Wetware: The Biological Basis of Intellectual Giftedness

Why is "giftedness" such a puzzle for parents? Why is there so much confusion? The most common plea heard on TAGFAM is "my child is different; please help me understand why -- I think she's gifted."The goal of this article is to introduce you to "wetware," the brain and its functions, and to help you understand, at the physical andbiological level, the puzzle of the intellectually gifted child.

OK. Stay with me folks. In order to understand what comes later, we're going to have to wade through some tough territory for a few minutes. If you're having trouble conceptualizing this stuff -- think in terms of what could happen if one of these areas of the brain was damaged or functioned suboptimally. Also, think in terms of how each of these areas contributes to the behaviors you see in your intellectually gifted child. Is your child hypersensitive to smells? Tags in clothing? Does she have a terrific memory? How about physical coordination? Keep these "differences" in mind ... maybe you'll start to see the connection between brain structures and those little quirks of behavior that leave others wondering what planet this child is from.

Chemicals. When you think about it, intellectual giftedness is merely the fortunate happenstance of genetics as expressed in the chemical relationships in the brain. A nerve impulse here, a neurotransmitter there. Synapse, neuron, pathways. Memory, cognition, perception, instinct, emotion, creative thought -- these functions all start with chemical processes in the brain. These processes originate in the sequences of instructions encoded in your DNA. Intellectual giftedness begins with the creation of new life. Sperm meets egg. Bang! Life! All systems go! Another intellectually gifted human being is in the making.

Obviously, the functioning of the human brain is more than just a few chemical reactions. Development of the central nervous system begins as early as 16 days after conception and, by the sixth week, the neural tubes which later become the cerebral hemispheres are present in the fetus. The cerebral cortex begins to develop by the 10th week. Thus, early in the pregnancy, chemical reactions and processes begin to define who and what we will be -- our genetic inheritance begins the process that gives rise to our intellectual abilities. For some, in utero exposure to toxins, stress, and other environmental factors will result in damage or other events which change, limit, or prevent the development of their full intellectual potential. Even before birth, the child's environment has a powerful influence upon the later expression of intellectual abilities.

Our understanding of the brain and how it functions has increased dramatically in the past two decades due to technological advances in diagnostic and imaging equipment. The development of Computer-Aided Tomography (CAT), Positron Emissions Tomography (PET), Magnetic Resonance Imaging (MRI) and other brain imaging techniques have made it possible for investigators to study the intact, whole, living human brain. Prior to the development of these techniques our understanding of the brain was limited and derived mainly from studies of individuals who had experienced loss or impairment of functionality due to disease, stroke, or physical injury. These types of studies have increased our knowledge of the anatomical structures of the brain (neuroanatomy) and the chemical processes by which it functions (neurochemistry). Studies of stroke victims, in particular, allowed investigators to identify specific areas of the brain as being associated with certain behaviors or functions. More recent studies have shown that the brain is able to use cooperating groups of neurons in differing regions to accomplish a function or produce a behavior.

After the initial in utero growth of the human brain, there are normally growth spurts from ages 3 to 10 months, 2 to 4 years, 6 to 8 years, 10 to 12 years, and finally from 14 to 16 years of age. In addition to the physical growth process defined in the beginning by one's DNA, the brain undergoes physical changes related to exposure to environmental factors. The physical development of the brain benefits from some types of environmental factors, i.e. loving parents, good nutrition, interesting sensory stimuli and is harmed by others, i.e. exposure to lead or other toxic metals, child abuse, lack of physical contact with care givers. Both physical and social factors in the environment affect the brain's growth and development. Normal, healthy growth requires a supportive, loving, stimulating, and safe environment.

Next, we get into the really tough stuff. Stick with me, there are sometreasures to be uncovered in what comes next!

--- Parts of The Brain and Related Systems ---

The central nervous system (CNS) is composed of the brain and the spinal cord. The peripheral nervous system sends sensory information to the CNS and sends motor commands from the CNS to the rest of the body. The autonomic nervous system sends nerve impulses to the body's internal organs. Sensory receptors in the peripheral organs (eyes, ears, skin, etc.) relay sensory information back to the CNS. The autonomic nervous system has other functions related to keeping the body's organs functioning in a balanced manner. [Aha! Maybe the "good" side of that annoying hypersensitivity is an increased ability to process sensory inputs.]

The overall structure of the brain is usually defined in terms of gray matter, the neuronal cell bodies, and white matter, primarily made up of myelinated neuronal axons. [You've been dying to know the difference, right?] The brain's "gray matter" makes up the cerebral cortex and the cerebellum (cerebellar cortex, and the subcortical cerebral and cerebellar nuclei). The cerebellum is involved in the control of muscles (motor movements) and posture adjustments. Because of its many connections to the cerebral cortex, it is possible that the cerebellum also plays a role in more complex brain functions (e.g. thinking).

The cerebral cortex is divided into four lobes: frontal, temporal, parietal, and occipital. Some neuroanatomists include the limbic system as a fifth lobe of the cerebral cortex. Within the cerebral cortex are regions which have been identified as the primary motor, primary sensory, motor association and sensory association areas. These areas of the brain are responsible for the planning of motor activity, the interpretation of primary sensory inputs, and the organization of all the sensory and motor information that the brain receives from the nervous system.

The frontal cortex is the site of motor activation, intellect, conceptual planning, aspects of the personality, and aspects of language production. Portions of the frontal cortex are involved in the movement of single muscles, the coordination of movement for groups of muscles, and the integration of primary sensory information. The temporal cortex is the seat the brain's memory, language, and emotion functions. The parietal cortex is the location of the association cortices for visual, tactile, and auditory input processing. The left parietal lobe is preferential in the processing of verbal information. The right parietal lobe is preferential in the processing of visual-spatial information. The occipital cortex is the primary sensory cortex for visual input.

The cerebral cortex is divided from front to back into left and right hemispheres. These hemispheres are connected by the corpus callosum and other small commissural tracts. In most humans, one of the two hemispheres is dominant and contains the area of the brain used to express language. In 97% of the population, the left hemisphere is dominant; 99% of right handed individuals and between 60% and 70% of left-handers are left-hemispheric dominant. Some individuals experience mixed dominance for handedness and others experience mixed dominance for language. There are tests which involve sensory inputs, either hearing or vision, that can be used to determine which hemisphere is dominant. Persons who have a dominant left hemisphere have a right ear advantage (hear better). For vision the right visual field has an advantage for verbal inputs and the left visual field has an advantage for spatial input when the left hemisphere is dominant. For right hemisphere dominance the advantages are reversed, right for left, e.g. left ear, right eye for spatial, and left eye for verbal.

Studies of individuals who have experienced brain damage have led to the development of several theories about hemispheric function. A good book to read on this topic is "Left-Brain/Right-Brain." The left hemisphere is thought to be the seat of rational thought, analytic thinking, sequencing, abstracting, and logistical abilities. The right hemisphere is thought to be the seat of perceptual, visual-spatial, artistic, musical, and synthetic activity. The right hemisphere is also thought to be involved in both the perception and expression of affect (emotion) and the perception of social cues in the environment. More recent studies have shown that while these generalizations hold in most cases, there is increasing evidence of exceptions. [In other words, the information about left and right hemisphericity is probably true but don't bet the farm on it.]

The major function of the limbic system is memory. Earlier suppositions held that the limbic system was the primary seat of one's emotions. Two components of the limbic system, the hippocampus and the amygdalia, play critical roles in learning and memory. The amygdalia is also thought to play a role in the integration of memories and facial recognition and social behavior. Two types of memory have been postulated by researches: working memory (short-term) and consolidated memory (long-term). Short term memory is thought to involve neurochemical changes at specific synapses. Long term memory is thought to arise from the synthesis of new protein molecules which create permanent changes in the brain's synaptic architecture. [Oh! So that's why the two are different ...]

--- Defining Intellectual Giftedness ---

Intellectual giftedness is "mental quickness and mental flexibility." Developmental delays or developmental precociousness affect the expression of one's intellectual abilities. Environmental influences can enhance or retard maturation. Physical development of the brain and development of brain functions can be significantly and irreversibly affected by physical trauma or environmental factors. Some children are more intellectually capable than their age-mates due to a combination of factors, both physical and environmental. Environment can't give the child more than he started with physically; it can, however, adversely affect the development of the brain. Differences in intellectual capacity or expressions of behaviors seem to arise from the complex interplay between what you start with, the environment influences the child experiences, and the child's individual developmental patterns.

Hopefully, the above explanations have the set the stage for the assertion that there is only one type of giftedness -- intellectual giftedness.

There is a clearly defined biological basis for the development of "superior" intellectual abilities. The label "superior," however, is a value judgement placed upon the expression of those abilities as specific behaviors. There are other more popular definitions of giftedness in use but these appear to appear to be more a description of certain behaviors which are held in high esteem in our culture. Definition by description is, perhaps, a valid way of looking at the issue of giftedness. But, does a definition based upon shifting cultural norms help us to understand the needs and abilities of intellectually gifted children?
I think not.