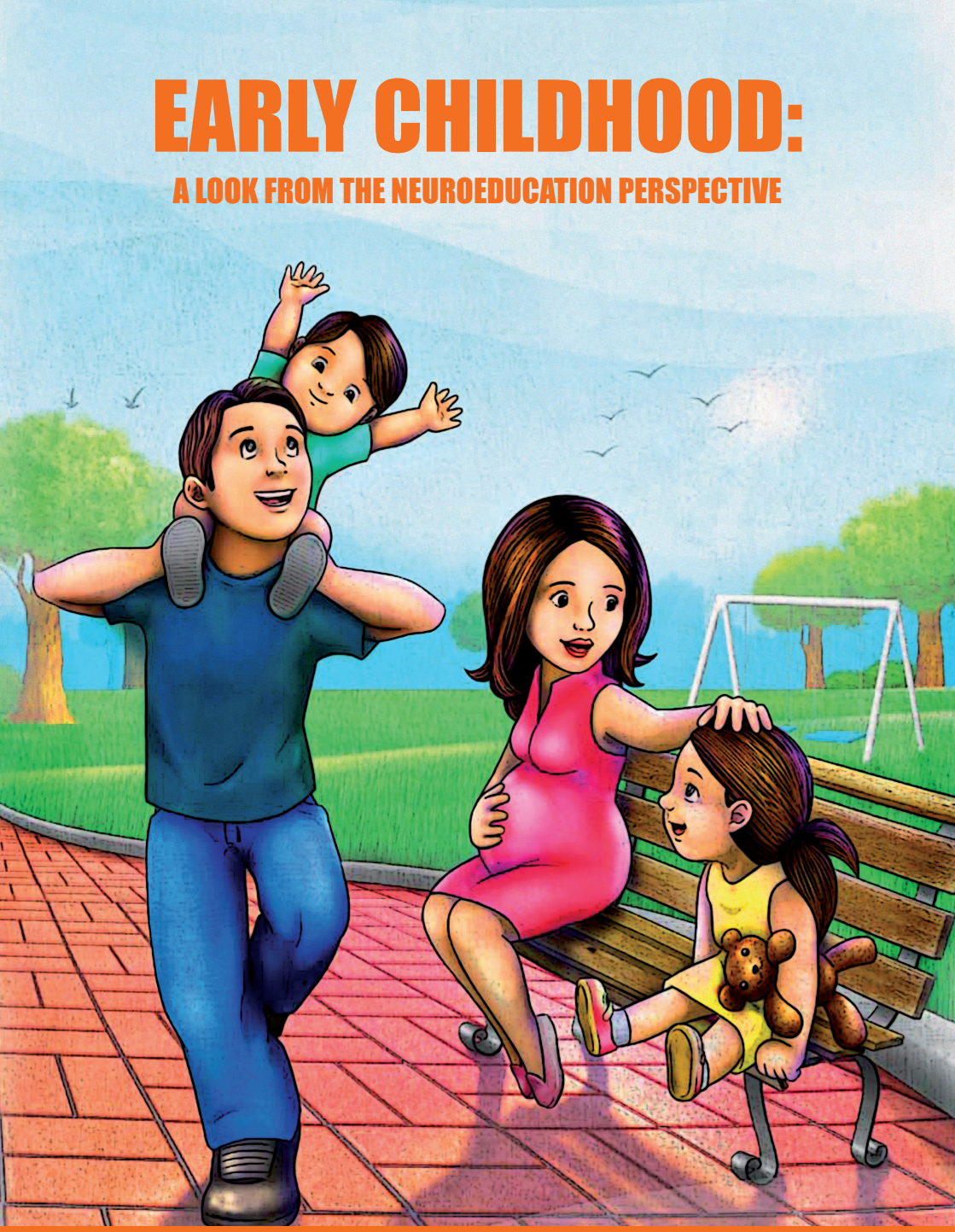
EARLY CHILDHOOD:

A LOOK FROM THE NEUROEDUCATION PERSPECTIVE



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CEREBRUM
Centro Iberoamericano de Neurociencias,
Educación y Desarrollo Humano

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(Materials for Use in the Media,
Advocacy and Outreach)

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Preface

The first years of life are critical to an individual's development, because it is at this stage that genetics and experience with the environment outline the brain's structure and define human behavior.

Undoubtedly, early childhood is a crucial stage in the development of human life. Here lie all the foundations for future learning, as growth and brain development resulting from the synergy between genetic code and the environment allow for a unique way of learning and the development of social, emotional, cognitive, sensory perception and motor skills, which will form the basis of a lifetime.

As parents, educators, governmental and nongovernmental organizations begin to understand that early childhood care and education (ECCE)—especially at this

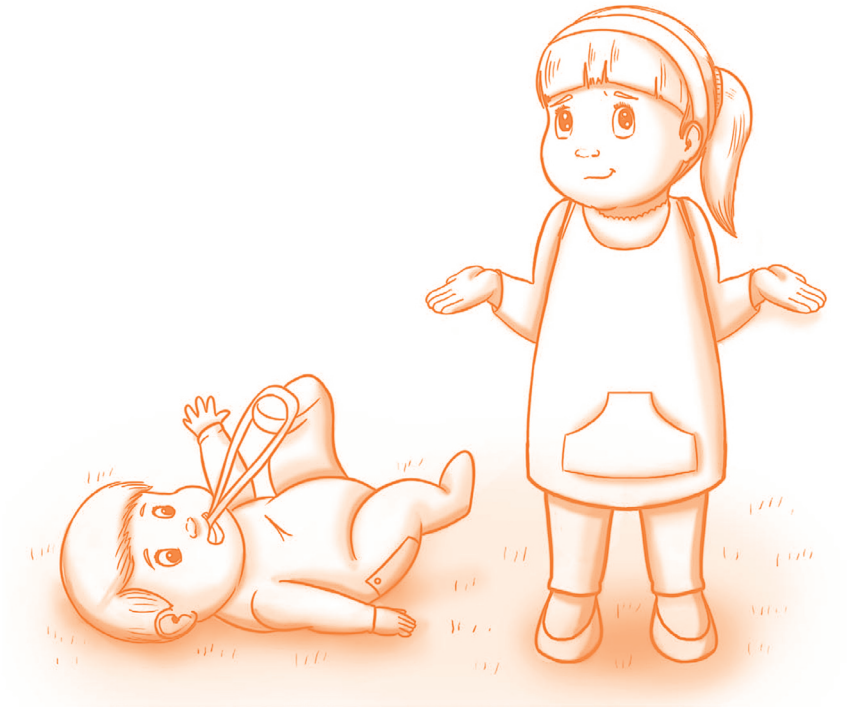
stage in life— plays a leading role in the structuring and functionality of the nervous system and the brain, studies in Neuroscience (sciences that study the brain and nervous system), especially those related to the brain development process, are changing the dialogue on the issue. Despite all the arguments presented, we know that the level of awareness and information on early childhood education and care is not enough.

The first years of life are essential for human development, as early experiences outline the brain's structure and future behavior. At this stage, the brain undergoes phenomenal changes: it grows, develops and passes through critical learning periods, requiring an environment rich in significant experiences, multi-sensory stimuli and adequate physical resources, but above all, an environment enhanced by the care, responsibility and affection of a devoted adult.

In this publication, intended as a reference document, one will find the scientific basis for why measures of early childhood care, education and development must be developed. It is a training and analysis tool aimed at parents, educators, journalists, health professionals, public entities, private companies, and anyone who, in connection with children, wishes to enhance their knowledge on this stage of human development and aspires to have a neuroscientific basis for familiar, institutional and community educational practices in early childhood. Furthermore, the publication is ready for use in the media.

Chapter I

Neuroeducation: A New Ally for Early Childhood Care and Education Programs



> To develop our societies it is necessary to expand and improve "comprehensive early childhood care and education, especially for vulnerable and disadvantaged children."

In recent years, several institutions and countries worldwide have highlighted the importance of early childhood care and education for the sustainable development of our societies.

Under the global collective agreement, "Dakar Framework for Action" (2000), regarding Education for All,[1] six key objectives were established. The first proposes "expanding and improving comprehensive early childhood care and education, especially for vulnerable and disadvantaged children," leading to the need to construct policies that allow all children access to care programs and quality education within a framework of equal opportunity and human development. This in turn, lies in the context of children's rights, as established at the United Nations Convention on the Rights of the Child.

Against this background, it is important to ask whether the success of the child development process and its respective impact lies only in the possibility of children

1 UNESCO – Education for all. http://www.unesco.org/education/efa/ed_for_all/dakfram_eng.shtml

having access to some kind of program. And what would the **key success factors** of such ECCE programs be? If we review investigations and reports from the literature that provide basic guidelines for improving program quality, a common success factor that can be found in all is **the profile of the educator** (parent or teacher) **and other educational agents** involved in early childhood. This shows that program effectiveness is directly related to parent and educators' initial and ongoing training, since the quality of children's development is affected by the attitudes, knowledge and lifestyle of the person who educates them.

On the other hand, research on children's environments has shown that their relationship to adults greatly impacts brain development as early as the prenatal stage [1]. Food, the exposure or use of certain chemicals, as well as the expectant mother's mood, are among other influential factors for a brain in full formation. Care of the physical environment, caresses, conversations, games, affection and songs are other elements present from birth in the relationship between parents, educators and children. Interpersonal relationships are the backbone of child development, since from adults children learn the

The effectiveness of early childhood care and education programs is directly related to the parent and educator's initial and ongoing training.

emotional, social, and cognitive skills needed to adapt to their environment. The greater the knowledge an adult has about the brain development process, the higher their likelihood to act favorably during the stage of early childhood.

In his research on the role of the early childhood educator and his or her influence on the growth of a baby's brain, Shanker[2] notes that the adult caregiver serves as an "external brain" that encourages and supports the baby. He states that the experiences from this adult-child relationship are vital for sensory integration, sensory-motor coordination, emotional development, as well as the attention and self-regulation processes [2].

The brain undergoes major changes during one's lifecycle—especially in the prenatal stage and early childhood—and its growth and development are the results of the harmonious interaction between genetic and environmental experiences. Although every child is born with a genetically programmed brain that extracts all the information needed from the environment to develop, one's experiences in early childhood—or lack thereof—will define the brain development process, since at this stage "critical learning periods" can be identified for certain skills, such as language acquisition.

Most ECCE programs undoubtedly consider the role of parents and educators (or other professionals involved)

2 Stuart Shankner is Professor of Psychology and Philosophy, director of the Milton and Ethel Harris Research Initiative York University, Canada.

Experiences in the early stages of human development (prenatal and early childhood) strongly influence the brain's structure and functionality, which is reflected in the quality of each individual's sensory, emotional, intellectual, social, physical and moral abilities.

to be of utmost importance. It is therefore necessary to review and reconsider some aspects of the training of those directly or indirectly working with children. Experiences in the early stages of human development (prenatal and early childhood) strongly influence the brain's structure and functionality, which is reflected in the quality of each individual's sensory, emotional, intellectual, social, physical and moral abilities. It is at this stage that the adult's role as "facilitator and mediator of significant experiences" becomes more complex if he or she is not up-to-date on how the brain evolves during these first years of life, and its impressive malleability with regard to learning and the surrounding environment.

To understand how the adult's profile and the quality of the experiences of the environment in which children live can affect cerebral development, and in some cases leave indelible marks on different aspects of adult life [3], there are now solid bases that are the result of research

in the social sciences, psychology and particularly the neurosciences.

In this context, **Neuroeducation** emerged: a new line of thought and action, in which neuroscience, psychology and education converge. Its main objective is to bring parents and educators to knowledge related to brain functioning. Neuroeducation allows for the comprehension of cerebral mechanisms underlying learning, memory, language, sensory and motor systems, attention, emotions, and behavior, to name a few. It also helps identify risk factors for cerebral development, including malnutrition, negative emotions, anemia, high stress levels, and verbal or physical abuse. This information will give adults greater opportunities to reduce or prevent risk factors in order to make children's environments healthier and more appropriate.

Neuroeducation brings one closer to the latest cerebral research and the neural circuit functions involved in math, reading, art and music, enabling educators (parents or professionals) to have a stronger base for its educational innovation. Research has also shown that the practice of certain skills can change the brain's wiring, establishing new synaptic connections or strengthening existing ones. In regard to inquiries related to the brain's executive functions, for example, and corresponding to the prefrontal cortex (which takes approximately 20 years to mature), evidence shows that these begin developing in early childhood. According to Garcia-Molina et al., "the development of executive functions involves developing a set of cognitive skills that will enable the

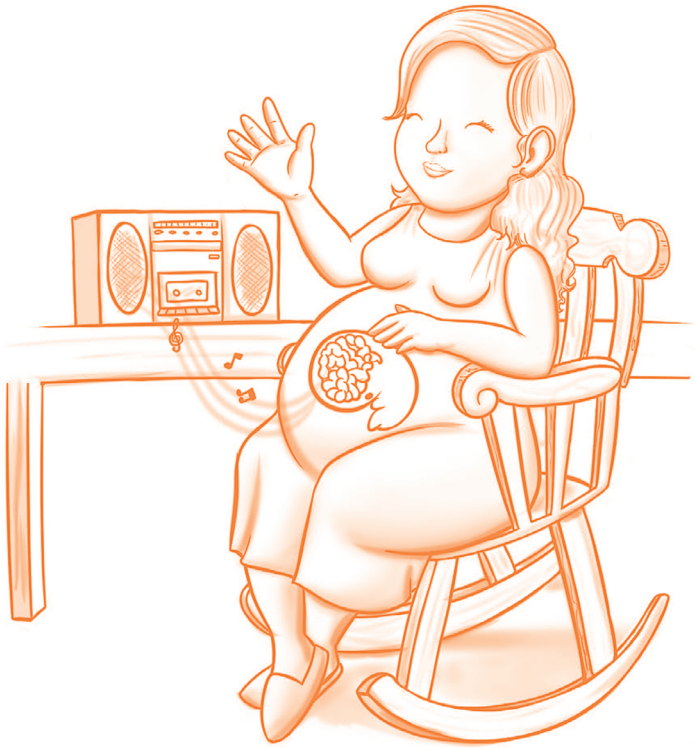
child to maintain and manipulate information and act accordingly; self-regulate their behavior in order to act in a reflective and non-impulsive manner; and adapt their behavior to changes that may occur in the environment. Early alterations in executive development dramatically limit the child's ability to cope with novel situations and adapt to changes in a flexible manner." [4]

It would be ideal to establish minimal training in Neuroeducation as the primary requirement for all educators, as well as for parents and the community at large. After all, early childhood is a commitment for all.

Neuroeducation will allow parents, teachers and other educational agents to understand what the brain is, how it develops and how it works, thus increasing the likelihood of educational proposals harmonizing with the brain's natural learning systems and prevent risk factors in children's environments.

Chapter II

Understanding Children from the Start: The Prenatal Stage and Brain Formation



Men ought to know that from nothing else but thence [from the brain] come joys, delights, laughter and sports, and sorrows, griefs...and lamentations. And by this... we acquire wisdom and knowledge, and see and hear, and know... what are bad and what are good, what are sweet, and what unsavory. And by the same organ we become mad and delirious, and fears and terrors assail us... The brain exercises the greatest power in the man. This is the interpreter to us of those things which emanate from the air.

Hippocrates

We cannot talk about child development without simultaneously discussing the brain developmental mechanisms underlying this process, which begins in the womb.

The brain is the only organ in the body that takes a long time to grow and develop, undergoing striking anatomical and functional changes from the prenatal stage through early adulthood. This fantastic, enigmatic and complex process is the enormous demonstration of an organ that builds itself as well as an entire organism. Construction begins just three weeks after conception, when the vast majority of mothers are still unaware of the new life growing in their bellies.

First, the central nervous system originates from a full sheet of cells called the **neural plate**, located on the

dorsal surface of the embryo. Next, the plate folds upon itself, forming a groove that deepens as development proceeds, thus closing the walls that comprise it. This creates a tube, known as the **neural tube**.[3]

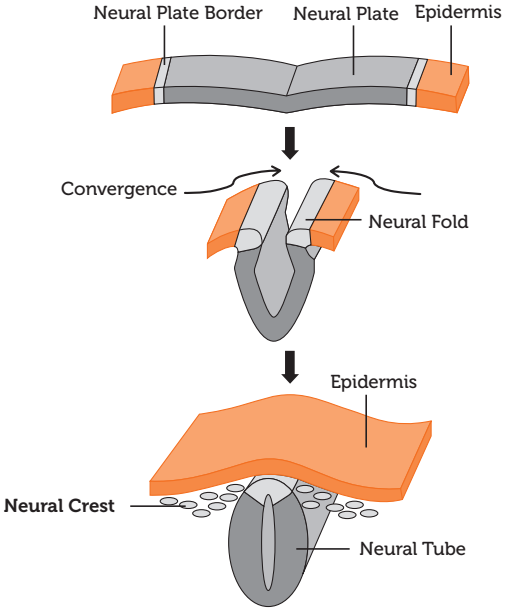


Figure 1

The spinal cord and brain begin to develop from this preparative structure, and the functionality of this primitive nervous system will become evident in the third week of prenatal development, when it is able to coordinate the development of other organs, allowing—in a very short

3 Figure 1. Neural_Crest.png. http://en.wikipedia.org/wiki/Neuroscience.

period of time—the eager parents to hear their baby's beating heart for the first time.

As the weeks pass, the nervous system develops, thanks in part to mechanisms involving the neurogenesis (birth) of the cells that comprise it, the proliferation (multiplication) of these cells, and their migration (journey these cells make) to stable areas of the system in which they will be located.

BRAIN GROWTH AND DEVELOPMENT IN THE BLINK OF AN EYE

As cells continue to proliferate, brain volume increases. Three bumps, the prosencephalon, mesencephalon and rhombencephalon (forebrain, midbrain and hindbrain, respectively), begin to emerge from the top of the neural tube. [4] These will eventually form the different parts of the brain, while the lower part will go on to become the spinal cord.

The development of the nervous system and brain follows a genetic programming, whose basic organization principles enable us to have knowledge on the amazing sequence of events that occur during fetal brain development. The metamorphosis of the three initial bumps in five vesicles (telencephalon, diencephalon, mesencephalon, metencephalon and myelencephalon),[5]

4 Figure2.http://upload.wikimedia.org/wikipedia/commons/4/4c/4_week_embryo_brain.jpg
5 Figure 3. http://en.wikipedia.org/wiki/File:EmbryonicBrain.svg

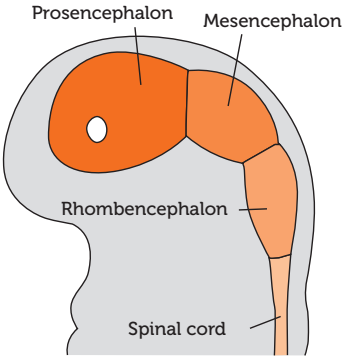


Figure 2

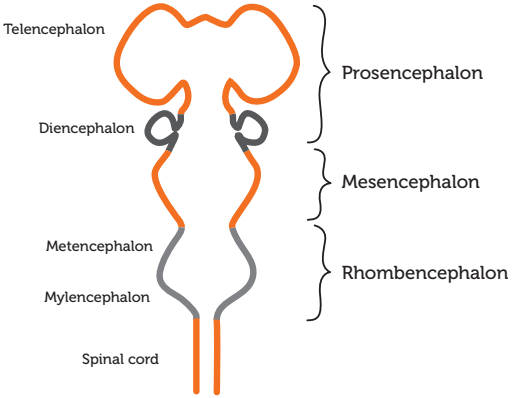


Figure 3

is one example, as is their subsequent transformation into new structures that make up the different parts of the brain and all their essential components.

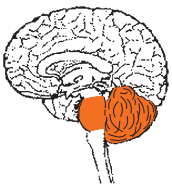
A closer look at the nervous system's lowest initial structures reveals the **spinal cord,** which connects the encephalon (brain) to other parts of the body. Furthermore,

The development of the nervous system and brain follows a genetic programming whose basic organization principles enable us to have knowledge on the amazing sequence of events that occur during fetal brain development.

it receives and processes sensory information from the skin, joints and muscles, and controls the movement of the limbs and core.

Directly above the spinal cord is the **rombencephalon**, which is divided into two vesicles: the myenlecephalon and metencephalon. Both will shelter areas essential for life and survival.

In the myelencephalon lies the medulla oblongata, which connects the brain to the spinal cord. The myelencephalon also includes several centers responsible for vital autonomic functions.



The pons is formed in the metencephalon, serving as a bridge between the cerebellum, medulla oblongata and the brain, and sending movement-related information from the hemispheres to the cerebellum. The cerebellum, in turn, coordi-

nates and modifies the activity resulting from the brain's impulses and commands, modulates the strength and disposition of motion, and is involved in learning motor skills and memory.

Next is the **mesencephalon**, which controls many sensory and motor functions (eye movements and visual and auditory reflexes coordination), and is also a relay station for auditory and visual signals.

Lastly is the **prosencephalon**, which is divided into two new vesicles: the telencephalon and diencephalon. These, in turn, give rise to essential structures with important functions.

Structures like the thalamus and hypothalamus will emerge from the diencephalon. The thalamus is known as the main relay station for sensory information headed to the cerebral cortex, and also has oth-

All of the brain's regions originate in the prenatal stage, and their respective roles are strengthened through the connections established between the cells that comprise them.

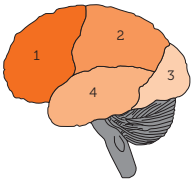
er functions related to movement, emotional behavior, learning and memory. The hypothalamus, which consists of a fairly complex set of nuclei, regulates the organism's homeostatic operation, participates in hormone release and regulation, and has a significant effect on behavior, being involved in thirst, hunger and sleep patterns.

The telencephalon will become the set of structures that distinguishes our species from any other on Earth, imparting intelligence, the ability to speak, feel, learn, remember, move and love. Some of these structures include the hippocampus (which, among its many duties, is involved in memory formation) and the basal ganglia, (involved in learning, and important for cognitive movement control). Furthermore, the limbic system can also be found here, consisting of several structures including the amygdala, which is associated with emotions, social behavior and even survival, as it integrates information from internal and external environments.

The **cerebral cortex** is what later evolves from the prosenphalon. Though it begins to develop around the eighth week of gestation, its maturation process is gradual and continues many years after birth. This structure is responsible for the more noble and refined skills unique to man. It deals with cognitive functioning and has a large number of nerve cells, as well as specific areas in both hemispheres called **lobes**. The first to emerge are the frontal lobes, followed by the parietal, temporal and occipital lobes.

Some of their many responsibilities and functions are:

1. Frontal: Thinking, planning, decision-making and opinion formulation, creativity, problem solving, behavior, values and habits. It is highly active.
2. Parietal: Sensory information (touch, pain, taste, pressure, temperature), and spatial, verbal and physical data.
3. Temporal: Hearing (sound pitch and intensity), language, memory and emotion.
4. Occipital: Visual information. In short, all of the brain's regions originate in the prenatal stage, and their respective roles are strengthened through the connections established between the cells that comprise them.



IN A "SEA" OF CELLS, A COMPLEX COMMUNICATION SYSTEM EMERGES

At just twenty weeks of gestation, the brain and nervous system have undergone remarkable morphological changes, and in the blink of an eye, its basic structure is already formed. In addition, several areas are beginning to work on circuits for managing special functions, such as hearing and vision. But, how did all of this come about?

The human brain is built with the help of approximately one hundred billion nerve cells called **neurons**, which

form the central nervous system's anatomical and functional units. A prototypical mature neuron (the most common) consists of three main parts: the dendrites (which receive information from other neurons), soma (the cell's metabolic center, containing the nucleus, which stores the cell's genes, and the rough and smooth endoplasmic reticulum, which synthesize its proteins), and axon (the neuron's principal conducting unit).[6]

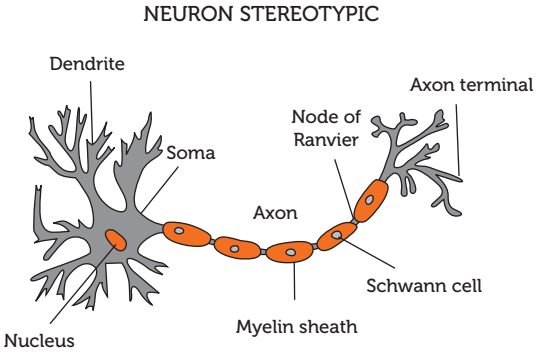


Figure 4

However, neurons are not the only cells present. They are supported by other types of cells called **glias**, whose functions include involvement in the production of myelin (a lipoprotein that coats the axon, isolates it and ensures high-speed information transmission), and cellular debris pickup. In addition, they are essential to the migration process, acting as "rails" that drive neurons to their final location in the network.

6 Figure 4. Neuron_Hand-turned.svg. http://en.wikipedia.org/wiki/Neuron.

During the prenatal stage and early childhood, the brain produces far more neurons and synaptic connections than it will ever need, as a means of ensuring that enough cells reach their destinations and properly connect.

Neurogenesis, the origin of neurons, begins early on, from the formation of the neural tube. It is estimated that around 50,000 – 100,000 new neurons are generated every second during the 15th and 20th weeks of life. Millions of neurons migrate to each of the newly-formed regions where, once established, they begin making contact with other added cells. Neurons begin to communicate through connections, a phenomenon known as **synaptogenesis**. The transfer of information between neurons occurs in specialized contact sites called **synapses**, which can be either electrical or chemical. In chemical synapses, information comes through chemical messengers called neurotransmitters. Synaptogenesis begins in the lowest part of the nervous system—the spinal cord—around the 15th week of gestation. At the time of birth, all neural circuits required for the baby's adaptation to his or her new surroundings are connected and myelinated.

During the prenatal stage and early childhood, the brain produces far more neurons and synaptic connections

than it will ever need, as a means of ensuring that enough cells reach their destinations and properly connect. However, as a way of organizing itself, the nervous system programs the cellular death of several neurons (apoptosis), and the **pruning** of thousands of synapses that failed to establish functional connections or "have already completed their task." Synapses involving "competent and active neurons in the network" are the ones that will remain, and each of these neural circuit's respective functionality is what will enable us to learn, memorize, perceive, feel, move, read, add or emit, from reflex responses to complex quantum physics-related analysis.

The **myelination** of nerve fibers begins in the spinal cord, and increases until reaching the brain. Here, different areas are slowly myelinated, respecting a long, genetically programmed process that will continue for years following birth. We now know that the subcortical areas controlling vital and reflex functions are myelinated before the cortical regions that control more sophisticated skills, the prefrontal cortex being the last to myelinate.[7] After synapses are established, nerve fiber myelination is highly relevant to the emergence and strengthening of functions; the more myelination, the greater the functionality of neural circuits. While genes control the process of myelination, environmental factors can affect its extent and quality. Malnutrition, both in the pregnant mother and her child, is one of the factors affecting the

7 Some neuroscientific longitudinal studies have shown that myelination of the prefrontal cortex can continue until the age of twenty.

While genes control the process of myelination, environmental factors can affect its extent and quality. Malnutrition, both in the pregnant mother and her child, is one of the factors affecting the myelination process.

myelination process, since glial cells are also sensitive to nutrition quality.

PRENATAL CARE AND ITS INFLUENCE ON THE BRAIN

It is vitally important to inform pregnant women about the development of their baby's brain during the prenatal stage, as their health and emotional well-being can influence and shape this process. It is worth noting that although the mother and child's blood streams are separated by the placental barrier, several substances are able to penetrate this, impacting fetal brain development (nutrients, vaccines, drugs, vitamins, alcohol, and nicotine, to name a few). It is also necessary to consider that there are other risk factors that can influence infant development, such as the mother's age and nutritional state, x-rays, maternal diseases and disorders, genital herpes, viral diseases, pregnancy toxemia, negative RH blood, the mother's emotional state, stress, and the father's state of health, genetic diseases and virus transmission to the mother.

The mother's experiences during this stage, positive or not, determine the new individual's subsequent stages of development [1, 2, 3]. Exposure to harmful, toxic or radioactive substances during the prenatal stage causes irreversible damage and disrupts the nervous system's normal development pattern. This is due to the fact that the signaling and regulation of gene expression during early neural development are vulnerable to the effects of genetic mutations such that the actions of many drugs and toxins can compromise the normal nervous system's organization and formation [3, 4, 5, 6].

The prenatal stage is the first stage of life, and the womb is man's first environment. It is here where we witness the miracle of life.

On the other hand, a lack or excess of basic nutrients during the first months of intrauterine life significantly reduces the consolidation of neural structures in the fetus, while adequate nutrition in early life and postnatal development permit the strengthening of learning processes in later stages [7]. Fetal nutrition sets the stage for brain functionality following birth, hence the importance of good maternal nutrition.

Folic acid is essential for the formation of new cells, promoting the enzymes that help in the production of

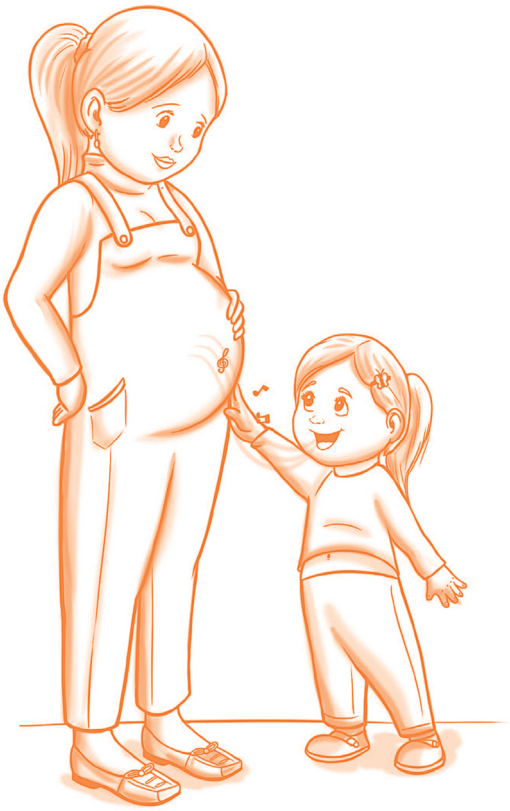
genetic material. Its intake is important, especially prior to and in the first weeks of pregnancy, since the latter is when neurogenesis begins and the brain starts to develop.

A human being begins to build him or herself in the prenatal stage. In order to respect the sequence of events related to brain structure and functionality at this stage, it is crucial that the fetus receive tranquility and good nutrition from its mother. Furthermore, it is also important to moderate the stimuli received from prenatal stimulation programs, as periods of rest are also necessary for nature to follow its course; overstimulation can alter the rhythm of this natural process.

The prenatal stage is the first stage of life, and the womb is man's first environment. It is here where we witness the miracle of life, the enigmatic capacity of the brain which, though not yet sufficiently mature, begins to build an organism through a mixture of stability and change that, at the same time it allows it to BE, it also lets it project itself in order to evolve and BECOME.

Chapter III

Birth and the First Months of Life: Decisive Cerebral Moments



The ease or difficulty with which a baby is born, how quickly he or she begins to breathe, the effectiveness of the obstetrician, can all significantly affect the brain development process.

During the prenatal stage, several processes essential for human life have occurred. From the womb, the nervous system and brain structures—together in the wake of several functions—have prepared this being for a new phase: birth.

When a baby is born, we look tenderly upon the fragility of the little being in our arms. However, this delicate-looking being is a champion who has just undergone one of the most trying and unique experiences of life... his or her birth. A few of the situations the infant has just experienced include the head's emergence from a narrow channel (or the sudden extraction in the case of a caesarean section), the intensity of the light upon his or her eyes, the air rushing into his or her lungs, loud noises and sickening smells, not to mention that some babies emerge with deformities in their heads or scratches on their little bodies. But there he or she is: a champion ready to embark on a long journey.

At birth, a baby's brain weighs about a quarter of what it will weigh as an adult, thanks to all that has taken place

in the womb. But birth itself is also a special milestone for the baby's brain: on the one hand, the successful completion of the entire growth and development process that imparted the conditions needed for birth and to face the new environment, and on the other, the fragility of the moment. The ease or difficulty with which a baby is born, how quickly he or she begins to breathe, the effectiveness of the obstetrician, can all significantly affect the brain development process. Interruptions in the brain's oxygenation process may be critical and can cause varying degrees of brain damage. An estimated 30% of cerebral palsy cases are the result of a lack of oxygen during the perinatal period. A birth under appropriate conditions plays a decisive role, allowing the baby a harmonious adaptation to the new environment—full of sounds, lights, smells, temperatures and textures—as well as facilitating the task of finding an "external brain" to assist in the adaptation to the new surroundings.

By the postnatal stage, important aspects that shape child development can be observed, such as some anatomical, functional and sensory characteristics that reflect the level of development of the newborn's nervous system.

Following birth, the baby's everyday experiences will play an important role in his or her brain development. The number of new synapses increases exponentially in the postnatal period, especially during the first two weeks of life, which in turn increases the number of neurons in the hippocampus. At this stage of development, the production of new neurons (neurogenesis) and the connections between them (synaptogenesis) increases

the possibility of modifying brain function modification (brain plasticity), which primarily depends on early experiences [1, 2]. This means that if at this stage the baby is deprived of **affection**, neuronal death phenomena (apoptosis) in the brain will present itself, leading to increased susceptibility to stress and decreased immune response. This is why parental attention during early childhood is crucial for brain maturation, especially for the structures in charge of memory and emotions [3].

People require significant postnatal experiences in order to adapt to their new surroundings and learn a means of communication that enables them to survive. In this sense lullabies, the mother's talks with her baby, the tone and sound of her voice from the very first moments of life will help the baby produce and decode the speech sounds that form the basis of **language** [4, 5], as daily experiences will modify the neural circuits during the critical periods for learning spoken language. A critical period is the time in which a given behavior is especially susceptible to specific environmental influences, because it needs them in order to develop normally [6]. But critical periods are not only related

People require significant postnatal experiences in order to adapt to their new surroundings and learn a means of communication that enables them to survive.

to the acquisition of behaviors, they are also related to nervous system circuits. A widely known language-related critical period refers to the acquisition of a second language, which should generally be learned by puberty so as to achieve complete fluency [5, 7]. Neuronal activity generated by interactions with the outside world following birth provides a mechanism by which the environment can influence the nervous system's structure and functionality. The development of sensory perception and motor skills is also a crucial phenomenon in critical periods.

During early childhood, cerebral cortex circuits are in a state of high plasticity (adaptations of neuronal circuits against learning or contingencies) which makes them easily modifiable. At this stage of development, the absence of sensory experiences, particularly those related to vision and hearing, may have serious functional repercussions. As a remarkable demonstration of plasticity, activation in the primary visual cortex has been observed in blind people who lost their vision at an early age, while reading Braille [8]. However, when activity patterns are altered during a critical period early on in life, connectivity in the visual cortex and in visual function are also altered [9]. If these functional alterations in encephalic circuitry are not reversed before reaching the end of the critical period, they will be difficult or impossible to modify.

What we learn beginning in the first months of life is retained or stored in our brain thanks to **memory**, which is inferred from behavior.

There is no learning without memory, nor memory without learning [6]. Different intellectual and motor skills are acquired as the neural structures required to implement them mature. Memory systems are developed in conjunction with the maturation of neural circuits and, most remarkably, much of the information stored in our long-term memory was learned in early childhood. Are there still doubts that this stage is essential to human beings?

A newborn's brain needs to undergo several stages of maturation to acquire and display its various skills and abilities. Some of these skills, as we know, must be learned at a particular time in order to easily develop [10], as is the aforementioned case with language. Another area that deserves great attention is the motor area. The body is the brain's "strategic partner" in continuing its development process: information is sent from the body, and the body in turn receives information emitted by the brain. Since the baby begins practicing his or her first moves in the womb, nervous system areas associated with **movement** are the first to consolidate. To acquire motor skills, the baby needs opportunities to discover and use his or her body above all else. By lying face-down in the early months, balancing (low intensity and short duration), crawling, climbing, opening and closing are activities that allow for greater maturity of the brain and nervous system. Motor skills learned in early childhood (such as walking, running, catching, holding, throwing, bike riding, etc.) will be remembered throughout one's lifetime.

The acquisition of other skills is primarily mediated by environmental factors that have direct effects on

A newborn's brain needs to undergo several stages of maturation to acquire and display its various skills and abilities.

the structural and functional consolidation of these learnings in the brain. In this sense, **sleep** is considered an important agent for brain development since it implies the consolidation of biochemical learning [11, 12, 13]. The consolidation of long-term memory occurs when the brain undergoes deep sleep (REM), which takes place beginning in early childhood.

Another important factor to consider in the development and maturation of the infant brain is **nutrition**. Children's brains require certain nutrients (certain types of fatty acids) aside from water, sugar and salt, among others, to carry out essential functions such as neurotransmission and neurogenesis, and protect against oxidative stress [14, 15]. This successfully maximizes the cognitive potential of the subsequent stages of brain development. It should be noted that breast milk is undoubtedly the richest and most complete food in all aspects for babies. Research has shown that fatty acids found in breast milk are ideal for nervous system development, in addition to having an immune and psychological quality.

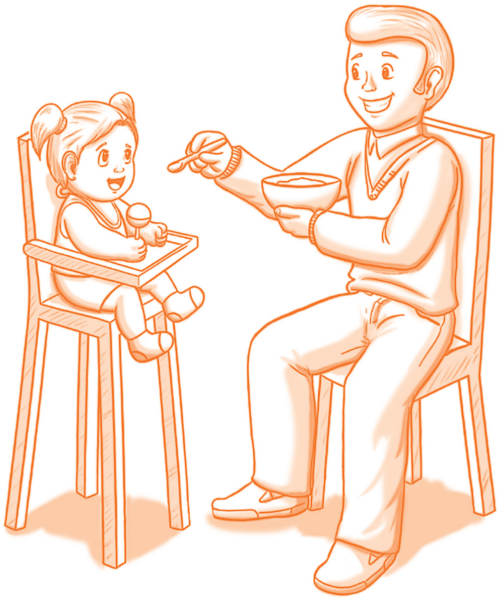
The role of **affection**, as well as sleep and nutrition during this early stage is essential for children's

neurobiological maturation and emotional, motor and cognitive development. We are currently aware of the importance of emotional bonding from the very start of life, as it enables babies to adapt to their environment, regulate their anxiety, become self-confident, seek autonomy and, above all, regulates the operation of all brain structures related to emotions and behavior.

Similarly, one cannot fail to mention **sensory perception** experiences as essential for brain development during the first months of life. Consider an example: neurons that were assigned to the visual circuit can only carry out its duties optimally when exposed to sensory experiences within the environment. Although they can open their eyes, babies cannot see nor interpret what is in their surroundings. Gradual myelination of these channels, combined with experiences involving light, objects, shapes, colors, movement and depth, are some elements that facilitate visual development to the extent that children may, in a few years, possess excellent visual acuity enabling them to find subtle differences between two similar images. Likewise, other sensory systems have experience-dependent development so that the adult can provide opportunities, care for the quality of stimuli and organize information so that from each experience, the baby's brain can draw the afferents needed to build him or herself, mature and reach full functionality.

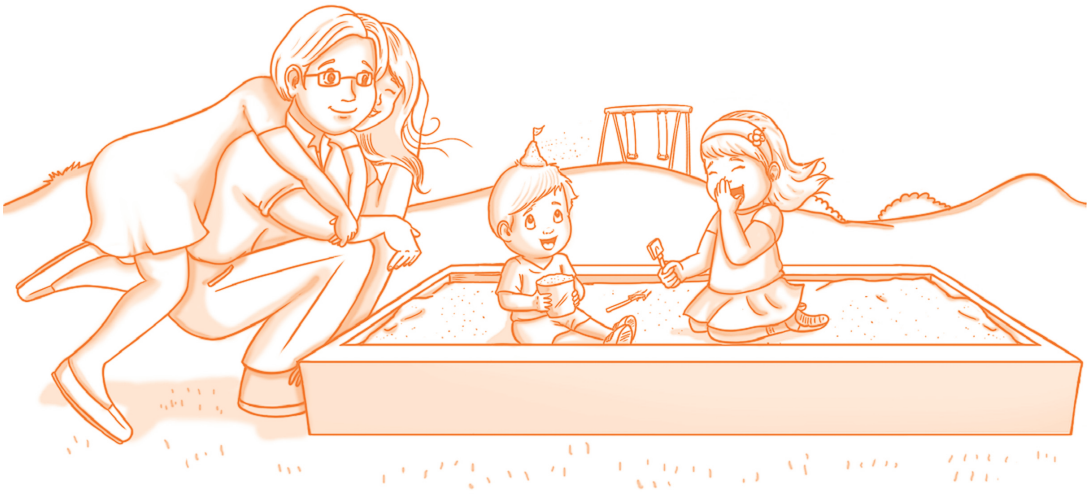
Early childhood is the springboard to our sensory and perceptual universe, enabling us not only to survive (as we approach or move away from a stimulus), but also

serving as the vehicle for conveying cognitive, motor and emotional information, especially.



Chapter IV

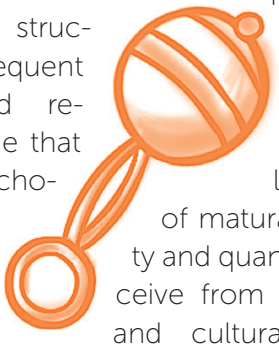
A Brief Look at Early Childhood



Childhood is, in short, a time to care for oneself.

"The process of human development is fascinating: an assembly of genetic and environmental factors that influence brain development and model the behavior, emotions, physical structure, cognitive abilities and personality, which enable one to adapt to his or her environment. It is a constructive process with a unique complexity for each individual, indisputably based on the first years of life.

"Ranging from birth to the age of eight, early childhood marks the most significant period in shaping an individual, since the foundations of personality and development are structured here—over which subsequent stages will be consolidated and refined. It is precisely in this stage that neurophysiological and psychological structures are in full process of maturation, and in this sense, the quality and quantity of influences that children receive from their family, socioeconomic and cultural environments will mold them in an almost definitive way. The entire process helps one see that education at this stage in life plays a decisive role, acting upon structures in full maturation and development.



"Early childhood is marked by significant physical growth, in addition to sensory and perceptual development. Here, one also witnesses the awakening of emotional, intellectual and social skills, as well as the significant development of language and the more diverse forms of expression: singing, dancing, moving, crying, painting, talking... talking... talking... are all everyday activities.

"Childhood is, in short, a time to care for oneself. An in-depth look transforms the manner of familiar or institutional care and education given during this precious stage of human life. Several studies have indicated that the physical, social, emotional, cognitive and sensory experiences to which children are exposed, are both critical and crucial to the organization of the nervous system and brain development, capable of leaving traces throughout one's lifetime. In this sense, parents, educators, psychologists, social workers and anyone living with a child, carry an enormous responsibility on their shoulders: understanding how the childhood development process occurs so as to know how to care for and stimulate the child."[8]

Among the most diverse range of studies conducted by neuroscientists, there is consensus on the importance of early childhood as a period that strongly impacts a person's future quality of life. This is because early childhood is a significant stage of brain growth and development, where the brain's high plasticity allows one's experiences to shape it both structurally and functionally,

8 Campos, Anna Lucía. "Neuroeducación: Cómo educar para que el cerebro aprenda." Cerebrum Ediciones. Peru, 2010.

Adverse experiences during childhood can traumatically affect a child, strongly influencing his or her mental health, or—in higher degrees—even lead to a constraint in brain development.

Research by the **Child Trauma Academy** shows that adverse experiences during childhood such as family violence, neglect, abuse and even parental depression, can traumatically affect a child, strongly influencing his or her mental health, or in higher degrees even lead to a constraint in brain development.

Just a few months after birth, parents can observe several skills on a daily basis that are the result of an increasingly developed brain. A baby's first words, first steps, smiles, hugs, songs and many other abilities are the result of the refining of the neural connection system, dendrite branching, the formation of new connections, pruning of those that failed to establish functional network connections, and the myelination process that enables the brain to become more functional with every passing second.

Bearing in mind that experiences will influence the "wired" brain, it is extremely important to provide adequate opportunities, resources and environments, as children

will have to learn many things in the following years—to listen, speak, walk, write, read, interpret the world around them, choose, classify and infer, among many others—that will form the basis for all future learning.

The brain triples in weight during the first year of life, demonstrating two constants in all crucial processes of human beings: growth (increase in cell mass) and development (cell specialization). In the second year it reaches ¾ of its total weight, and in the third it exhibits twice as much neural activity as that of an adult. Research by various neuroscientists show that the brain forms 1.8 million new synapses per second between the second month of gestation and the age of two, and that 83% of dendrite growth occurs after birth (Elliot, 2000).

Synaptic density masterfully increases not because of the increase of new neurons, but rather because of dendrite growth and increased neural connections. The vital energy, first steps, words and phrases, pranks, exploration, discovery, and the physical, social and

Brain development research has shown that it is precisely in childhood where the foundations for higher brain functions such as memory, logical reasoning, language, perception, to name a few, lay.

emotional skills that are increasingly significant every day, are visible proof of a brain in constant development.

Several studies concluded that in the first years of life the process of synaptic connections and brain plasticity are exuberant because, unlike the body, the brain does not add as many cells after birth, but it does grow extensions of them, resulting in a phenomenal system of communication. The synaptic explosion toward this complex neural network's significant structuring enables the simultaneous awakening of many sensory, motor, cognitive, social and emotional skills that will help the child to grow, develop and integrate into the surrounding world.

According to a study by Kurt Fischer, the brain undergoes a series of "growth spurts" between the ages of zero and around 25, reflected, for example, in things such as head growth, brain activity and the density of synaptic conjunctions between dendrite branching.

According to Fischer there are three "growth spurts" during the first three months of life, each accompanied by new skills related to primitive instincts and survival reflexes. Every experience lived during these and later stages prepare and lead the brain toward a new "growth spurt." In order to illustrate this, Fisher invites us to consider the following examples: between the third and fourth weeks of life, babies can follow objects with their eyes, and try to grab at those placed in their hands. Between the seventh and eighth week, babies start to act on reflexes, such that in hearing their mother or father's voice, babies will direct their eyes toward the source of the sound, and

upon seeing an object that catches their eye, try to grab it with their hands. Between the tenth and 11th week, babies not only direct their eyes toward their mothers to hear her voice, but they also attempt to respond with a smile, gesture or movement. Similarly, upon seeing the object they like, babies will open their fingers in attempt to reach it.

Between the third and 18th month, babies will experience new "growth spurts," leading to new sensorimotor responses regarding the perception of their environment. Unlike the first few weeks in which they operate under basic reflexes, during the seventh and eighth month—with their sensory motor skills now at a higher level—babies not only reach their object of interest, but take it in their hands and move it closer to their eyes to examine it in greater detail.

Between the 11th and 13th month, another impulse or "growth spurt" will take place that directly impacts reaction and perception. Now babies not only take an object and examine it from all sides, but upon hearing others talk, they will move their mouths and lips in attempt to imitate the sounds of the words they hear.

By the second year, toddlers will have undergone numerous sensory and motor experiences that will have helped their brains reach their next level of potential: the ability to represent objects, people and events through mental symbols.

Thus, Fischer, as one of the pioneers in explaining the events that unfold inside babies' heads, describes different impulses or "growth spurts" that occur during

brain development, and links them to the various skills that emerge year after year. What is interesting is that precisely during these first three years of life is when many of these growth spurts occur in tandem with the accumulation of myelin in different cerebral regions, and the explosion of synaptic connections.

Since its molecular formation, the brain survives thanks to its ability to learn and adapt. Higher brain functions, like language, not only stem from the ability of cerebral areas specialized in function, but also depend on children's adjustments to their social environment as well as their interaction with others. Kandel (1997), one of the most renowned neuroscientists to date, contends that while the brain is able to learn and structure language—any language, be it spoken or written—there is a critical period for acquiring this ability. The period between the ages of two and eight is marked by the strong relationship with one's environment and the people who comprise it. Kandel also states that following this stage, the capacity to acquire language is greatly reduced.

Studies conducted in Romania's overcrowded orphanages (Ames, 1997), where hundreds of babies and children spend most of their time lying down, hungry, with no relationships, communication, play or appropriate care revealed that most children between the ages of two and three did not walk, talk or play. Their brain (PET) scans showed inactivity in the temporal lobes, areas responsible for several auditory, linguistic, and emotional skills. Many, though adopted by Canadian families, failed to develop in accordance to their chronological age.

Experience-dependent "brain wiring" uses information from the emotional, physical, social and cultural environment to continue with the cerebral architecture project begun in the womb.

Indisputably, brain development research (Gazzaniga, 2002) has shown that it is precisely in early childhood where the foundations for higher brain functions such as memory, logical reasoning, language, spatial and visual perception, and auditory discrimination, to name a few, lay. Likewise, it is also in early childhood that the platform for talent development is built. Understanding the process of brain development and the principles governed by the nervous system associated with learning and behavior make a huge difference in parent and educators' roles regarding the development of children's talents.

Development, as an integral process, brings together several areas, some with integrative capacities, as in the case of emotion. In this regard, the first three years of life merit special attention. While it is wrong to say that what one does not learn during this time will be impossible to ever learn, it is precisely at this stage that certain conditions are necessary for optimal brain development. One such condition is **emotional bonding** with an adult, which does more than just form the basis of a child's emotional development and self-regulation, as

mentioned by Dr. Shanker. Love and affection are also the basis of social (solid relationships strengthen social skills, self-confidence and empathy), sensorimotor (touch, caresses and physical games contribute data to the somatosensory system), and intellectual development (storytelling, singing songs, and discovering colors, shapes and sizes build cognitive skills).

Neuroscientific studies indicate that the myelination of various cerebral areas follows an ordered sequence, promoting neurological organization from the bottom of the spinal cord to the prefrontal cortex, which in turn is directly related to cerebral maturity and development. As mentioned, several myelinated structures in the prenatal stage allow areas that control vital skills such as breathing, sucking and swallowing to be highly functional at the time of birth. On the other hand, other structures become functional several years after birth, making the abilities of different development areas consolidate, together with the growth resulting from the genetic indication of environmental stimuli influence.

For instance, while vision-controlling brain structures are highly functional in the first six months, nerve fibers controlling the hand's delicate movements or hand-eye coordination will only be completely myelinated at around the age of four. This once again leads us to reflect on the close relationship that should exist between neuroscience and education, considering that many educators—unaware of the complex process of CNS and brain maturation—overlook this gradual development, linked to a gradual awakening of all

cognitive, sensory, physical, social, emotional, moral and reflective skills. It is worth noting that although the brain has specific areas and innate abilities that open up the collection of skills, recent studies point to the strength and influence that the environment exerts on human development. It is in early childhood where these skills can be learned, stimulated and refined; where the brain's plasticity enables the formation of a healthier and more balanced personality, creating a positive identity for future stages of development, provided the environment is appropriate.

In this regard, parents and educators have the primary role of providing children with all the experiences and resources needed to build their own development process. Moreover, as experience-dependent "brain wiring" uses information from the emotional, physical, social and cultural environment to continue with the cerebral architecture begun in the womb, it is essential that adults change several mental patterns and begin preparing a more suitable environment in which children can experience the individuality, sense of wonder, trial and error, intuition, creativity, autonomy, "individual" information processing, as well as the opportunity to challenge, question and change paths.

In regard to many proposals for ECCE programs, there is a significant breach between what parents and educators know about child brain development, and what they do in practice. The acquisition of said knowledge is vital, as this privileged stage is marked not only by children's great ability to learn and develop skills, but also by their

profound desire to do so. In short, for children, learning is directly related to survival.

We could ask ourselves: how much should one care for young children? Some believe that keeping them entertained by playing, running or watching television, in addition to feeding, sheltering, and making sure they get enough sleep, solves "the problem." We need to realize, though, that early childhood is fundamentally important, since in it lays the groundwork for future healthy development.

Chapter V

Influential Factors on Child Development

The effects of malnutrition in early childhood can be irreversible, including inadequate cerebral growth.

Although the brain has great learning potential and early childhood provides an ideal setting, there are certain factors that can significantly influence child development and all learning that takes place at this time. Among them are:

- Nutritional factors
- Emotional factors
- Genetic factors
- Environmental factors (family, socioeconomic and cultural environment)

- Brain injuries
- Firsthand experiences
- Prior learning

Of the aforementioned factors, the first merits special attention. During early childhood, children undergo a very large growth and development process, and good nutrition is essential because of the body's vital activity. However, everything begins in the mother's womb, and so she must worry about getting a proper, healthy and balanced nutrition. A mother's nutritional deficiencies during the prenatal period have severe consequences, affecting fetal growth and causing alterations in its immune system, increasing the risk of infection and diseases like pneumonia.

For a newborn, breastfeeding should be exclusive; it is the only stage in which children receive all nutrients from a single source. Breast milk is the best food for babies, and it should be the only food ingested for approximately six months. From six to nine months, in addition to milk, babies should gradually increase their intake of liquids and increasingly-consistent blended foods. From nine to twelve months it is necessary to incorporate a greater variety of increasingly solid foods, and between the ages of one and two, children should begin eating home-cooked meals. After the age of two, children should be fully incorporated into the family diet. A pediatrician can better guide the gradually incorporation of new foods.

The body takes the food that children ingest and converts it into the nutrients necessary for proper growth. Certain

foods are essential to the human body, such as proteins, iodine, iron, vitamins, minerals, calcium and water. One should avoid foods high in fat, salt and spices, as well as those with excessive carbohydrates.

For a child to grow properly, a balanced diet is required in terms of food quantity and quality. Otherwise, non-balanced diets can lead to malnutrition or, on the other end of the spectrum, obesity.

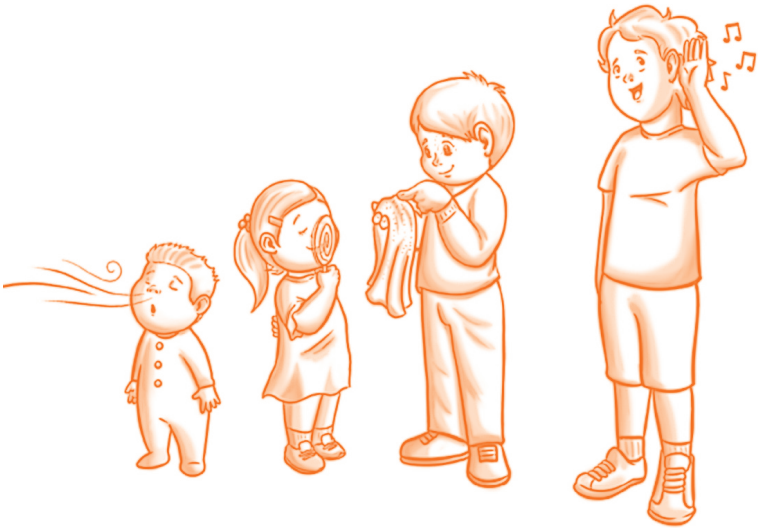
The effects of malnutrition in early childhood can be irreversible: difficulties in cognitive development, anemia, stunting of growth, being underweight, inadequate cerebral growth, motor development problems, dental disease, behavior problems, and socializing problems are all examples of such effects.

Childhood obesity is also a major issue. Excessive intake of junk food, combined with physical inactivity such as sitting in front of the television, computer or video games, throws off the balance of all systems, which can leave an indelible mark on the quality of later life.

Good nutrition in early childhood is fundamental because it ensures proper growth and development, avoids the deficiency of important nutrients, and prevents possible cardiovascular disease, hypertension and obesity.

Research by Dr. Regino Piñeiro (Cuba) reinforces the enormous link between nutrition and cognition. "For a normal cerebral function and development, the brain needs the intake of both macronutrients (carbohydrates,

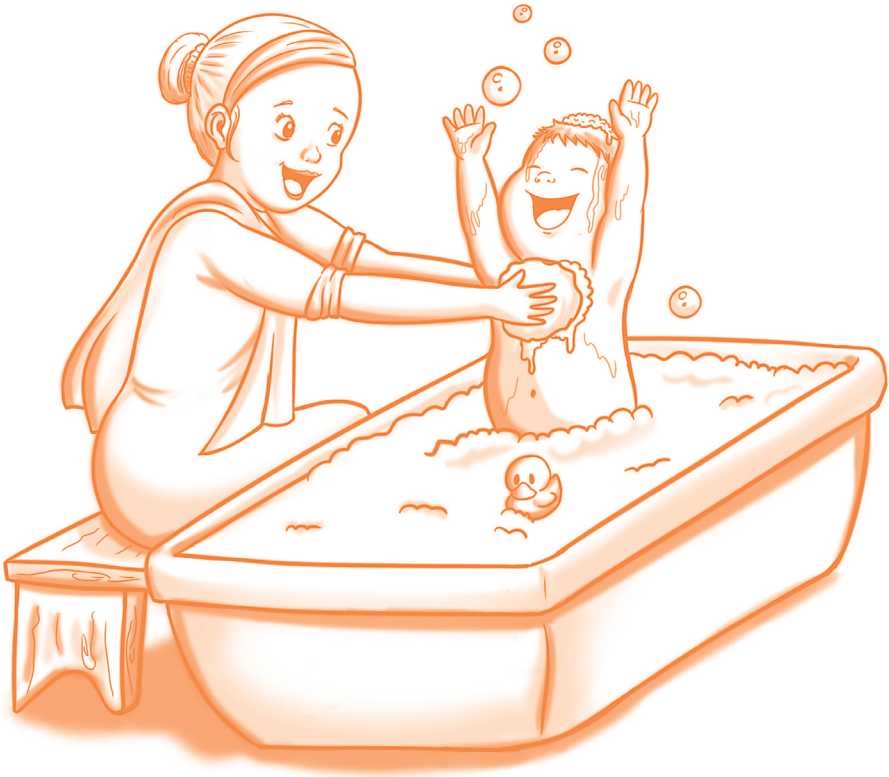
fats and proteins) and micronutrients (vitamins and minerals). Malnutrition in early life affects attention levels, memory and motor activity, leading to possible decreased psychomotor development and learning capacity."[9]



9 Piñeiro, Regino. *Nutrition and Brain Function in Children*. Cerebrum Ediciones. Peru, 2010.

Chapter VI

Messages to the Community for a Commitment to Early Childhood



All children are born with rights and it is each child´s right be cared for by people who understand the brain´s workings and potencial..

In accordance with this document's scope, to achieve greater early childhood comprehensive care and quality education we must begin to spread and share vital information that parents, educators and the community at large need regarding this critical stage in human development, which is so fleeting and never returns, leaving its mark on an entire lifetime...

One strategy to add voices, join forces and create specific situations for this to happen, is to propose that spoken, written and televised media spread the slogans and messages suggested in this document. The goal is to engage public and private institutions in this "crusade," where the final conquest will be understanding this wonderful, powerful and enigmatic human brain and the importance of early experiences in its development.

REFLECTIONS FROM THE VOICE OF AN ADULT:

1. All children are born with rights, and it is each child's right to be cared for by people who understand the brain's workings and potential.
2. The process of brain development begins three weeks

after conception: everything that takes place in the prenatal stage can affect this process.

3. Knowledge of early childhood will transform the manner of care and education the family or other institutions employ.
4. All children have the right to equal opportunity access to quality care and education programs.
5. Teacher quality means quality child development.
6. Human development begins in the womb and is the result of a harmonious relationship between genetics and environmental experience.
7. A mother's nutritional deficiency brings severe consequences to the development of her child.
8. Good nutrition is the key to good intellectual development.
9. Every child's individual experience will affect the development quality of his or her brain's potential.
10. Intellectual, emotional, physical, social and perceptual skills develop during the first years of life, and are the result of a brain in full development.

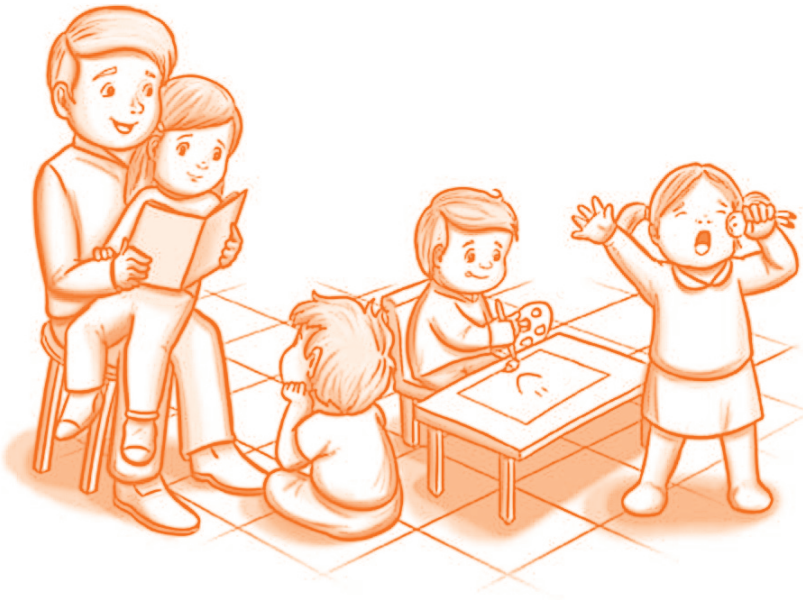
SLOGANS FROM THE VOICE OF A CHILD:

1. Mom, I feel what you feel.
2. Mom, what you consume during pregnancy is what nourishes me.
3. The experiences I undergo during my first three years of life affect the development of my brain.
4. The experiences that I live in my childhood are crucial for my adult life and for my performance in school.
5. If you understand how my brain works, you will better assist me in my development.

6. My brain is just starting to develop; don't ask me to do what I'm not ready to do.
7. Talk to me, sing and read to me... I can hear you.
8. If my parents lead healthy lives, there's a greater chance I will have a healthy development.
9. If my mom doesn't have good nutritional habits, my development will not be its best.
10. Tell me stories: a brain that listens is one that speaks, reads and understands.
11. Let me sleep; sleep is an important factor for my brain's development.
12. Early childhood marks the most significant period of my growth and development: invest love and affection, and communicate with me.
13. Want me to grow well? Provide me with positive and meaningful experiences for my given context.
14. Let me enjoy my childhood, I'll only live it once.
15. What happens during my early childhood will leave marks throughout my entire life. Some marks and scars cannot be seen; these are results of my emotional and affective experiences. See that I don't have them.
16. I learn by imitating, set a good example for me.
17. Breast milk is the best nourishment for me (the baby).
18. Feed me well now in order to avoid future irreversible consequences.
19. What happens in my community affects my development.
20. Learning is a fun game. Give me plenty of opportunities to do it.

These are some suggestions of messages that can be spread by the media. From these, many others can be created.

References



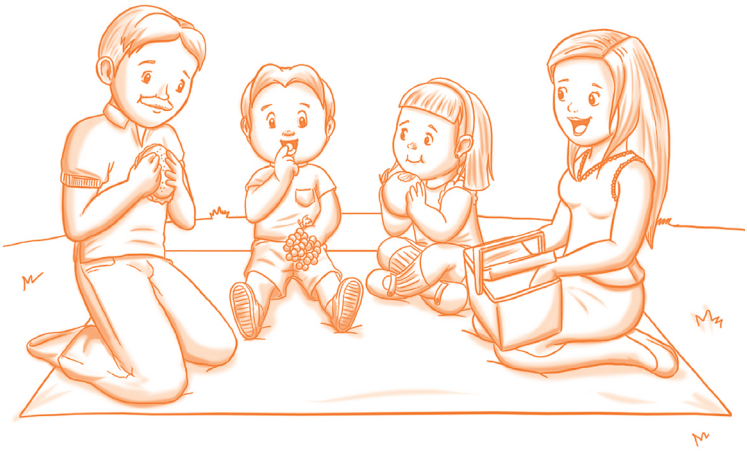
References to Chapter I: Neuroeducation: A New Ally for Early Childhood Care and Education Programs

1. M. Diamond, J. Hopson. *Magic Trees of the Mind: How to Nurture Your Child's Intelligence, Creativity, and Healthy Emotions from Birth through Adolescence.* Plume. New York, 1999.
2. Stuart Shanker. "Self-Regulation: Calm, Alert, and Learning." *Education Canada.* Vol. 50 (3). Canada, 2010.
3. Felitti et al. "Relationship of Childhood Abuse and Household Dysfunction to Many of the Leading Causes of Death in Adults: The Adverse Childhood Experiences Study." *American Journal of Preventive Medicine* 14 (4): 245-258.
4. A. García-Molina, A. Enseñat-Cantallops, J. Tirapu-Ustárroz, T. Roig-Rovira. "Prefrontal Cortex Maturation and the Development of Executive Functions during the First Five Years of Life." *Rev. Neurol,* 2009; 48: 435-440.

References to Chapter II: Understanding Children from the Start: The Prenatal Stage and Brain Formation

1. Purves et al. *Neurociencia.* 3rd Edition. Panamerican Medic Editorial. Spain, 2003.
2. B. Morales et al. "Critical Periods of Cortical Plasticity" *Rev Neurol*, 2003; 37 (8): 739-743.
3. Fumitaka Homae et al. "Development of Global

Cortical Networks in Early Infancy." *The Journal of Neuroscience*, April 7, 2010; 30(14): 4877-4882.
4. Ira Adams-Chapman. "Insults to the Developing Brain and Impact on Neurodevelopment Outcome." *Journal of Communication Disorders*, 2009; 42: 256-262.
5. Leslie K. Jacobsen, Marina R. Picciotto, et al. "Prenatal and Adolescent Exposure to Tobacco Smoke Modulates the Development of White Matter Microstructure." *The Journal of Neuroscience*, December 5, 2007; 27(49): 13491-13498.
6. Lars Henning Pedersen et al. "Fetal Exposure to Antidepressants and Normal Milestone Development at 6 and 19 Months of Age." *Pediatrics* Volume 125, Number 3. March, 2010.
7. Aryeh D. Stein et al. "Nutritional Supplementation in Early Childhood, Schooling, and Intellectual Functioning in Adulthood." *Arch Pediatr Adolesc Med,* 2008; 162(7): 612-618.



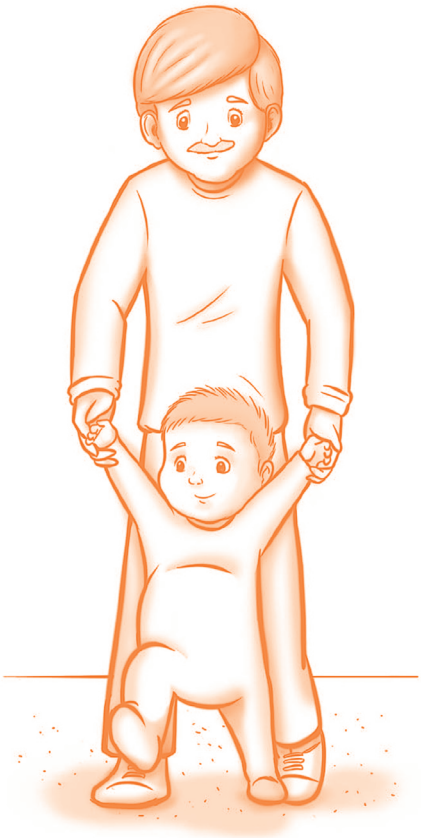
References to Chapter III: Birth and the First Months of Life: Decisive Cerebral Moments

1. S. Hernández, F. Mulas, L. Mattos. "Functional Neuronal Plasticity." *Rev Neurol*, 2004; 38: 58-68.
2. M. A. Izquierdo, D. L. Oliver, M.S. Malmierca. "Plasticity Mechanisms (Functional and Activity-Dependent) in the Adult Auditory Brain and Development." *Rev Neurol*, 2009; 48: 421-429.
3. Hengyi Rao et al. "Early Parental Care is Important for Hippocampal Maturation: Evidence from Brain Morphology in Humans." *NeuroImage* 49 (2010): 1144–1150.
4. J. Johnson, E. Newport. "Critical Period Effects in Second Language Learning: The Influence of Maturational State on the Acquisition of English as a Second Language." 1989; 21: 60-99.
5. A. Newman, D. Bavelier, D. Corina, P. Jezzard, H. Neville. "A Critical Period for Right Hemisphere Recruitment in American Sign Language Processing." *Nat Neurosci*, 2002; 5: 76-80.
6. Morgado. "Psychobiology of Learning and Memory: Recent Fundamentals and Advances." *Rev Neurol*, 2005; 40: 289-297.
7. Pascal Belin, Marie-Hélene Grosbras. "Before Speech: Cerebral Voice Processing in Infants." *Neuron* 65, March 25, 2010.
8. N. Sadato et al. "Activation of the Primary Visual Cortex by Braille Reading in Blind Subjects." *Nature*, 1996; 380: 52-68.
9. N. Sadato, T. Okada, M. Honda, Y. Yonekura. "Critical Period for Cross-Modal Plasticity in Blind Humans: A Functional MRI Study," 2002; 16: 389-400.

10. Maria V. Popescu, Daniel B. Polley. "Monaural Deprivation Disrupts Development of Binaural Selectivity in Auditory Midbrain and Cortex." *Neuron* 65, 718-731, March 11, 2010.
11. J. L. Heraghty, T. N. Hilliard, A. J. Henderson et al. "The Physiology of Sleep in Infants." *Arch Dis Child*, 2008; 93: 982- 985.
12. Alice M. Gregory et al. "Parent-Reported Sleep Problems During Development and Self-reported Anxiety/ Depression, Attention Problems, and Aggressive Behavior Later in Life." *Arch Pediatr Adolesc Med*, 2008; 162(4): 330-335.
13. Christopher G. Vecsey et al. "Sleep Deprivation Impairs cAMP Signaling in the Hippocampus." *Nature* 461, 1122-1125. October 2009.
14. Jennifer L. Miller et al. "Early Childhood Obesity is Associated with Compromised Cerebellar Development." *Developmental Neuropsychology*, 2009, 34: 3, 272-283.
15. Caroline Fall. "Maternal Nutrition: Effects on Health in the Next Generation." *Indian J Med Res* 130, November 2009, 593-599.

References to Chapter IV: A Brief Look at Early Childhood

Kurt Fischer, Samuel Rose. "Dynamic Development of Coordination of Components in Brain and Behavior." *Dawson and Fischer*, 1994.



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