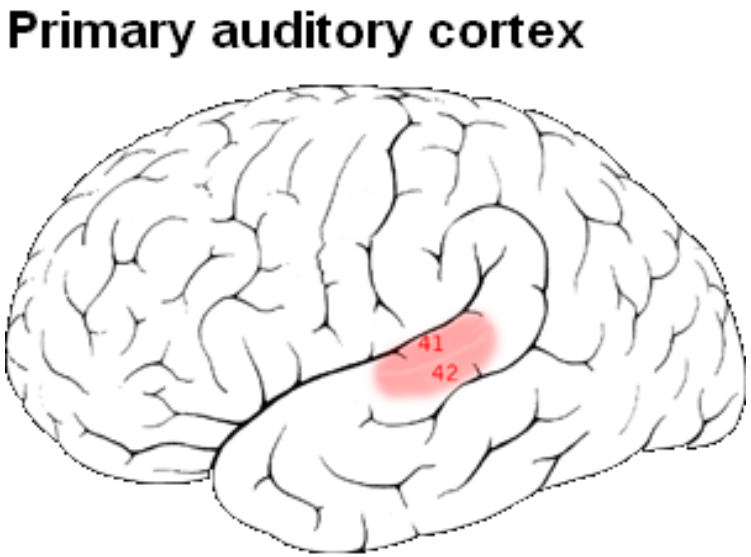
- In terms of weight, the average adult human brain weighs in at 1300 to 1400 grams or **around 3 pounds**.
- In terms of length, the average brain is around **15 centimeters long (approximately 6 inches)**
- For comparison, a newborn human baby's brain weighs approximately 350 to 400 grams or **three-quarters of a pound.**
- **Neurons** are the structures that serve as building blocks of the brain and nervous system. They transmit and carry information, allowing different parts of the brain to communicate with one another as well as allowing the brain to communicate with various parts of the body. Researchers estimate that there are around **100 billion neurons** in the human brain.

https://www.verywell.com/how-big-is-the-brain-2794888

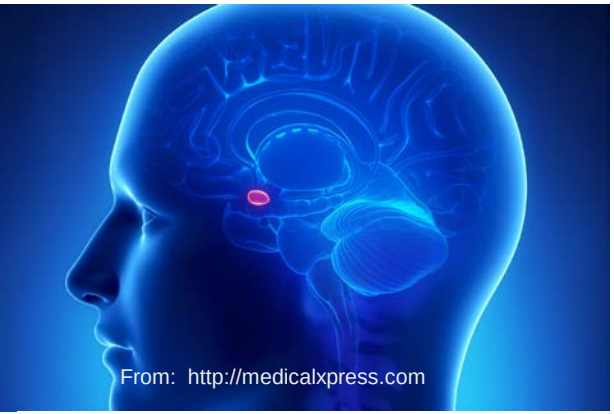

Skull
Dura
Cerebrospinal fluid
Blood vessel
Frontal lobe
• movement
• intelligence
• reasoning
• behavior
• memory
• personality
Temporal lobe
• speech
• behavior
• memory
• hearing
• vision
• emotions
Parietal lobe
• intelligence
• reasoning
• telling right from left
• language
• sensation
• reading
Occipital lobe
• vision
Cerebellum
• balance
• coordination
• fine muscle control
Brain stem
• breathing
• blood pressure
• heartbeat
• swallowing

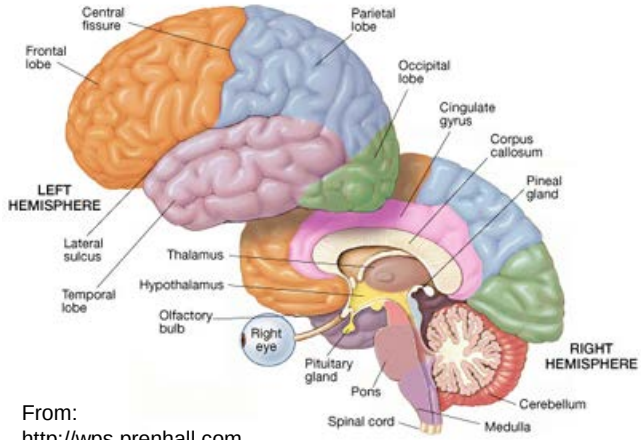
Brain Development: Hearing and Listening

Auditory Cortex is the region of the brain (temporal lobe) most involved with perceiving sounds and working to make those sounds meaningful.

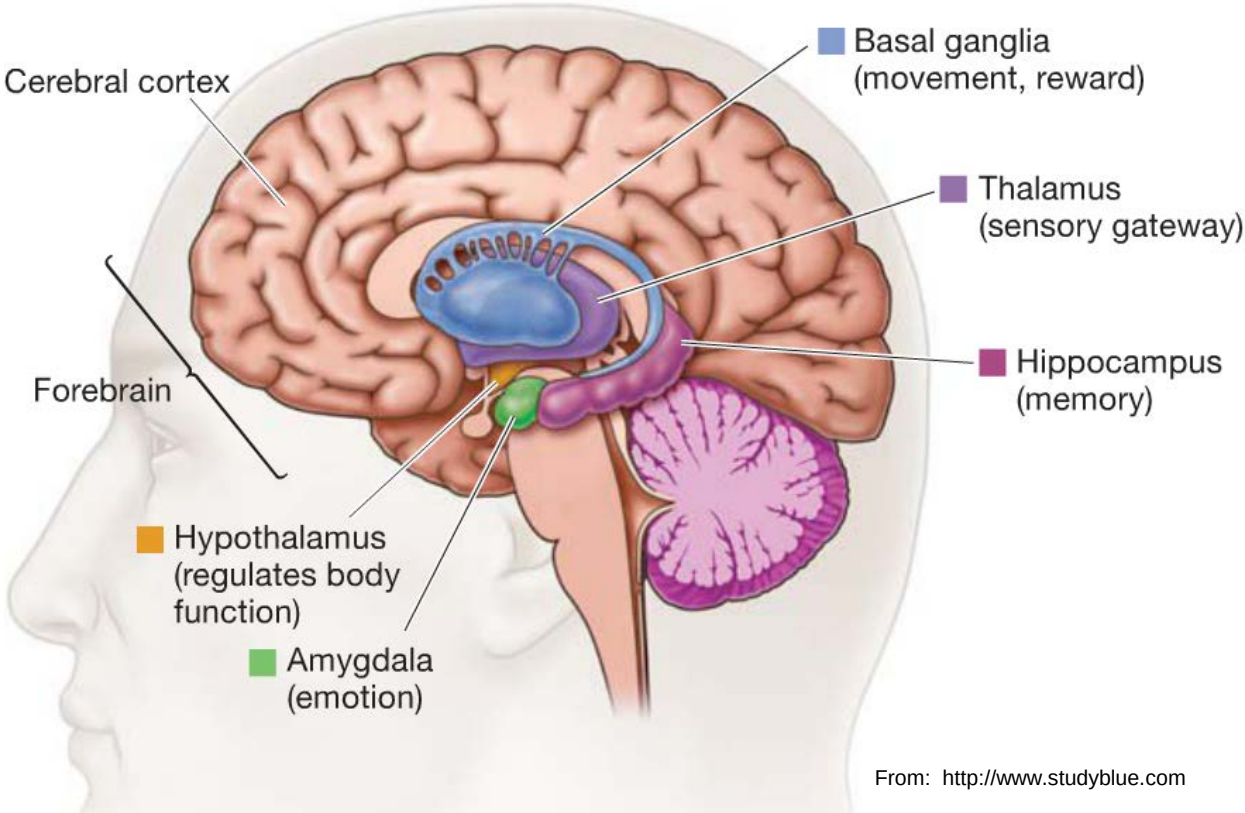


Amygdala





From: http://wps.prenhall.com



From: http://www.studyblue.com

Auditory Cortex and the neurosensory system for hearing do the most development prenatally after 20-25 weeks gestation (though it can happen earlier).

- The hair cells are able to transmit information to the brainstem and then to the temporal lobe of the brain.
- Even in utero “learning” begins and the neuronal pathways in the brain form
- The expression of genes can be altered by the environment (being in a noisy environment, chemicals, deficient nutrition, and other reasons)

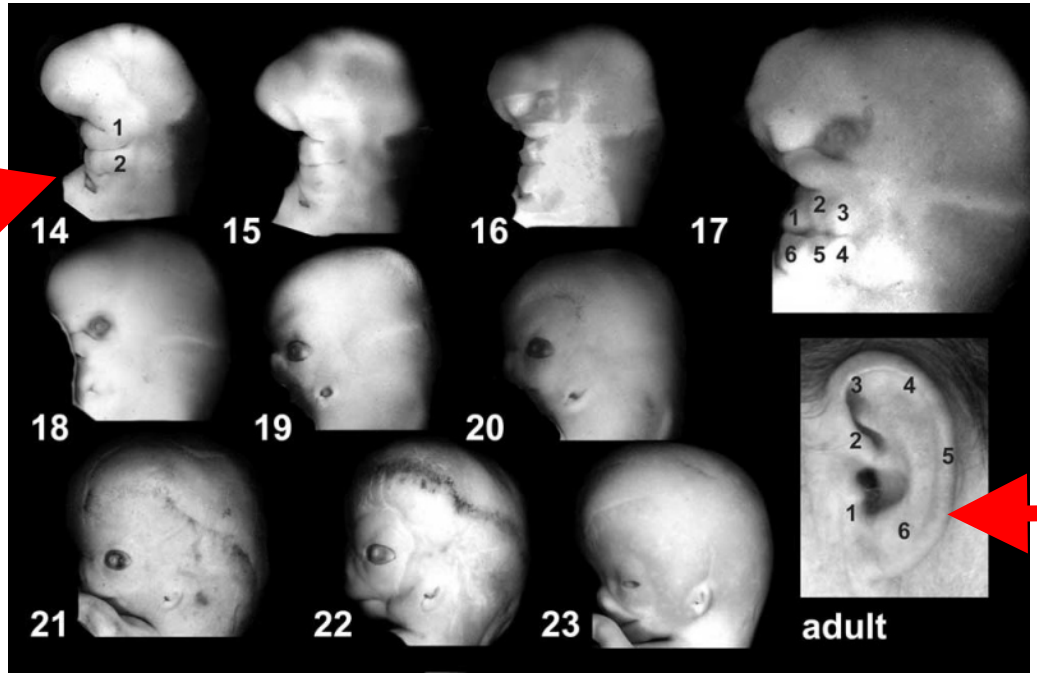
Research has demonstrated that a fetus or child immediately after birth can:

- Identify mother's voice
- Identify their mother's native language
- Familiar with certain vowels
- Recognize music
- Recognize early pitch, pattern, intensity, and rhythm differences

Development of the Hearing System

Outer Ear begins developing at 5-6 weeks gestation

Week 5



Week 8

Image from
https://embryology.med.unsw.edu.au

Development of Hearing System

- Middle Ear Ossicles (Malleus, Incus, and Stapes) begin to develop between weeks 4 and 7 of gestation.
- Malleus and Incus come from the first pharyngeal arch
- Stapes develops from second pharyngeal arch

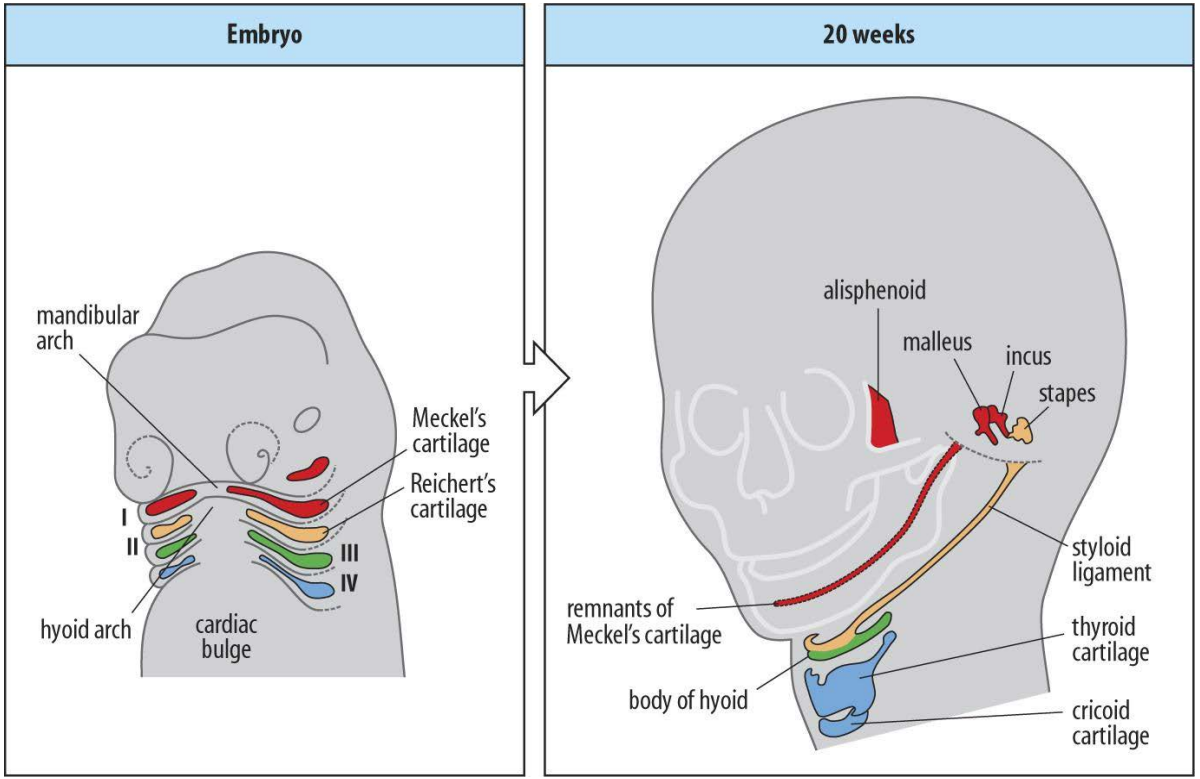


Image from: http://www.mun.ca/biology/desmid/brian/BIOL3530/DEVO_15/devo_15.html

Development of Hearing System

The inner ear develops between the 4th and 25th week of gestation

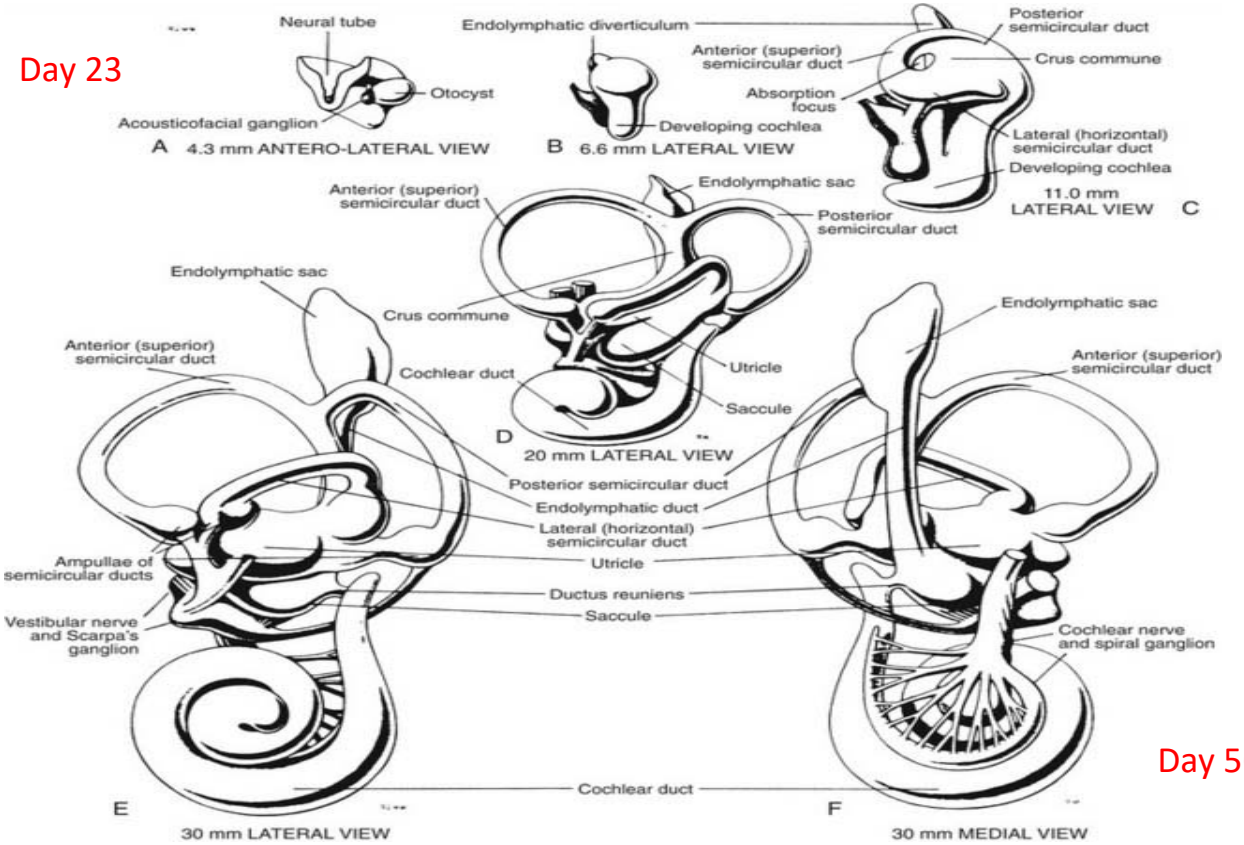


Image from:
http://clinicalgate.com/anatomy-of-the-vestibular-system/

Evidence for Hearing and Listening in Utero

- Exposure to sound in utero with the addition of Rapid Eye Movement (REM) sleep help the fetus develop auditory memories/ neural synapses (Graven and Browne, 2008).

- Fetuses between 30-40 weeks gestation exposed to intense low-frequency noise interspersed with quiet and absence of voice were found to arrive at 40 weeks with 2 months of language delayed (Graven and Browne, 2008).

- *Fetuses in noise cannot hear mother's voice, music, and meaningful sounds in utero and do not develop the same language skills by birth*

Similarly, our children born with hearing loss are not hearing what they are supposed to hear in utero and are not being born with the auditory and language skills typical of newborns-- these children are already behind!

How does a Fetus and a Newborn Listen?

The child attaches meaning to sounds through experiences with sound. The brain will develop neuronal pathways to help learn and efficiently apply meaning to the sound.

In short, children build listening through Neuroplasticity

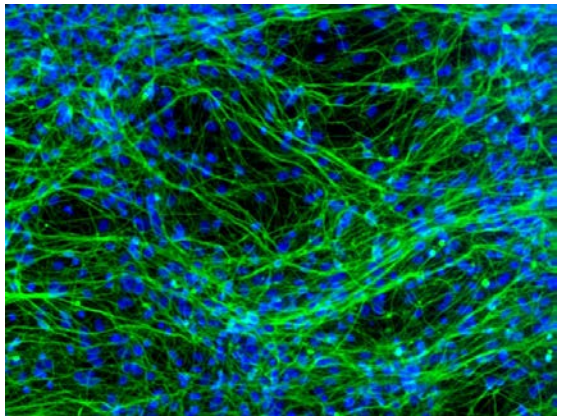
Neuroplasticity

- Neuroplasticity is “the ability of neuronal groups to adjust function based upon input” (Cardon, Campbell, and Sharma, 2013).

- In the auditory cortex, your auditory system interacts with your cognitive system to develop new pathways and responses.

Neuroplasticity

- First 3.5 years of life: neurons and pathways are created rapidly
- After 4 years of life:
  - pruning occurs and unnecessary neurons and synapses are eliminated
  - Cross-modal processing occurs and hinders later processing



What Are the Facts? Let's Review!

- A child with a hearing loss is already potentially around 20 weeks behind at birth
- The critical window for auditory cortex development is birth to 3.5 years
- The critical window for language development is birth to 3 to 5 years
- Children need over 20,000 hours of listening experience before the age of 5 to develop the neural framework for literacy (Blaiser, 2012)
- The greatest time of neuroplasticity is in the first years of life

What are the Facts? Let's Review

- Food and Drug Administration in the United States indicates cochlear implants for children older than 1 year old

MAJOR PROBLEM! What can we do?

For our kids with severe to profound hearing loss, appropriate amplification may not be available for a year

To develop the auditory cortex, waiting a year is already too late

How do we do auditory therapy with a child who is severely-profoundly deaf when they do not get enough benefit from hearing aids to learn spoken language?

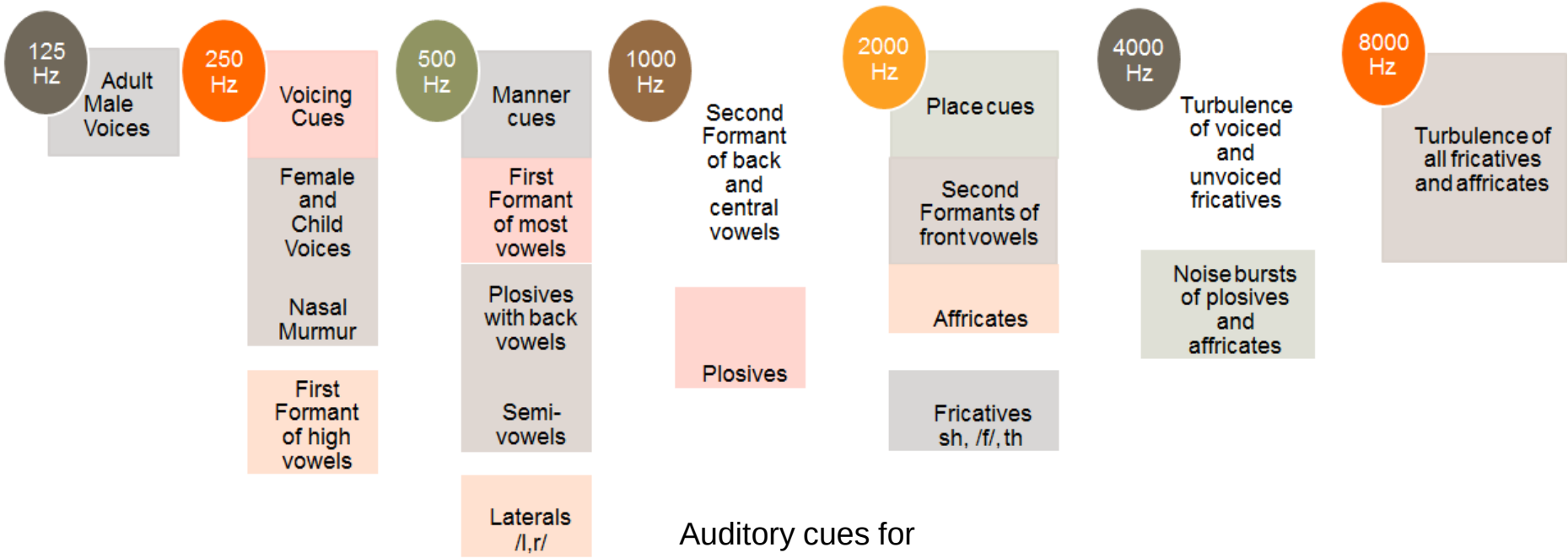
What can we do to maximize brain development?

We can maximize hearing (brain development) to start building the synapses!

This requires:

- Most appropriate amplification that is possible
- Full time use of amplification
- Appropriate therapy services
- Auditory therapy beginning immediately

What Can A Child Hear? (Ling, 1989)



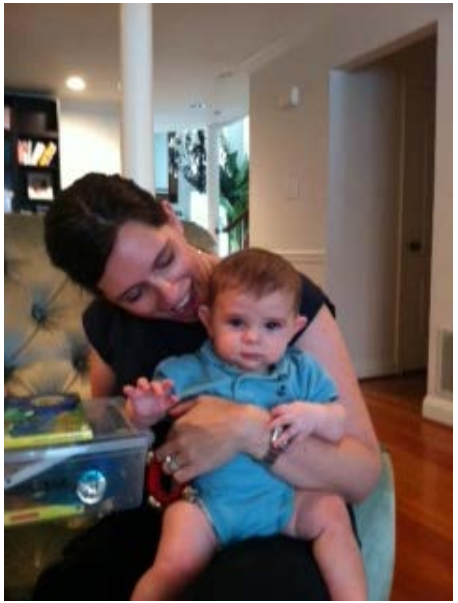
Auditory cues for prosody/suprasegmentals are mostly found in frequencies up to 1000 Hz

Normal Auditory Skill Development

LISTENING	UNDERSTANDING (Receptive Language)	SPOKEN LANGUAGE (Expressive Communication)	SPEECH SOUNDS (Articulation)
0-3 mo: · Startles to loud sound · Quiets when hears parent's voice · Smiles when parent talks **3-9mo:** · Looks for sounds · Likes toys with sound · Likes music **9-12 mo:** · Begins to understand common words · Follows simple directions ("want up," "come here") · Likes songs, rhymes	**0-3 mo:** · Quiets when people start talking · Responds to faces · **3-9mo:** · Occasionally turns to own name · Recognizes emotions in voices **9-12 mo:** · Knows some body parts, animals, clothing · Starts providing gestures for common phrases (waves for "bye")	**0-3 mo:** · Vocalizes for hunger, anger, pleasure · Occasionally vocalizes to voices **3-9mo:** · Blows raspberries, coos, yells · Vocalizes when needs or wants something · Vocalizes in response to singing and talking **9-12 mo:** · Sentence-like jargoning · First true word · Vocalizes to songs	**1 year:** · Uses /b,d,m,n/ · Varies vowels and consonants when babbling

“DO YOU WANT TO MAKE YOUR CHILD SMARTER?”

+



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How does the brain develop? Key Concepts

- Over time, from the bottom up
- through billions of connections between neurons across brain areas
- through the interaction of genes & experiences
- inextricable intertwining of cognitive, emotional, and social capabilities

https://developingchild.harvard.edu/science/key-concepts/brain-architecture/

Once again we ponder……

WHAT INFLUENCES BRAIN DEVELOPMENT? HOW DO WE KNOW?

NATURE

NURTURE

Mentimeter Poll of Audience

Do you think:

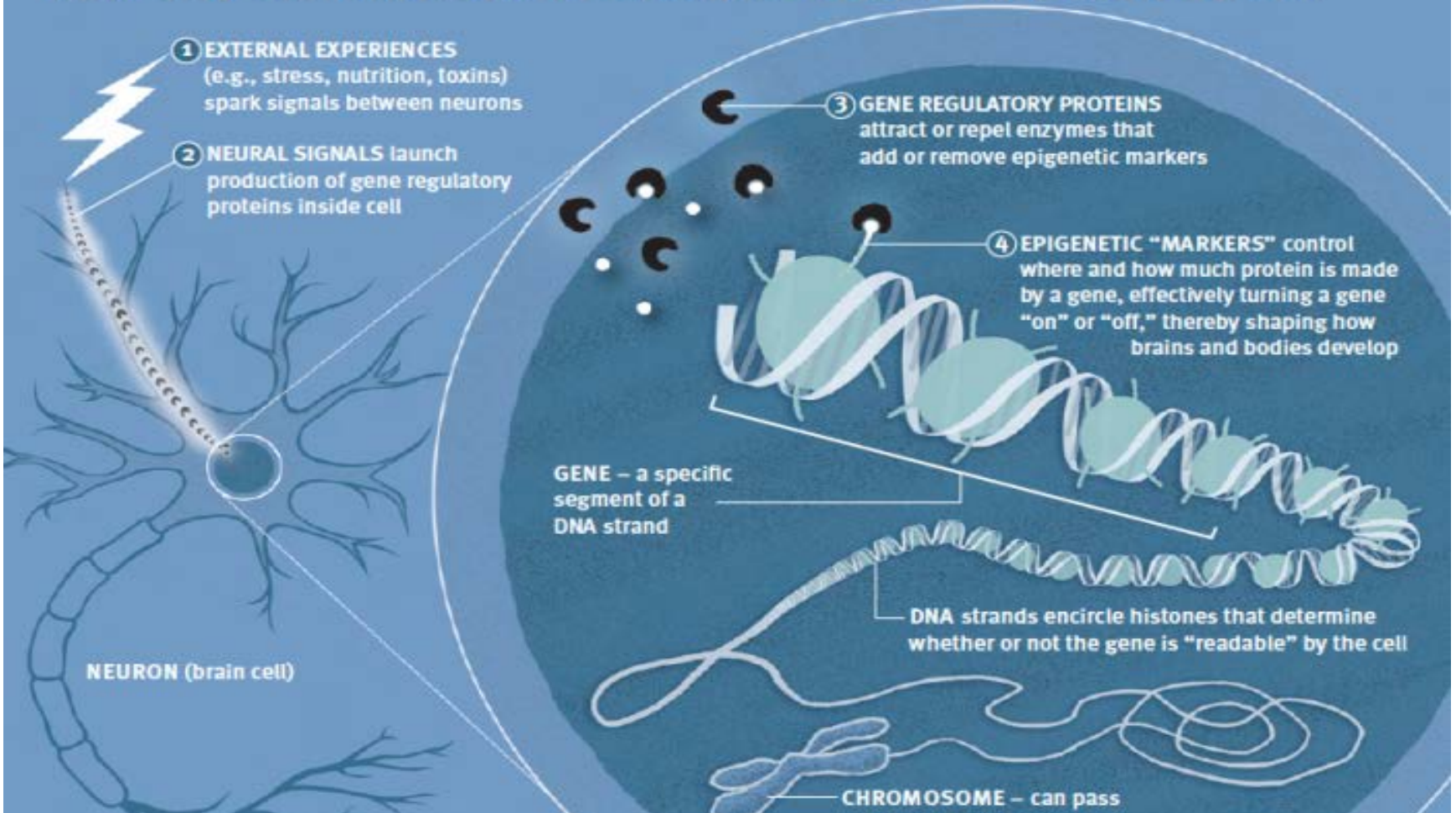
1. Genes are fixed at birth
2. Genes are not fixed at birth
3. I have no idea, but am interested to learn
4. I have no idea and want to leave this session

Go to www.menti.com and use code 62 83 22

Epigenetics….say WHAT?

https://www.youtube.com/watch?v=k50yMwEOWGU

How Early Experiences Alter Gene Expression and Shape Development



Epigenetics

- the study of environmental factors that change whether DNA will be “expressed” without altering the DNA sequence itself

- factors that change the likelihood that a genetic ‘book’ will be read

Champagne and Mashoodh, 2009

Brain Architecture

Child Development Core Story Part 2: Serve & Return

http://developingchild.harvard.edu/resources/project-for-babies/

Serve and Return

1. Notice the serve and share the child’s focus of attention.
2. Return the serve by supporting and encouraging.
3. Give it a name!
4. Take turns...and wait. Keep the interaction going back and forth.
5. Practice endings and beginnings.

https://46y5eh11fhgw3ve3ytpwxt9r-wpengine.netdna-ssl.com/wp-content/uploads/2017/06/HCDC_FIND_ServeReturn_for_Parents_Caregivers.pdf

“Responsive parenting is key to a process called pruning. Pruning is how the brain creates the most efficient pathways possible.”

“Skill begets skill”

Megan Gunnar, Ph.D,
Director,
Institute of Child Development
University of Minnesota

Responsive Caregiving

‘When caregivers are responsive and create a stable environment, children experience less stress and have a strong foundation for positive learning, health, and behavior.’

https://developingchild.harvard.edu/resources/three-early-childhood-development-principles-improve-child-family-outcomes/#responsive-relationships

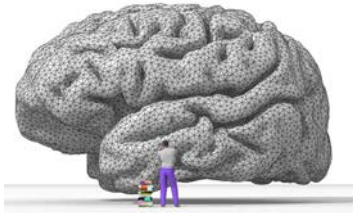
Brain Architecture

Children who have had:

- positive adult interactions
- adequate nutrition
- minimal exposure to stress

….arrive at school better able to learn because of strong brain architecture!

This is our challenge!



Building a Healthy Brain

- Genes + Experiences shape the brain
  - genes=hardware
  - experiences=software
- Babies learn in the context of relationship
- Emotions drive learning
- Early relationships form the basis for all later relationships

What does this look like in practice?

Let’s brainstorm activities/strategies/techniques that work on serve & return and encourage responsive parenting!

Go to www.menti.com and use code 62 83 22

Positive Life Experiences

- Basic needs of child are always met
- Reciprocal social interaction between child and attentive caregiver
- Caring adult helps to ease stress (well-functioning stress response system)
- Children learn best when adults are engaged with them in the learning process

Three Types of Stress Responses

Positive Stress Response

- normal part of healthy development
- mild/brief elevations in stress hormone

Tolerable Stress

- body’s alert system activated for longer period of time
- brain and organs can avert damaging effects if a supportive adult helps child adapt

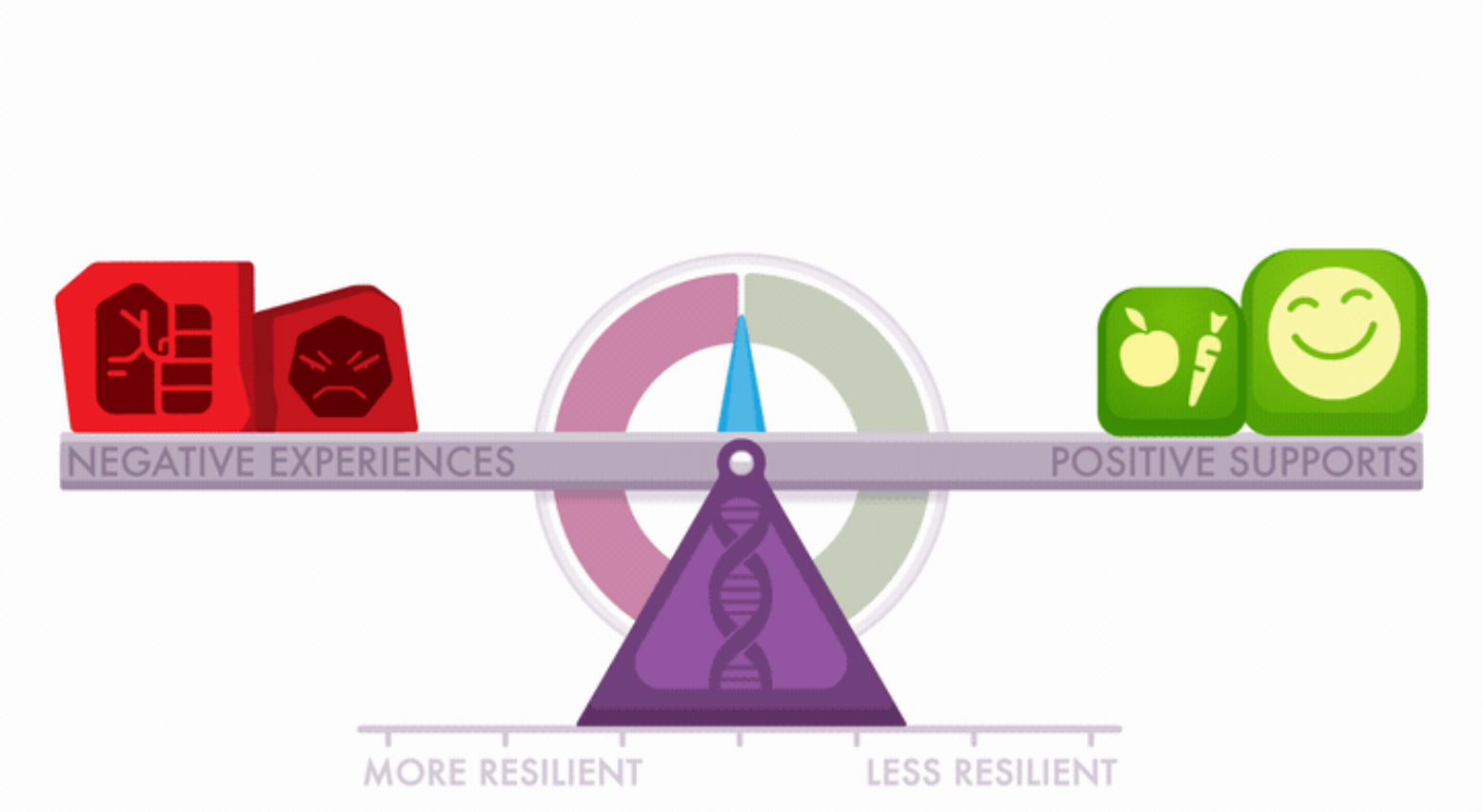
Toxic Stress

- major, frequent and/or prolonged adversity
- support of caring adult is not adequate

Adverse Childhood Experiences (ACE)

- abuse
- neglect
- inconsistent relationships (non-responsive caregiver)
- lack of adequate nutrition
- caregiver with serious depression or mental illness
- caregiver struggling with addiction

Impact of Positive Support and Resilience



Time for Fun!

Time Schedule

Years 1-3 completed for discussion by:

Year 8 completed for discussion by:

Pause after Year 3 for Discussion

What observations can you share?

What are your predictions for your brain?

YEAR EIGHT

What observations can you share?

If your brain toppled:

- when did this happen?
- what were the causes?

How do we tie what we know about early auditory development together with responsive social interactions and epigenetics in the first 12 months of life?

How Does Hearing Loss Impact Development?

BRAIN DEVELOPMENT:

- The neural pathways in the auditory cortex are not as strong if they have not been accessed (may not be established or will be pruned if not used/efficient). This does NOT mean they CANNOT be developed or strengthened.

- By age of 7 brain starts processing other senses such as touch and vision in the auditory cortex if not stimulated

- “Skill Begets Skill” If the basic cortices are not developed, then future skills may pose more of a challenge (spoken language development, reading, higher level language)

How Does Hearing Loss Impact Development?

Epigenetics:

- Adds stress to child

- Adds stress to family

- Change in parent-infant bonding

How Can We FOSTER Brain Development?

- Identify what auditory skills a child can access with their residual hearing/hearing aids and target them
- Educate parents on strategies for appropriate bonding with baby
- Educate parents on how to be responsive to the baby's needs
- Teach parents about quantity and quality of words
- HIGH EXPECTATIONS

Many Elements Out of our Control, But We Can:

- Help families identify resources (support, financial, educational) that make their journey easier

- Emphasize the things the family CAN control
  - Talking to the baby, touching baby, reading books to the baby, keeping technology on and working, anticipating baby's need… …ences in brain development and epigenetics.

SCENARIO #1

You meet a family with a 3 month old baby who has been diagnosed with severe-profound hearing loss. The family thinks they may try to get a cochlear implant when the baby is old enough. They are not rushing to buy hearing aids because the audiologist and ENT said that they would not help anyway.

How Can You Apply Brain Development/ Epigenetics to Working With a Family?

With your group, discuss:

1) Knowing what you know about brain development, what can you say to this family?

1) What can you say and what can you do with the parents to help promote positive genetic expression?

Scenario #2

The family purchased hearing aids and are consistently putting them on the baby. The baby's family tells you that they are feeling overwhelmed. Mom and Dad have missed a lot of work for the audiology and ENT appointments. They want to take the baby to fun experiences for learning, but there are not enough hours in the day to get everything done. They are really happy to have found an educational video series to help baby learn while they cook and do household responsibilities.

How Can You Apply Serve and Return to Working With a Family?

With your group, discuss:

1) Knowing what you know about the benefits of serve and return, what can you say to this family?

1) What can you say and what can you do with the parents to help promote serve and return?

TAKEAWAYS… What Will YOU Do Differently?

On your card, write:

1) What is your key takeaway from this session?

1) What specifically are you going to do differently to help brain architecture of the children with whom you work?

QUESTIONS?

Contact information

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Lindsay Zombek: Lindsay.Zombek@uhhospitals.org

Resources for More Information:

Center on the Developing Child Harvard University: http://developingchild.harvard.edu/

Hearing First: www.hearingfirst.org

NCHAM: http://infanthearing.org/

The Brain Architecture Game: https://dev.thebrainarchitecturegame.com/

The Brain Certification Story: http://www.albertafamilywellness.org

The Scientist in the Crib- Gopnik, Meltzoff, Kuhl

Thirty Million Words Building a Child's Brain-Dana Suskind

Zero to Three: www.zerotothree.org

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