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Neurodevelopment in the First Decade of Life

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Section A

Overview
Features of Development

- Developmental milestone:
  - Attainment of a skill that typically develops sequentially and is a function of maturation

- Streams of development include:
  - Motor
  - Cognitive
  - Language
  - Social
  - Emotional/affective
The Two Cell Types of the Brain

- Neurons
- Myelin
The Structure of the Brain

- Cell body
- Axon (one)
- Dendrites (many)
- Synapses
The Structure of a Neuron
Formation of the Brain Starts at Day 16 of Fetal Life

- The outermost of three layers of the embryo will become the brain through a process called **neural induction**
  - This is referred to as the **neural plate**

- The plate then buckles, folds and becomes a tube through a process called **neurolation**

- One end of the tube becomes the brain and the other the spinal cord
Buckling

3 weeks
4 weeks
5 weeks
7 weeks
11 weeks

4 months
6 months
8 months
9 months
Brain Development

- Brain cells (neurons) **proliferate** at an exponential rate and travel to their final place in the brain through **migration**

- Proliferation is both **symmetric** (one cell divides to become two identical cells) from about day 22 to 49 and **asymmetric** (one cell replicates but the next cell does not) a process that goes from week 7 to week 18
Migration: the process by which brain cells travel to their final location

- Starts at about week 8 of gestation and ends at about week 18 of postnatal life
- This process results in the formation of the 6 layers of the adult brain
- Migration is from inside out (e.g., the inner cortex is formed first; the outer cortex last)
First the ventricle area (where proliferation starts and migration begins) sends cells to the areas of the neural tube forming the:
- Prosencephalon (forebrain)
- Mesencephalon (midbrain)
- Rhombencephalon (hindbrain)

The forebrain and hindbrain split again but not the midbrain.
Evolution of Single Neural Plate

Embryonic day 6
- Neural plate
- Wnt, RA, FGFs

Embryonic day 7
- Neural plate
- Anterior visceral endoderm
- Dickkopf, Cerberus

Embryonic day 8
- Neural plate
- Anterior visceral endoderm
- Wnt
- TLC
- Forebrain
- Spinal cord
- Midbrain & Hindbrain

Adapted by CTLT from Nature Reviews, Neuroscience.
The process of enlargement causes the brain to buckle and by about 7 months takes on the shape of an adult brain.
Axons, Dendrites, and Synapses

- A single long axon grows in response to environmental stimuli (material between cells) and surface materials on other nerve cells.

- Dendrites grow and reach out in many directions in response to electrical activity, chemical environment, and incoming axons.
The Structure of a Neuron

- Dendrites
- Microtubule Neurofibrils
- Neurotransmitter Receptor
- Synapse (Axosomatic)
- Synaptic vesicles
- Synapse (Axodendritic)
- Axon hillock
- Axon
- Nucleus (Schwann cell)
- Microfilament
- Microtubule
- Myelin Sheath
- Node of Ranvier
- Rough ER (Nissl body)
- Polyniosomes
- Ribosomes
- Golgi apparatus
- Nucleus
- Nucleolus
- Membrane
- Mitochondrion

Public Domain
Factors that Affect Axonal Growth

- Anoxia
- Malnutrition
- Toxins
- Genetic abnormalities
- Scarring

Axons that are damaged or do not grow initially tend not to re-grow
Synapses

- Generally connect axons and dendrites

- Two forms: **electrical** and **chemical**

- Chemical synapses send electrical impulses from an axon to dendrite through release of neurotransmitters (e.g., serotonin)

- Two mechanisms of synapse formation: genetic and environmental

- Strength of the chemical connection depends on use
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Synaptic Gap

Source: http://commons.wikimedia.org/wiki/File:Neuronal_Synapse.jpg. Creative Commons BY-SA.
Long-Term Potentiation

- A memory model brought about by increased synaptic strength
- Stimulated by sustained, rapid activity in neuronal circuits
- Involves newly acquired information (e.g., learning a new phone number)
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Dendritic Proliferation

Synaptic Pruning and Myelination

- Improved brain function
  - Increased efficiency of local computations
  - Increased speed of neuronal transmission
Myelin

- The “white matter”
- Fatty material
  - Improves speed of electrical transport; works as insulation of axons
  - May also improve neuronal functioning
  - Myelination occurs in different parts of the brain at different stages