Section 2-2 Development

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COGS 17 A04

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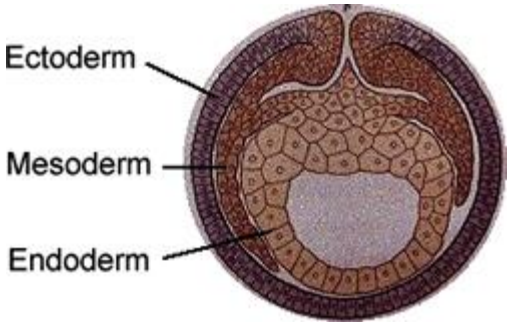
Embryonic Development

- 3 layers of cells
  - **Outer Layer:** Ectoderm → Nervous System & Skin
  - **Middle Layer:** Mesoderm → Bones, Muscles, & Blood Vessels
  - **Inner Layer:** Endoderm → Organs & Glands

- Over the first 2 weeks of development, embryo morphs from a sphere of cells to an elongated “worm”

- As the ball morphs into a “worm”, the 3-layer structure is maintained



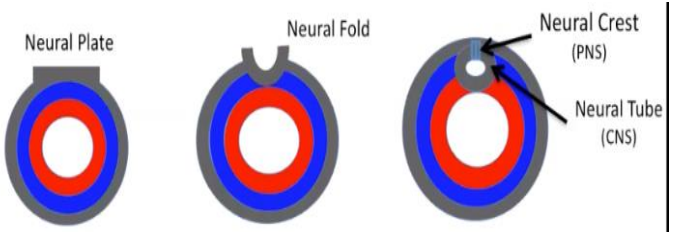
Embryonic Development

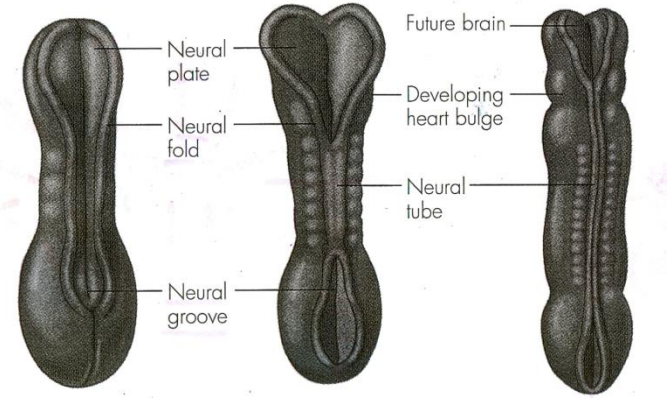
- Dorsal ectoderm thickens and hardens to form the **Neural Plate**
  - The edges of the plate forms ridges called **Neural Folds** curl up-towards each other along the longitudinal axis until they touch and fuse

- By week 4, the curling-fusing process is completed to form the **Neural Tube**
  - Becomes CNS
  - anterior end > Brain
  - posterior end > Spinal Cord

- Dorsal surface of the Neural Tube forms the **Neural Crest**
  - Forms the Ganglia of ANS, peripheral Neurons & Glia

- Hollow center of the Neural Tube forms the Ventricles and Central Canal





21 days 22 days 28 days

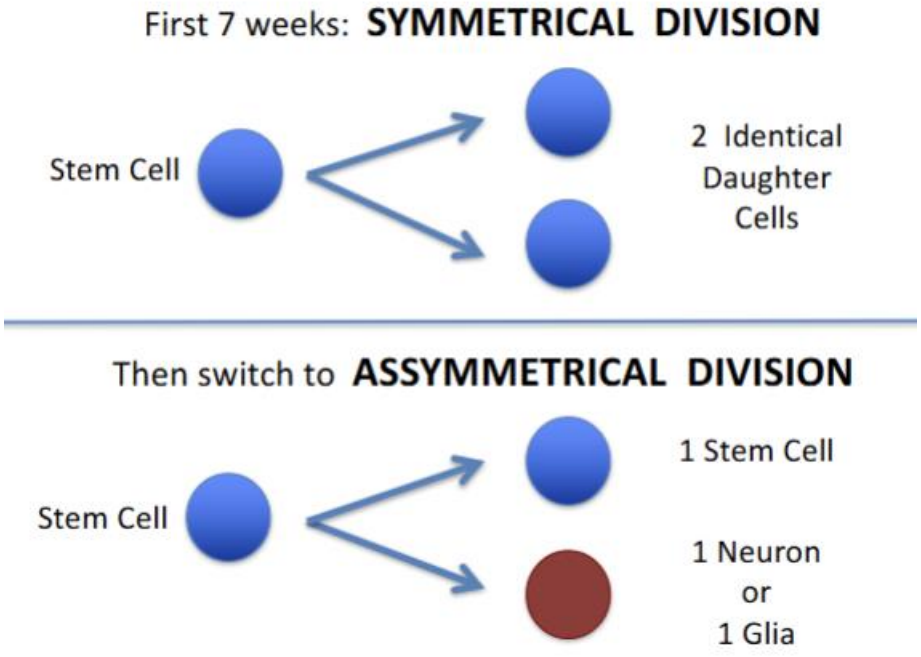
Proliferation of Cells

- **Stem Cells**

= Ectoderm cells that line the inside of the Neural Tube (Ventricular zone)

  - During the **first 7 weeks**: Undergoes **Symmetrical Division** (produces two identical daughter cells) increasing the size of the Ventricular Zone

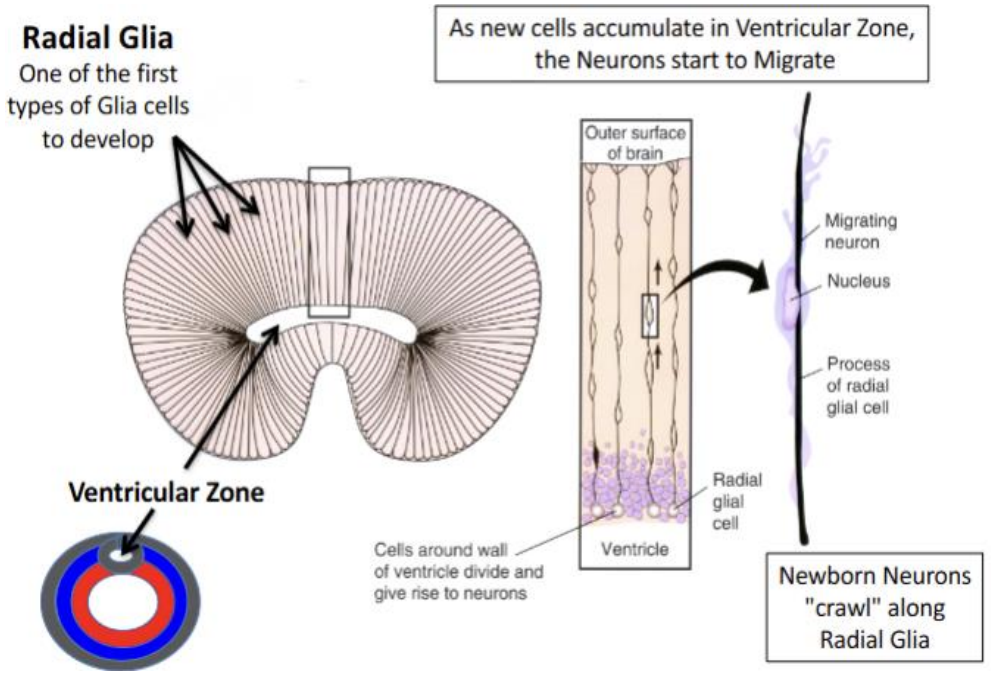
  - **After week 7**: shifts to **Asymmetrical Division** (produces one stem cell, one neuron or glia) lasts for ~3 months to produce over 100 Billion Neurons in cortex



Migration and Differentiation

- Some Stem Cells become **Radial Glia** cells that extends fibers outwards from the Ventricular Zone
- Neurons can “crawl” along the fibers of Radial Glia
- Drift outwards following chemical gradient (= Neurotrophins) signaling

- **Differentiation** is the process where cells specialize into a specific role or class
  - different genetic & local environmental factors affect differentiation

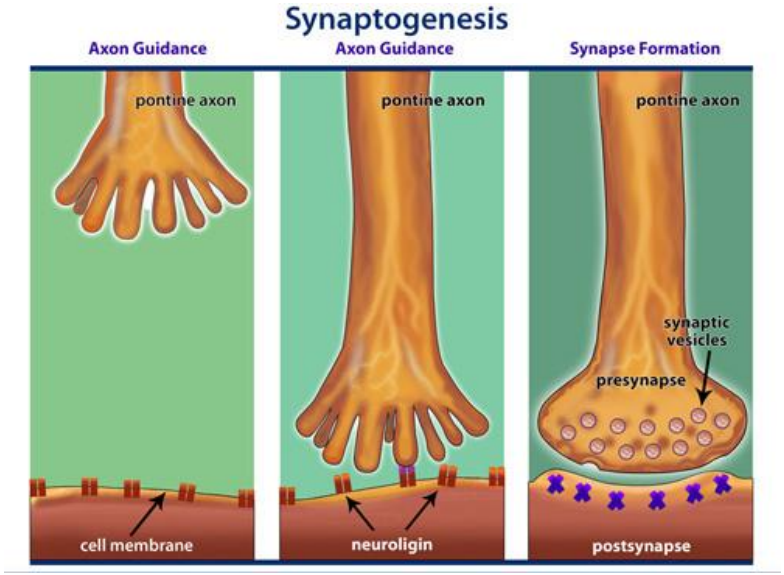


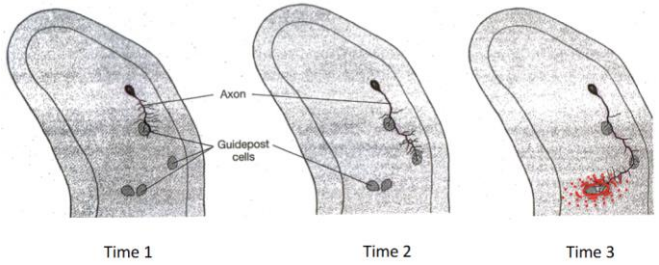
Synaptogenesis

= Developing synapses between cells

- Neurons grow Axons and Dendrites once they've settled down after migration

- Axons must seek out appropriate target post-synaptic cells ("with which to communicate?)
    1. Filopodia on the growth cone at the end of the axon can detect local chemical gradients
    2. Guidepost cells can also stick to growing axons and direct it towards a target cell
    3. Others depend on Chemical Trails produced by Glia cells or other migrating Neurons/Axons

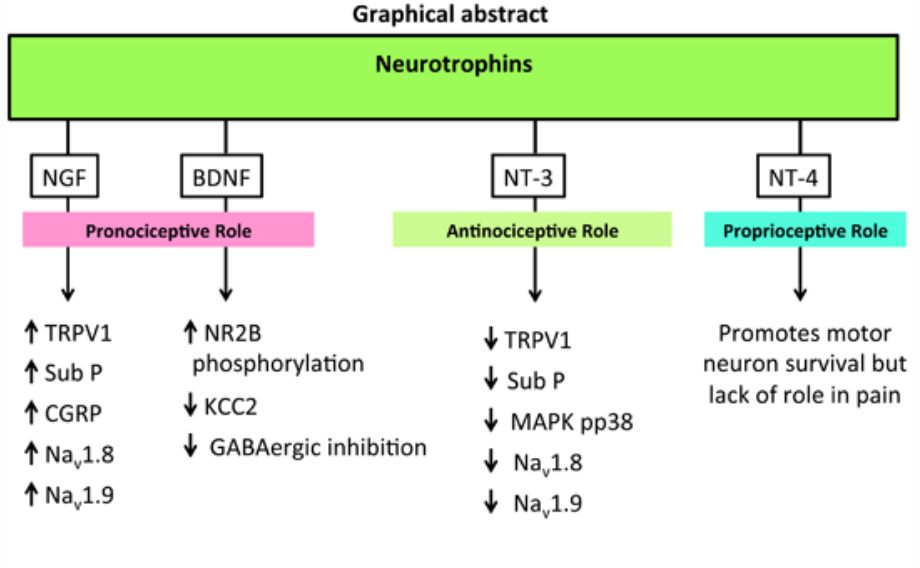




Synaptogenesis

- **Chemical trails - Neurotrophins**
  = chemicals that attract/repel and promote survival and activity of Neurons

  - Muscles produce NGF (Nerve Growth Factor) that attract and promote survival of Sympathetic Nervous System Axons
  - CNS can produce BDNF (Brain-Derived Neurotrophic Factor) which promotes the axon survival and



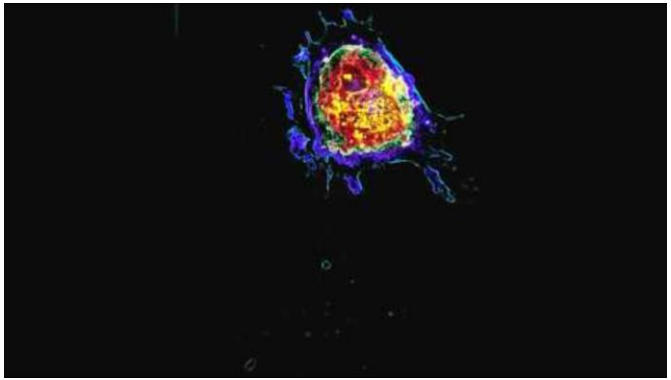
Apoptosis

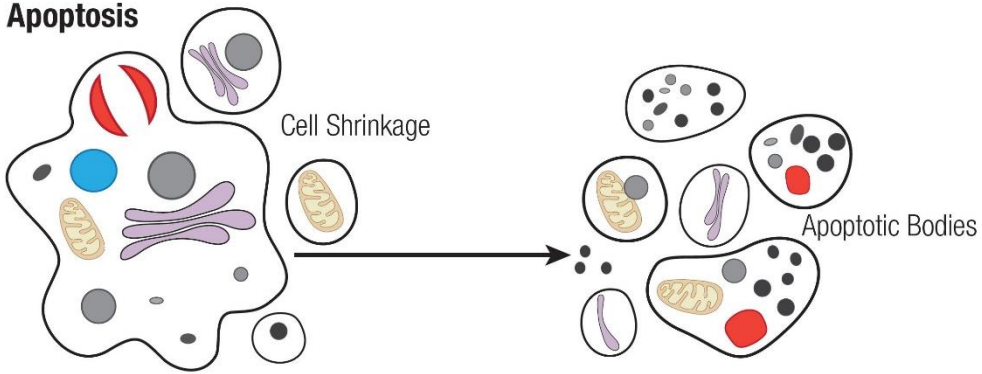
Suicide Gene → Programmed **cellular death**

- Activated when certain conditions are met (abnormal cellular growth or failed connections)

- During development, the nervous system **massively overproduces** cells
- Axons initially branch widely and connects to multiple sites. Overtime, only a few sites are strengthened and maintained

- As neurons compete for connections, “losers” die off





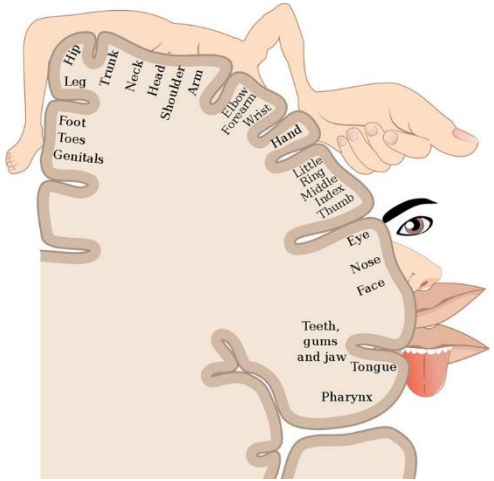
Patterns of Co-Activity

- *"Cells that Fire Together, Wire Together"*

- NT release by developing presynaptic cell → produces postsynaptic response → postsynaptic cell releases neurotrophins to promote the presynaptic cell survival
    - Neurotrophin is only effective on active presynaptic cells, so the more **correlated the pre/post activity** of a given pathway, the more likely it will **strengthen**

- Cells that don't receive strong feedback are targeted for apoptosis
- When out-competed die, remaining connections will produce Collateral Sprouts that will take over synapses

- Adjacent presynaptic cells tend to correlate their bursts of activity, which tend to make connections to adjacent targets, forming a topographic map where spatial relationships are preserved



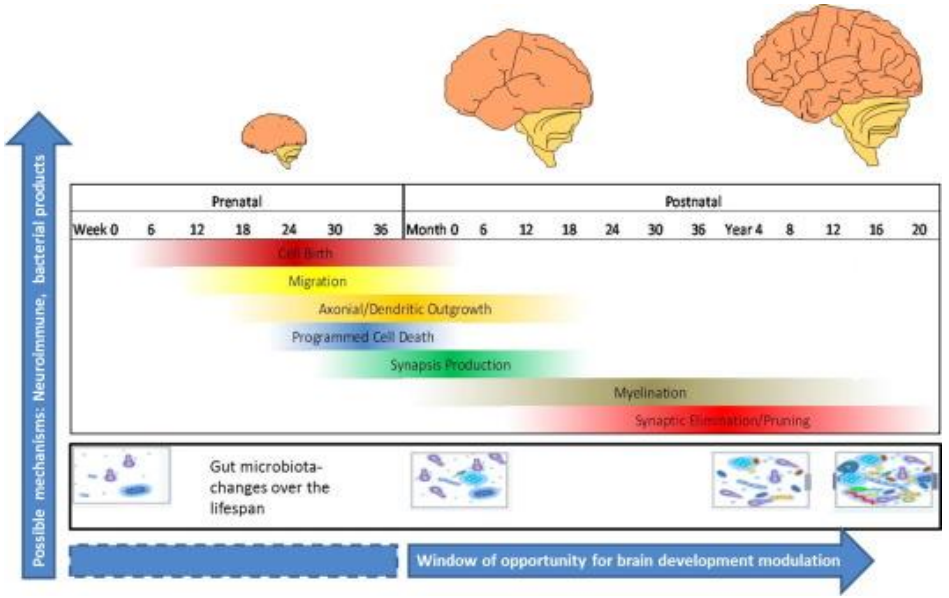
Further Development

- Brain growth continues after birth, mainly due to the increase in cell size and branching (dendritization)
  - Newborn: 350g
  - 1 yo: 800-1000g
  - Adult: 1200-1400g

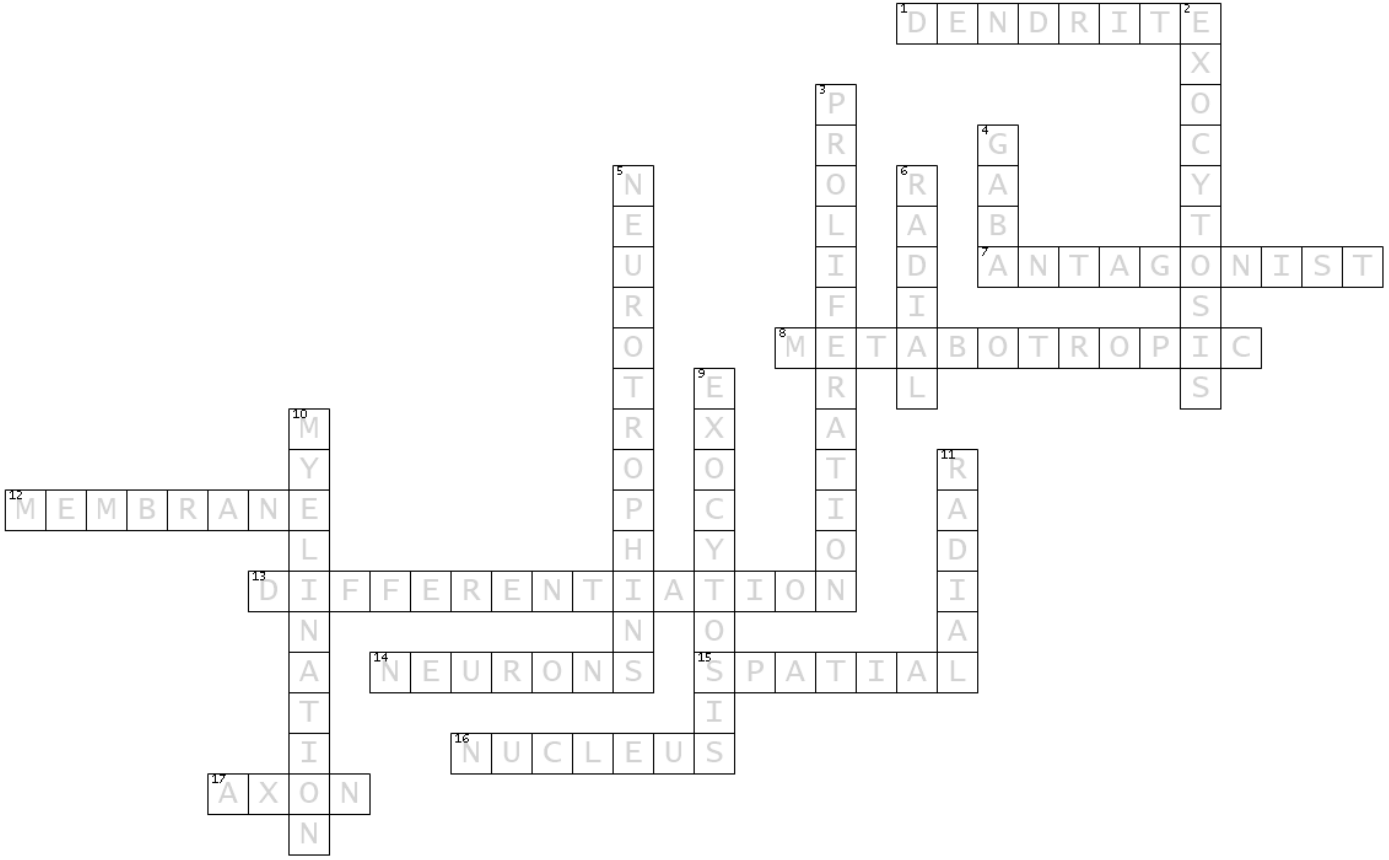
- New neurons are rare, but they do occur in some places (e.g., Olfactory Bulb, Hippocampus, Cerebellum)

- Maps initially formed during fetal development continues to be shaped by experience

- Myelination continues through adulthood



Crossword Answer



Kudos to us for keeping our brain busy and good luck on your Midterm!

When you use 100% of your brain