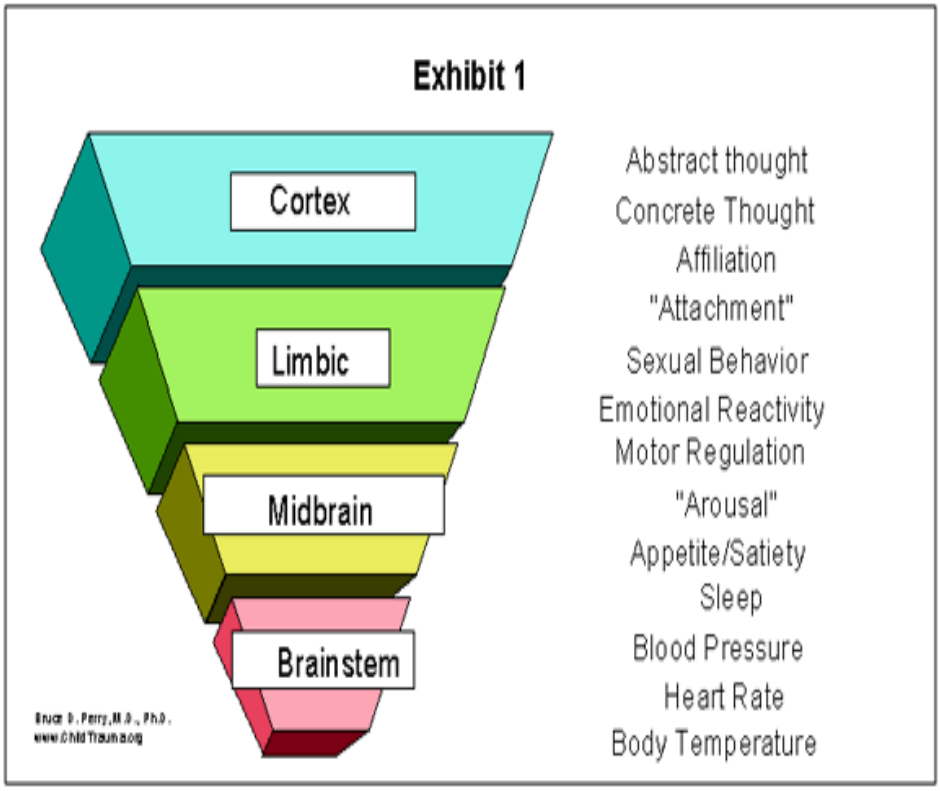
Why does an understanding of brain development matter?

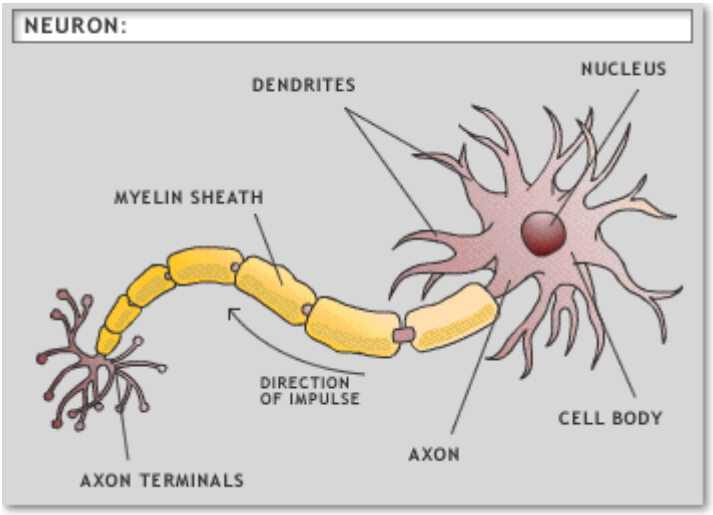
In the last ten years there has been an explosion of interest and research in brain development. New technologies such as MRI scanners have allowed us to observe brain activity in a non intrusive way. There is a growing scientific consensus that maltreatment in infancy can have long lasting effects on the brains of children which affect their capacity to learn and to manage social situations. This work is also, however, beginning to help us to understand how to intervene more effectively to enable children and young people to recover more quickly and completely from adverse experiences in childhood.

How does the brain develop?



The brain develops sequentially from the bottom up so the first areas of the brain to develop are the brainstem and the mid brain. These brain areas govern the bodily functions necessary for life and are referred to as ‘autonomic functions’. The limbic system and the pre frontal cortex develop last. The limbic system and the prefrontal cortex regulate emotions and social behaviours and are involved in memory formation and abstract thought.

The brain consists of brain cells or neurons. These have a cell body, dendrites (branch like structures) that receive information from other cells and an axon (a long tail like structure) that transmits information to other cells.



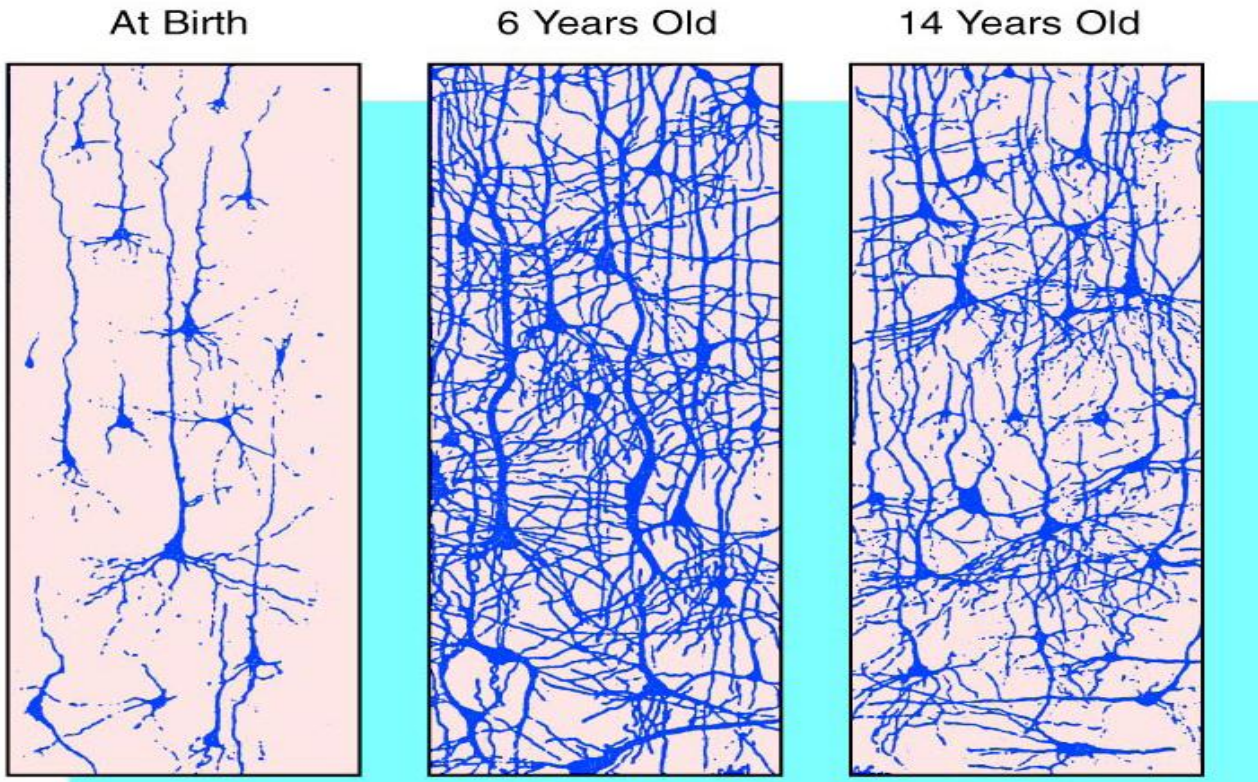
How do brain cells work?

Transmission of information through the neuron is an electrical process. The cell body integrates the electrical signals arriving from the dendrites and, according to the strength of these signals generates a nerve impulse which travels down the axon to an axon terminal. Axon terminals lie close to the dendrites of neighbouring neurons. When the nerve impulse reaches an axon terminal it causes the release of a chemical - a neurotransmitter - that travels across the gap, or synapse, between a terminal and the dendrite of the neighbouring neuron. Neurotransmitters attach to receptors in the neighbouring dendrite and trigger an electric charge that travels down the dendrite to the cell body. Our behaviour is the consequence of billions of cells talking to each other via these chemical and electrical processes.

Early brain development

At birth, a baby's brain contains 100 billion brain cells –about the same as an adult brain. The main structures of the brain are in place about three months before the baby is due to be born. Nevertheless the brain of a new born baby is much less “finished” than that of most other baby animals. The brains of the most highly evolved animals are least hardwired at birth so the brains of human babies are very sensitive to their environment as they learn and their brain grows. In the first three years of life the brain goes from 25% of adult weight to 90% of adult weight. This growth is as a result of a huge proliferation of synaptic connections between nerve cells and the hard wiring of these connections within the brain. The infant brain is hugely responsive to its sensory and emotional environment and experiences create or consolidate connections between cells by transmitting information from one cell to another. Connections that are regularly activated create “preferred pathways” in the brain. Over time the axons of the cells that form these pathways become coated in myelin which acts as an insulator and improves the speed and efficiency of transmission of these signals. Babies need new experiences - if they are not exposed to stimulation they will make fewer connections and those they do make will be less well developed. New born babies have very little control over their environment and are dependent on others to provide

appropriate sensory and emotional experiences. By about the age of three, the brain has made many more connections than it will ever need. Connections that are not regularly used are “pruned” so that fewer connections exist in adulthood than in early childhood, as illustrated by these slides of human brain[1].



Proliferation and decline in synaptic connections in children

Critical periods

The development of certain parts of the brain can only take place within a “critical period”. If a baby receives no visual sensory stimulation then the synaptic connections necessary for developing vision will not take place and after a certain age no matter how intensely those neurons are stimulated vision will not develop. The critical time has passed. There is no evidence that the early months of life are a critical period for emotional and cognitive development in this extreme sense. There is developing evidence, however, that babies are sensitised to engage with adult caregivers in ways that promote positive secure relationships. The development of a number of core emotional abilities come from the frequent activation of pathways associated with arousal and soothing. For infants who are chronically stressed and frightened alternative connections are created and these become the preferred and reinforced pathways. As babies are dependent on adults to regulate stress these infants’ mechanisms for dealing with stress become very

[1] Courtesy of Prof Peter Seaman

distorted. Either they may become over reactive and respond adversely to the slightest stimulation or they may switch off and become very unreactive even in highly threatening situations.

Crucial cognitive skills are also laid down in the first months and years through the experience of relating to others. These include an early understanding of cause and effect, a sense of the progression of time, a capacity for interpersonal communication and the early development of emotional intelligence. Although very few people will have clear memories of their earliest years children learn more in the first three years than they ever will again.

What is the impact of negative early experiences on children when they go to school?

These core cognitive and emotional abilities are essential for effective functioning in the world of formal education. If they are not in place children may, with difficulty, manage to learn a number of formal skills such as reading or doing maths but they are unlikely to be able to integrate their learning and their achievement is likely to be patchy. Many children who have been neglected or abused in infancy or early childhood fail to develop effective executive functioning. These executive functions allow children to use their intelligence effectively by controlling impulsive behaviour and emotional outbursts, organising themselves and materials, planning, initiating, motivating, shifting, developing working memory and self monitoring. Teachers may be surprised and frustrated that a child who apparently understands a quite complex concept is unable to use it effectively in a different situation or is unable to hold on to an idea over time. An intelligent child may appear to be lazy or defiant when in fact they are unable to manage a task that a much younger, less able child with a more positive history would easily cope with.

Later brain development

During primary school years the brain develops in response to the formal learning environment as well as continuing the everyday process of synaptic reinforcement begun in infancy. Motor skills are reinforced and the pathways that are the basis for abstract reasoning begin to be developed. Recent research now suggests that as children reach their teenage years a further important phase of brain development occurs. This is centred in the frontal lobe of the brain and particularly in the prefrontal cortex which is associated with higher levels of reasoning. This involves a further proliferation of synaptic connections and the pruning of these in a use dependent way. This again means that the synaptic pathways that are used regularly will be reinforced and those that are not will eventually be lost. Myelination of these regularly used pathways make them both more efficient and more durable.

Impact of puberty

Simultaneously with changes in the prefrontal cortex the adolescent brain is flooded with hormones, as a result of the onset of puberty that affects emotional development. These changes happen more quickly than the changes in cognitive functioning. There is some evidence that the combination of these changes mean that adolescents are LESS able to make sensible assessments of social situations and risk than they were in their later primary school years. Economic and cultural changes have also meant that children in the developed world are reaching puberty at a significantly earlier age. This makes the task of integrating the cognitive and emotional changes in their brains an even harder task

Risks and opportunities

Although this time of increased activity in brain development leaves young people vulnerable to adverse experiences it also allows an opportunity for positive change and development. In contrast to their early years young people are no longer dependent on their adult caretakers to provide the opportunities for developmental experiences. The decisions that teenagers make about activities they regularly engage in will literally influence the structure of their brains. Encouraging and supporting young people to make positive choices of friends, leisure activities, learning experiences and social interactions can help them to change the way their brain functions and consequently have a major impact on their wellbeing and achievement. Clearly this is no easy task as looked after young people are subject to all the normal stresses and strains of adolescence and in addition carry their heritage of difficult and distressing earlier experiences with them. It is important, however, to recognise that this research suggests that this period of a young person’s life is a real second chance.