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MEDICAL MEMO

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What's Brain Got To Do With It?
Or Your Child's and Teen's Brain

This article seeks to provide the reader with an understanding of how new research in neuroscience, especially on brain development, enlightens our tasks as parents, therapists and doctors. For this discussion I have drawn much from the works of Jay Giedd MD, Bruce Perry MD, Daniel Siegel MD, Carol Tamminga MD, Paul Lombrosa MD, and Time magazine's 5/10/04 cover article entitled "Secrets of the Teen Brain".

Neither Nature nor Nurture is the most important determinant of how our lives develop. How we develop is based on the **interplay** between Nature (heredity, genetics, biology) and Nurture (environment, parenting, education, experiences). The brain's programmed genetic development and our environmental life experiences interplay causing brain cells (neurons) to grow, to die, to form new connections, to lose connections, to turn on, and to turn off. These changes are most pronounced in the womb and during the first three years of life. Humans achieve their maximum brain cell density between the third and sixth month of gestation - the culmination of an explosive period of prenatal central nervous system growth. In the last trimester of pregnancy many "unnecessary" cells are pruned out. The ability to change, to be modified, and to develop continues but less so as we get older. We are born equipped with almost all the neurons we'll ever have. At birth the infant brain has 100 billion neurons and another trillion glial (support) cells. Few more neurons will develop in the years to come but the wiring of connections between nerve cells is yet to stabilize and reach adult form. The brain has been programmed by genetics to lay out the best guess of the circuits needed for vision, hearing, language, response to the environment, sleep, calming, nurturance, learning, physical skills like walking, interactions with other people, and so on. Experiences greatly influence how all this gets refined (developed). We begin with and form trillions more connections than we can ever possibly use. Based on our experiences, millions of nerve cell connections are eliminated, kept, downgraded, or reinforced.

As an **example**, let's take the visual cortex. There are 2500 synapses per neuron at birth. This increases to 18,000 at 6 months, averages 15,000 per neuron at 2 years, continues at this level till age 10 and is then pruned down through the teens to what is needed as an adult. Congenital cataracts will inhibit this normal brain development and cause cortical (brain based, not eye) blindness if the cataracts are removed too late. Human brain cells are more plastic (changeable to fit other needs) than other animals but there are still some sensitive and critical periods, which if not met, permanent deficits can occur.

Research has shown that if a child is not played with, interacted with, nurtured, exposed to stimuli, and is rarely touched it will develop a 25% smaller brain. Another way of saying this is that an enriched life environment of varied stimulating experience results in 25% more neuronal connections. Children **need**, and the healthy development of a child's brain and chance to reach his or her full human potential **requires**, hands on involved parenting, cuddling, talking to, interactions, and stimulating experiences. These experiences cause neurons to react, which in turn, activates the gene that codes for making the protein needed to connect that neuron to another and another. The connections between these neurons are now a

group or a circuit. **Experiences thus shape and reshape the structure of the brain**. We thus develop a unique brain with our own mind, emotions, thinking style, temperament, personality, and reaction patterns.

Memory is also becoming better understood. The mind is able to generate a pattern of neural firing at the time of seeing an object with the eyes or by instead imagining it with the mind.

Remembering is not pulling a book from the library or a file from a computer nor is it merely the reactivation of a prior experience (sight, smell, touch, feeling, emotion, thought, event, etc); but rather it is the construction and firing of a new neuron group containing features of the prior "image" and elements of "memory" from other related experiences as well as influences from the present state of mind. Memory is simply the odds that a certain group of neurons will fire again together. The "gist" of a situation may be remembered with great accuracy, but the details may be subject to unconscious bias from ongoing experience. Recollection can be extremely accurate. Recollection can also be susceptible to ongoing unconscious influences by other past, present, or future social and personal experiences.

If your child experiences abuse, molest, neglect, domestic violence, put-downs. yelling, screaming, and the chaos of parental conflict, alcoholism, or drug addiction then connections become hardwired into the brain to respond to all current and future experiences as if the dangers of fight, flight, and despair were always present here and now. A brain that is bathed in drugs, alcohol, or nicotine in utero; by the youth using such substances too young; by the overproduction of stress hormones due to excessive exposure to life stressors, traumas, chaos, or other maltreatment; this brain becomes pre-wired to respond to all of life with depression, anxiety, dissociation, or hyper-arousal over-reactions. Abused kids develop central nervous systems exquisitely tuned to danger. Studies show that chronic stress causes chronic overproduction of hydrocortisone, related glucocorticoids, and catecholamines that cause actual damage to neuronal connections (dendrites) which atrophy (shrink) in the hippocampus area of the temporal lobe, an area key in many cognitive skills including memory. Fortunately, the effects of short-term stress is reversible. After long-term stress, however, the neurons begin to die. If, however the child experiences nurturance, good nutrition and health, and is exposed to a broad range of developmentally appropriate challenges and stimulation your child's brain will keep and make connections that reinforce these adaptive abilities. This is why such things as learning a second language, riding a bike, swimming, learn to play a piano, or to throw a ball are easier when young and can last a lifetime.

Human brain size changes little over the child and teen years. By the time a child is 6, his brain is 90 to 95 % of adult size. Between the ages of 6 and 12 the neurons grow bushier by each neuron adding dozens of connections based on what is reinforced by learning and experience. These gray matter (nerve cells), emotional, sensory, and coordination pathways grow via reinforced dendrites and axons to reach their next peak at 11 in girls and 12 to 13 in boys. Unused connections are further pruned out in the teen years at the same time Myelin Sheath cells, the white matter protective coating around neurons, increases resulting in a more limited set of neuron pathways but faster more powerful nerve impulses. The brain is becoming more efficient but also losing some of its raw potential for learning and ability to recover from trauma such as drugs, alcohol, or injury. This pruning is guided both by genetics and an experience based "use it or lose it" mechanism. **Synapses that are used often are kept and even reinforced. Those that are not used are lost - how you spend your time and the experiences you have or don't have are critical**. Consider the relative values of developing skills in music, sports, memorization,

horse riding, languages, writing and reading, dancing, gymnastics, and spirituality versus skills in unbridled violence, video games, experiencing war, disaster, homelessness, getting high, abuse, neglect, deprivation, or malnutrition. Think of the potentially valuable brain circuitry lost or not developed! Think of the possibly detrimental circuits created instead!

Brain development proceeds from the back of the brain (cerebellum, visual occipital cortex) and deep (brainstem, thalamus, basal ganglia) sections toward the top (parietal and temporal lobes of the cortex) and lastly the front (the frontal lobes are located just behind the forehead). This means the part of the brain most important for "**Executive Functions**" like planning, breaking plans or project into steps, carrying out each step, and then bringing all the steps together into a coherent whole, organizing oneself, making well thought out decisions, controlling impulses, and using good judgment **are the last to develop**. The last part of the brain to grow up is the part capable of deciding "I'll do my homework first and take out the garbage and then I'll IM my friends". The part of the brain that makes teens responsible is still under construction.

The frontal and pre-frontal cortex also plays an important role in **motivation**. Partial development here in teens leads to the often observed propensity for teens to engage in behaviors that are either very exciting or very low effort, or both. Thus immediate and tangible results will make more sense to your teen. Losing his cell phone, car, or computer access for an alcohol violation means far more to him or her than a future on skid row.

The teen and college student's notoriously late **sleep** schedule shifted toward going to sleep in the wee hours of the morning and preferentially rolling out of bed about noon is partly promoted by the Pineal gland at the base of the brain putting out its sleep readiness hormone Melatonin later in teens.

Note that the ages of 11 to 15 are marked both by incomplete frontal cortex impulse control at the same time as **hormones** are kicking our children into puberty and adolescence. In the past the semi-rational thinking and emotional roller coaster of the preteen and early teen years were written off to hormones. **Now we understand that although hormones do play a role and do affect the brain, the main explanation for this lability and moodiness is brain development, or as some would say, the lack of brain development**. This interplay of faster neuronal connections and new social, psychological, and biological drives propel our youth toward an appetite for (or fear of) thrills, strong sensations, excitement, adventures, novel experiences, and impulsive behaviors that can be both adaptive and dangerous. The part of the brain that puts the brakes on such risky impulsive behavior is still under construction. It is evident, then, that anything that can increase impulsivity and lessen inhibitions, such as alcohol, drugs, peer pressure, mental illness, and powerful new experiences like fast cars or new drugs, or libido or bravado, can raise the risks.

The adolescent brain's propensity for uninhibited risk taking propels teens toward healthy independence via a willingness, even excitement, to try new things. This often includes sex, drugs and alcohol. **The very immaturity of the teen brain makes it more vulnerable to the stimulating, damaging, and addicting effects of nicotine, alcohol, and other drugs. Almost 45% of kids who start drinking alcohol by 13 will become alcoholic, while only 10% of those who wait till 21 will. One in three teens who start smoking as a teen will die of a tobacco related disease. Ninety percent of adult smokers began as a teen**. Addiction with all its health, psychiatric, legal and family costs comes more often and more severely to persons who start using as teens (or younger). Drugs, alcohol, nicotine, and the environments kids use them in, can cause permanent changes to the brain. The still

developing brain is simply more easily and severely damaged by bathing it in such toxins.

These insights based on brain development help explain the main causes of death amongst our youth from Middle School through College age. **The main cause of death in youth is accidents - by far most fatal accidents are motor vehicles and most of these involve alcohol and other drugs. #2 is suicide and #3 is homicide, both of which also often involve substance abuse. These 3 causes of death account for 75% of all deaths in our kids**. All other causes (cancer, heart disease, AIDS, infections like pneumonia, etc) account for only 25%. Please also remember that when young people drink it is usually to get drunk. Youth do not just have a glass of wine with dinner or a beer while watching the game; they binge - drink as much as possible as fast as possible to get drunk or worse.

Contrary to prior concern, research shows that stimulants like methylphenidate (the medicine in Ritalin and Concerta) actually enhance, not harm, the brain development of kids who have ADHD. Furthermore, anticonvulsant medicines, lithium, and perhaps atypical antipsychotics can have neuro-protective (brain health preserving or enhancing) effects for those who need them.

It's no accident that car insurance rates drop big-time at **age 25** and that car rental agencies decline drivers under that age. The Insurance Institute for Highway Safety reports teens are 4 times as likely to be in an accident and 3 times as likely to die in an accident than older drivers. Studies on brain development confirm that the prefrontal cortex region of the brain that inhibits risky behavior doesn't mature till about 25. This is especially obvious when the youth is distracted by cell phones, music, eating and drinking, and worst of all - having peers in the car. Boys mature, on average, one to three years later than girls. **Twenty-five is probably the best estimate for when the brain is reasonably fully mature in most of us**.

It is helpful to remember that a wide range of positive life experiences combined with good nutrition, exercise, adequate sleep, clean air, clean water, and the sense that there exists more important things than our own self interest all promote healthy minds, bodies, spirits, and brains.

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Find this issue of Medical Memo, past issues, and other helpful information at Dr. Leehey's web site:
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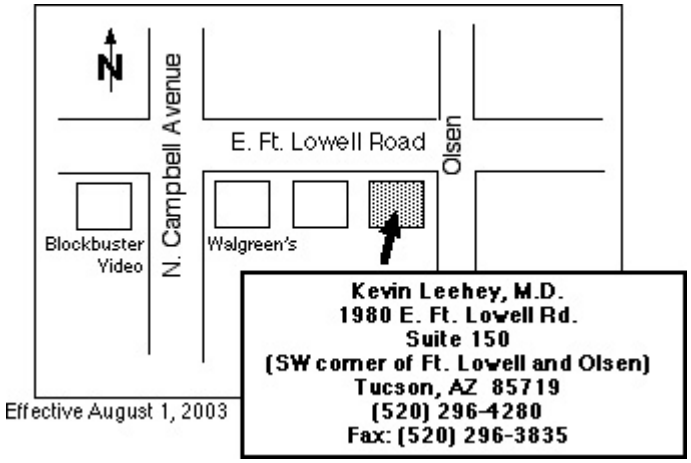

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