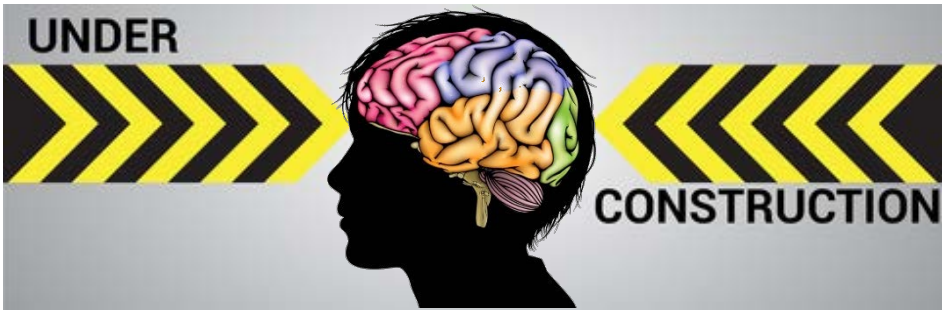
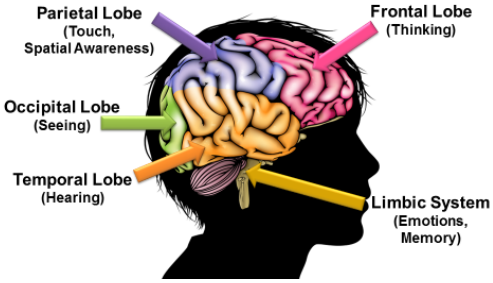


How do early experiences construct and wire up the brain?

Brains are built over time and in stages, like a house. As a matter of fact, constructing a brain is a lot like building a house. First, you build a foundation. Then, you frame the structure. Then, you lay the wiring.

Construction of the brain begins about 3 weeks after conception and by the time the baby is born, the basic structure of the brain is in place.

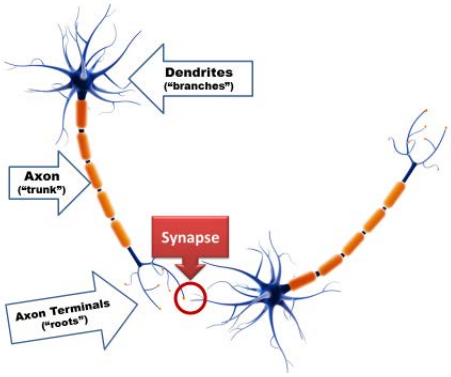
Babies are born with 1,000,000,000 neurons at birth, but most are not yet wired. Imagine a house with thousands of electrical outlets that don't work because they are not yet wired up! That is a pretty good picture of a child's brain at birth.



Like a house, the brain has different "rooms" with specialized functions.

Neurons are the building blocks of the brain. Some things you need to know about neurons include:

1. Neurons look like trees. The "branches" receive signals from other neurons. The signal travels down the "trunk" and out the "roots" jumping to the "branches" of another neuron. The point at which a dendrite branch and an axon terminal connect is called a synapse. The synapse is important because this is the point at which the communication signal passes from one neuron to another.
2. Neurons function like telephones. They send and receive "calls" (electro-chemical signals) to each other.
3. Neurons that "fire" together (activated at the same time) are "wired" together. Groups of connected neurons are called "neural networks." The more frequently a neural network is "fired" – the stronger it becomes.



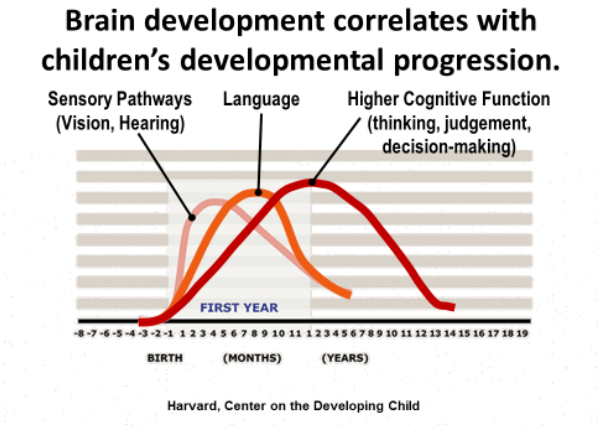
- **Changing Brains, University of Oregon Brain Lab:**
  https://www.youtube.com/watch?v=cU-pHVj-vFQ
  https://www.youtube.com/watch?time_continue=168&v=FefCHypcKhU
- **Zero to Three:** http://main.zerotothree.org/site/PageServer?pagename=key_brain

© 2016 Nicki Patton Rowe ♦ nickipatton@msn.com ♦ (859) 230 5193

NOTE: Brain development is a very complex process. This handout uses a variety of analogies to offer a simple, easy-to-understand explanation of how the brain develops during the early years. For more detailed information, please check out the resources included in this document, from which this information was obtained.

Neuroscientists have discovered that genes and early experiences (nature/nurture) work together to connect neurons. The first part of the process takes place automatically. Genes initiate the process during which neurons automatically begin making connections to other neurons. This process takes place at different times in different parts of the brain. Imagine a garden where different flowers bloom at different times of the year.

"Blooming" neural connections



This graph shows that the sensory pathways of vision and hearing are among the first areas of the brain to wire up, followed by areas of the brain that support language. Structures within the frontal lobe associated with higher order thinking skills such as judgment and decision-making are some of the last brain structures to be wired up. This area is still being wired up during the late teens and early 20's which is why juveniles are not tried as adults in most cases – because their brains are not yet capable of adult judgement and decision-making.

This blooming of neural connections takes place at an astonishing rate during the first few years – to the tune of 700 neural connections formed every second! And like a garden that becomes overgrown, the brain ends up with more connections (synapses) than it needs. So, the brain "prunes" (weeds out) unnecessary connections – connections that haven't been used. The phrase "use it or lose it" describes the process of the brain keeping the connections that it uses and losing the connections it doesn't need.

Unused neural connections are "pruned."

Children's experiences during the first 3-5 years have a huge impact on which neural connections are kept and which are pruned. That is why the quality of children's experiences are critical – both at home and in early childhood programs.

- *Brief: The Science of Early Childhood Development*, Center on the Developing Child, Harvard University, http://developingchild.harvard.edu/resources/inbrief-science-of-ecd/
- *Brain Basics,* Better Brains for Babies, Georgia http://www.bbbgeorgia.org/brainBasics.php
- *Children and Brain Development: What We Know About How Children Learn* University of Maine, Extension, http://extension.umaine.edu/publications/4356e/

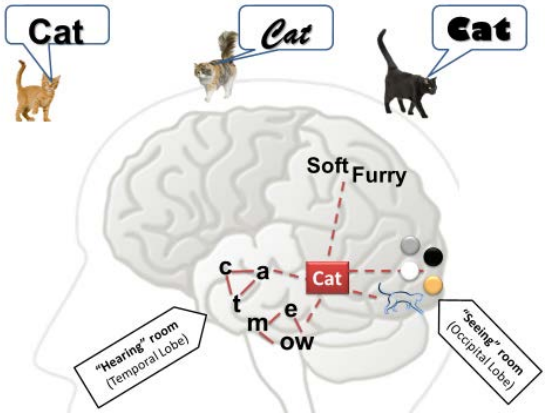
How does the brain construct knowledge?

The brain constructs knowledge by combining simple neural networks into more complex neural networks.

For example, when a child sees a cat, the visual image is processed in the "seeing" room of the brain (occipital lobe) where a neural network is formed representing the basic visual features of a cat. The more visual experiences a child has with real cats and images of cats, the stronger this neural network becomes.

Likewise, when a child hears the word cat, the auditory sound is processed in the "hearing" room of the brain (temporal lobe) where a neural network is formed that consist of the sounds that make up the word cat. The more times the child hears the word cat, the strong this neural network becomes.

Remember… neurons that "fire together" are "wired together." This is true of both individual neurons and neural networks. When a child both sees a cat and hears the word cat at the same time, the simple visual "cat" network and the simple auditory "cat" network are activated at the same time. With repeated experiences, these simple neural networks become wired together forming a more complex neural network that the brain labels "cat."



Over time and with additional "cat" experiences, the brain constructs a very complex "cat" neural network by linking neural networks that respond to the different characteristics that form the concept of cat. This is a very simple example of a very complex process that occurs each time your brain receives and processes new information.

Zull defines learning as "making changes among neural connections." In his book, *The Art of Changing the Brain*, he explains:

> "…There is a neural network for everything we know…it seems that every fact we know, every idea we understand, and every action we take has the form of a network of neurons in our brain… Complex experiences or ideas consist of extensive networks…Any change in knowledge must come from change in neuronal networks.. (2002, pp 98-99)."

- *The Art of the Changing the Brain* (James Zull) , in Educational Leadership (September 2004) http://www.ascd.org/ASCD/pdf/journals/ed_lead/el200409_zull.pdf

© 2016 Nicki Patton Rowe ♦ nickipatton@msn.com ♦ (859) 230 5193

Chronic STRESS

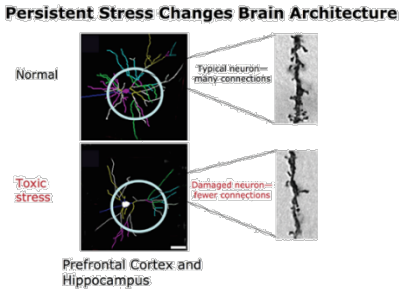
How Does Stress Change and Weaken the Brain's Structure?

Toxic stress response can occur when a child experiences strong, frequent, and/or prolonged adversity—such as physical or emotional abuse, chronic neglect, caregiver substance abuse or mental illness, exposure to violence, and/or the accumulated burdens of family economic hardship—without adequate adult support. This kind of prolonged activation of the stress response systems can disrupt the development of brain architecture and other organ systems, and increase the risk for stress-related disease and cognitive impairment, well into the adult years. (http://developingchild.harvard.edu/science/key-concepts/toxic-stress/)

Deep in your brain, inside the limbic system, the amygdala scans all incoming data for perceived threats. Acting like a 911 emergency call center, the amygdala sounds the alarm when danger is sensed, setting of a series of messages, some of which signal the release of stress hormones such as adrenaline and cortisol. After the danger passes, the amygdala stops sounding the alarm and stress hormones go back to normal levels.

But when in a chronically stressful situation, the amygdala continues to sound the alarm. Excessive activation of the body's stress response system results in elevated levels of cortisol in the brain. That's a problem because neuroscientists have determined that long-term exposure to excessive cortisol can damage the developing brain.

Cortisol can interfere with the chemicals that brain cells use to communicate with each other. Specifically, cortisol affects a part of the brain called the hippocampus which plays a major role in memory, learning and emotions. Excessive cortisol can also impact the prefrontal cortex, the "thinking" part of the brain where judgement and decision-making take place. When experienced during the early years, toxic stress can lead to underdeveloped neural connections and a weakened brain architecture.



Source: Center on the Developing Child, Harvard University http://developingchild.harvard.edu/resources/inbrief-the-impact-of-early-adversity-on-childrens-development-video/

- *Toxic Stress,* Center on the Developing Child, Harvard University, *Toxic Stress* http://developingchild.harvard.edu/resourcetag/toxic-stress/
- *Effects of Stress on Brain Development*, Better Brains for Babies, GA http://www.bbbgeorgia.org/stressEffects.php

© 2016 Nicki Patton Rowe ♦ nickipatton@msn.com ♦ (859) 230 5193