Section 3
Development

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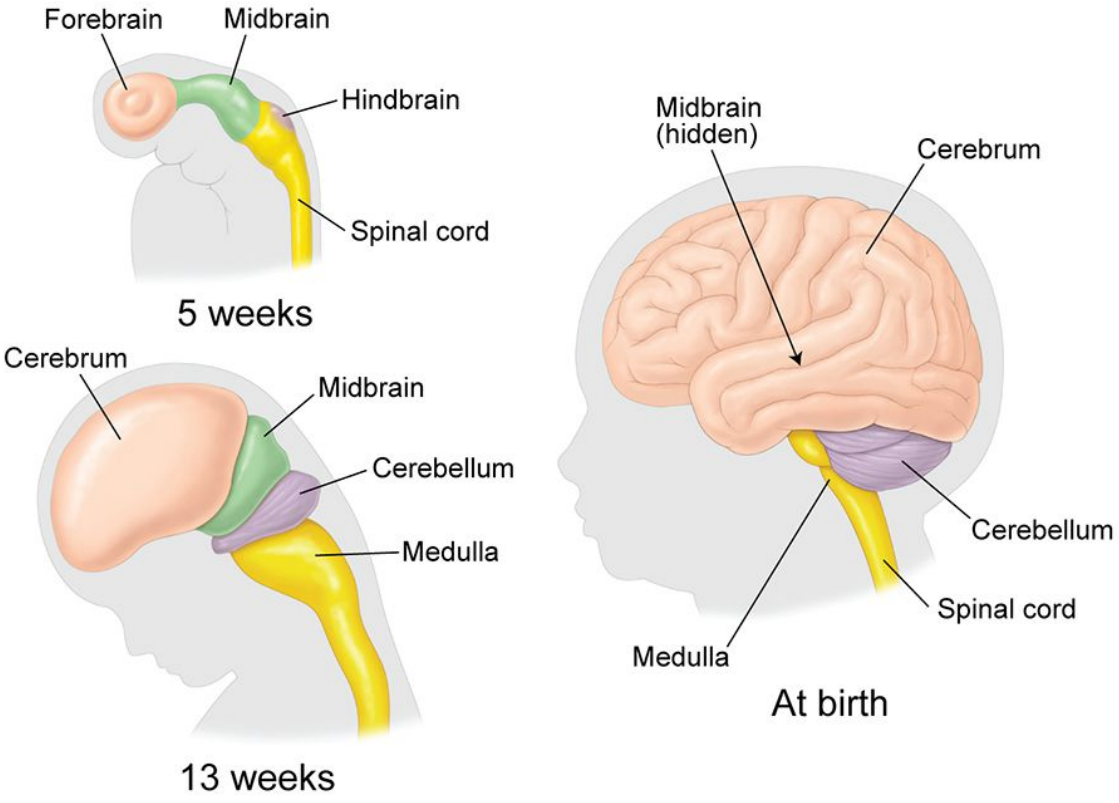
COGS 17 A05
04/21/25

MIDTERM I (125 Points)– Tomorrow

3:30-4:50 pm (80 minute)

Exam Online

Embryonic Development

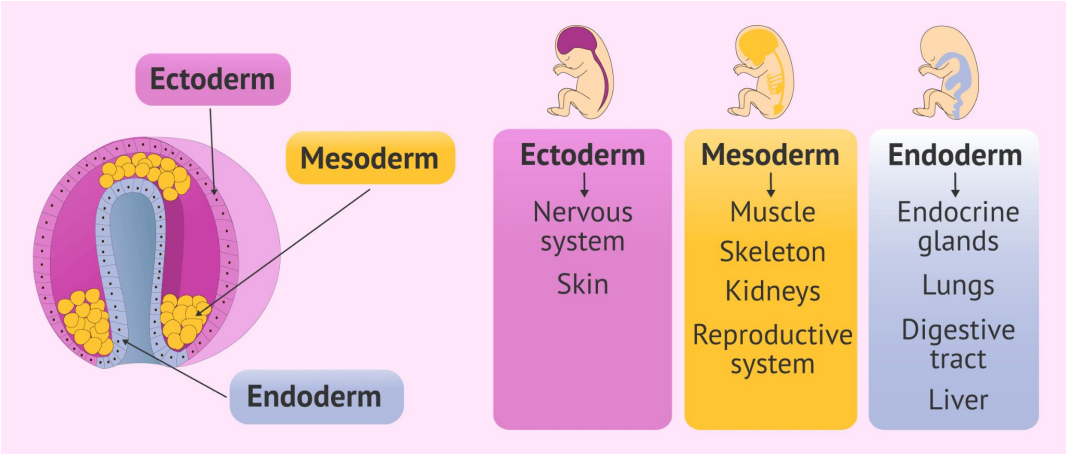


Embryonic Development

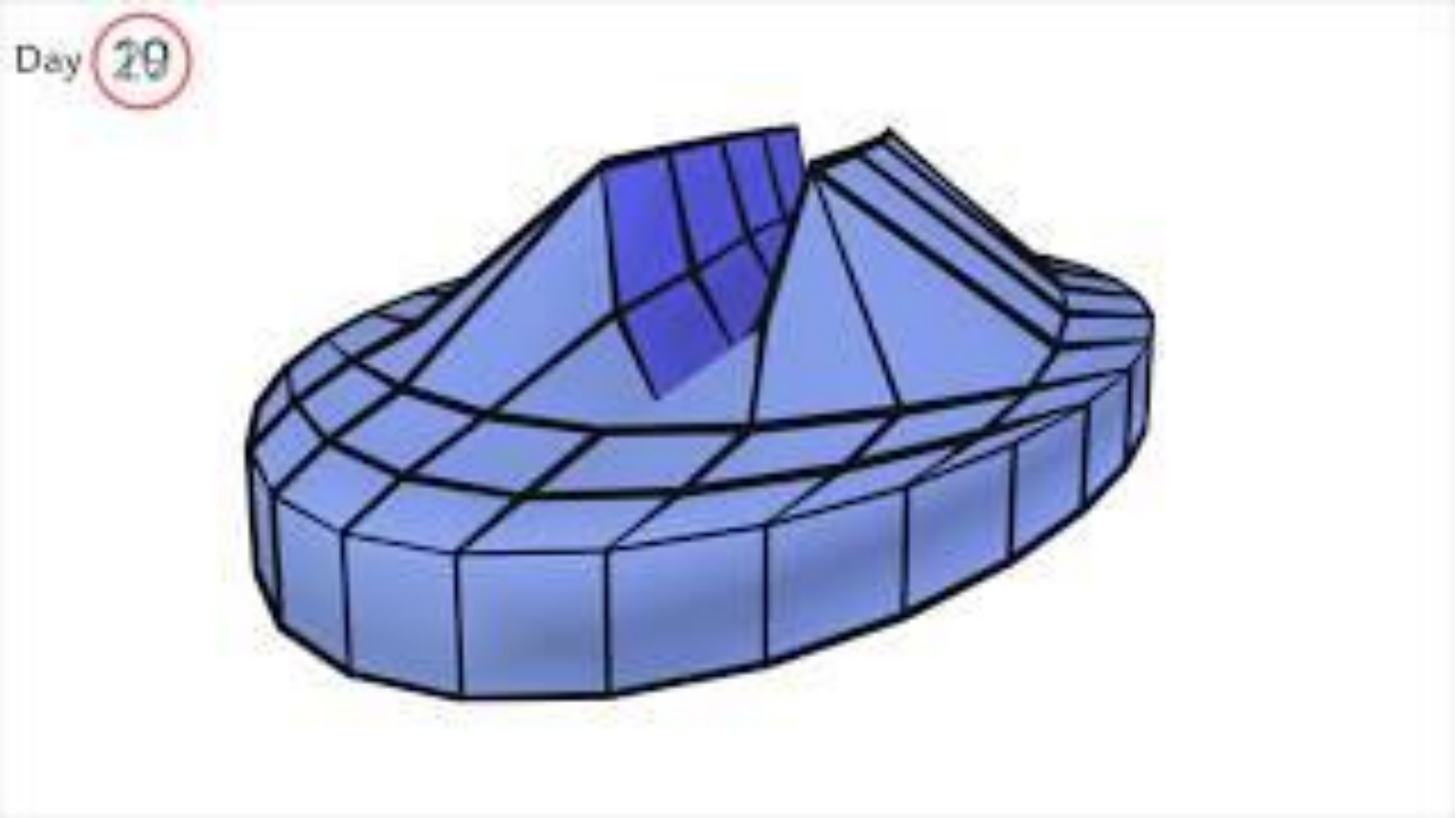
- Initially… 3 layers of cells

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

- Over the first 2 weeks, embryo morphs from a sphere of cells to an elongated “worm”
- As the ball morphs into a “worm”, the 3-layer structure is maintained

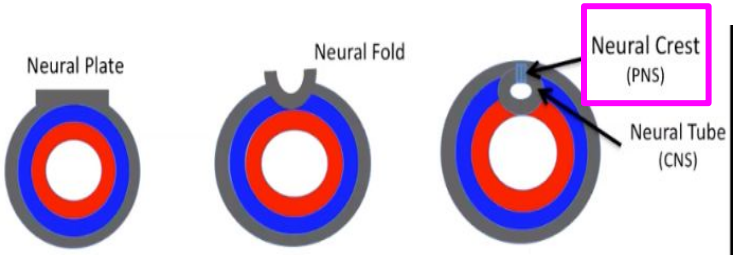


Embryonic Development



Embryonic Development

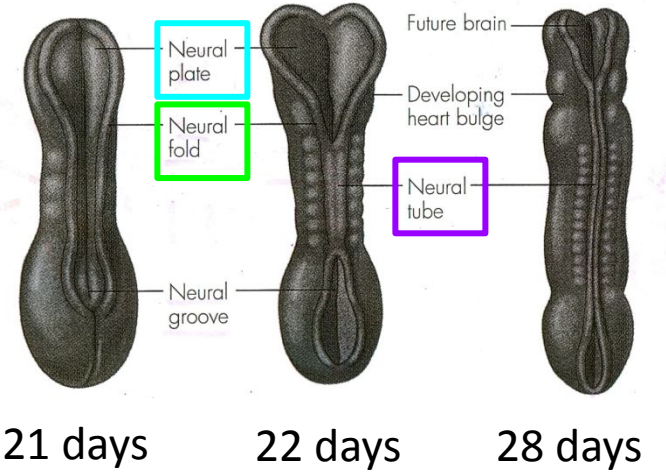
- Dorsal ectoderm thickens and hardens to form the **Neural Plate**
  - The edges of the plate forms ridges called **Neural Fo** curl up-towards each other along the longitudinal ax until they touch and fuse



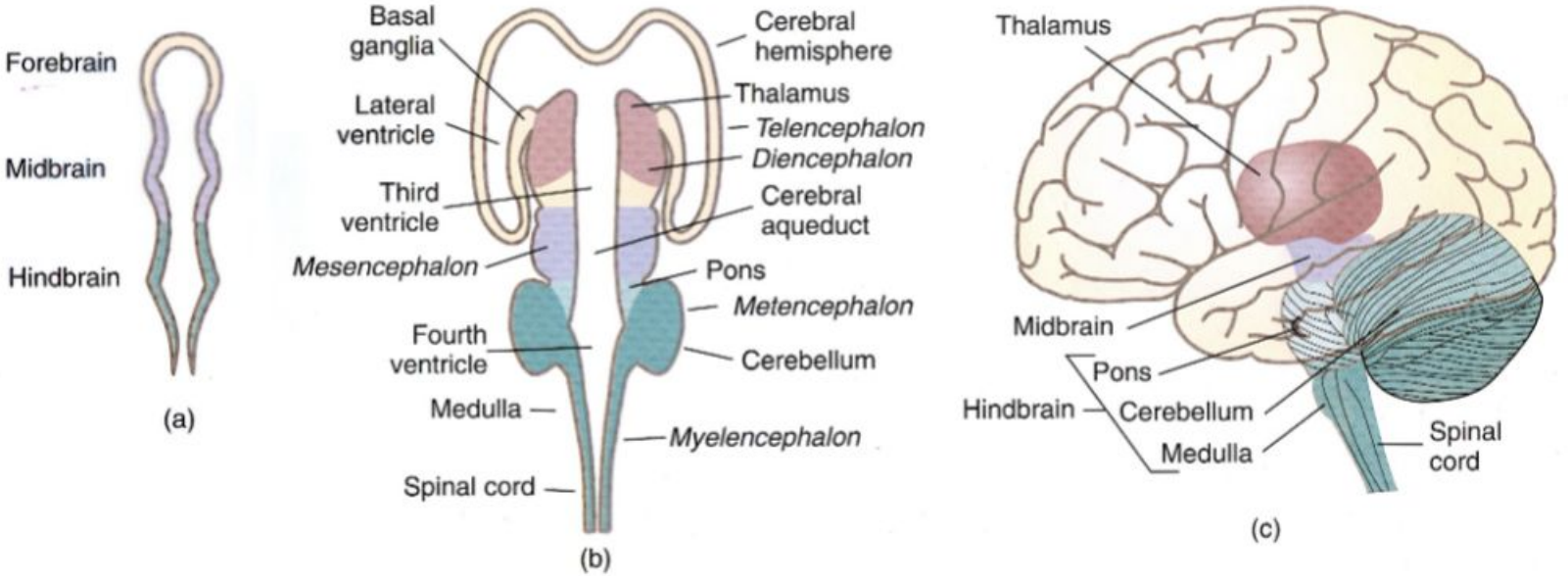
- By week 4, the curling-fusing process is completed to form the **Neural Tube**
  - Becomes CNS
  - anterior end > Brain
  - posterior end > Spinal Cord

- 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



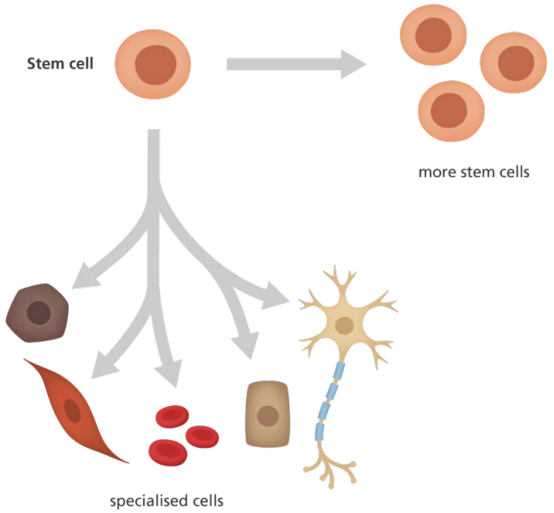
Embryonic Development

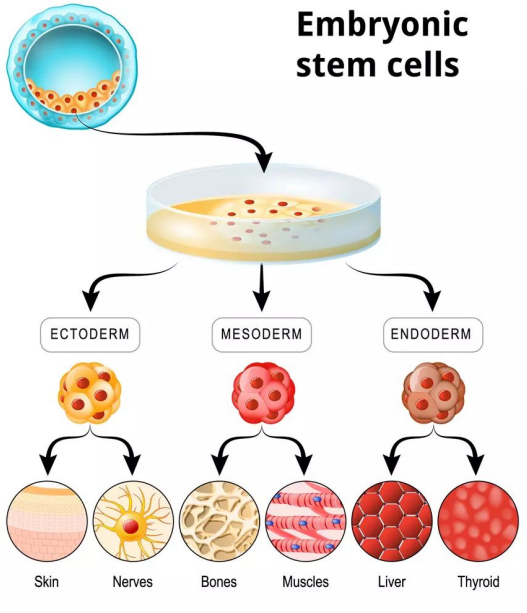


Proliferation of Cells

Stem Cells

- special cells that can turn into different types of cells
- In a developing embryo, they can develop into any type of cell





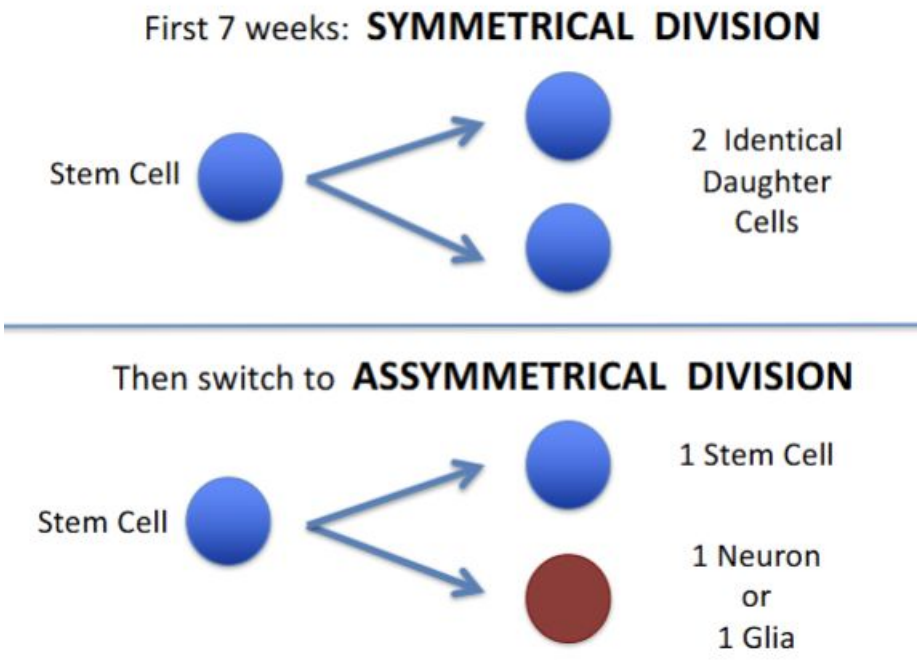
Proliferation of Cells

Ectoderm stem cells

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

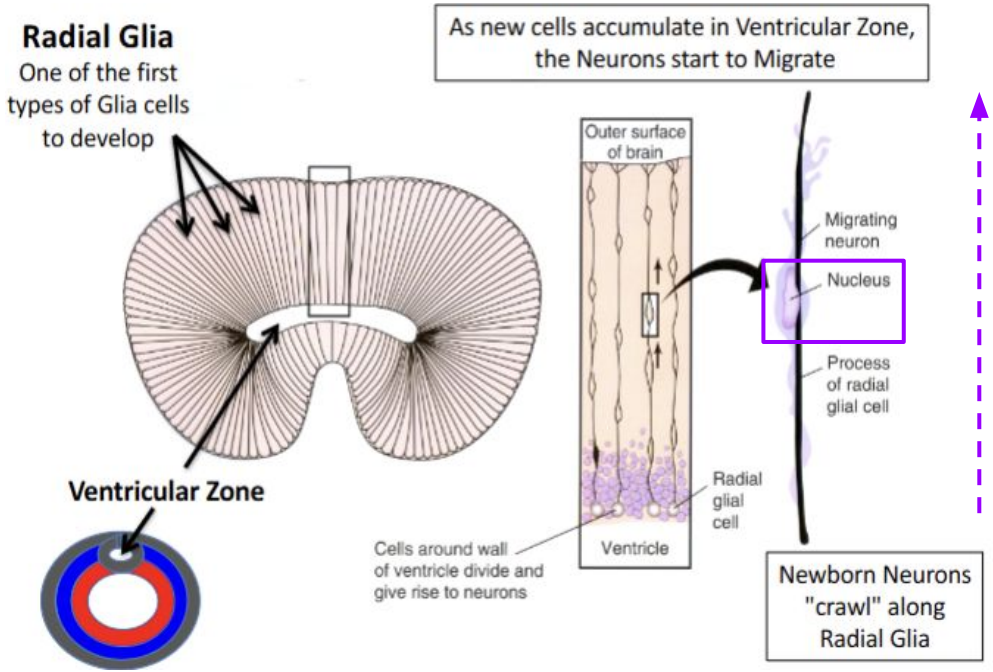
- **After week 7**: shifts to **Asymmetrical Division** (produces one stem cell, one neuron or glia) lasts for ~3 months to produce over 100 Billion Neurons in cortex

* Generally, Stem cells remain in place while Neurons **migrate** to their final destinations



Migration and Differentiation

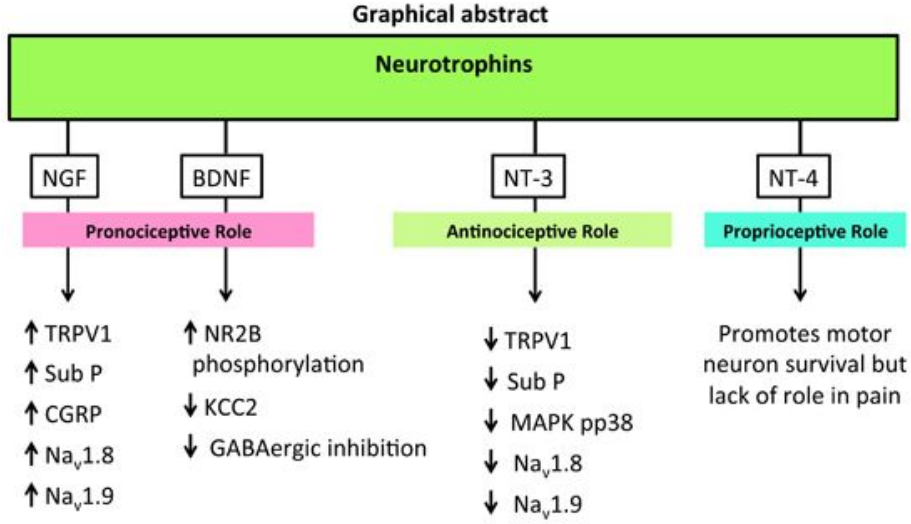
- some neurons migrate by “crawling” along **Radial Glia** that extends fibers outwards from the Ventricular Zone
- Other neurons may migrate by following chemical trails (= Neurotrophins) laid down by Glia cells or by other neurons
- **Differentiation:** Once in place, neurons differentiate into a wide variety of cell types
  - Autonomous (genetic) & Induction (local environmental) factors affect the cell’s ‘fate’



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



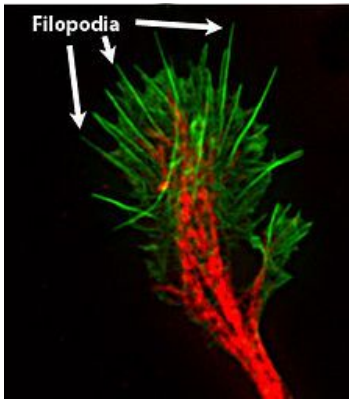
Synaptogenesis

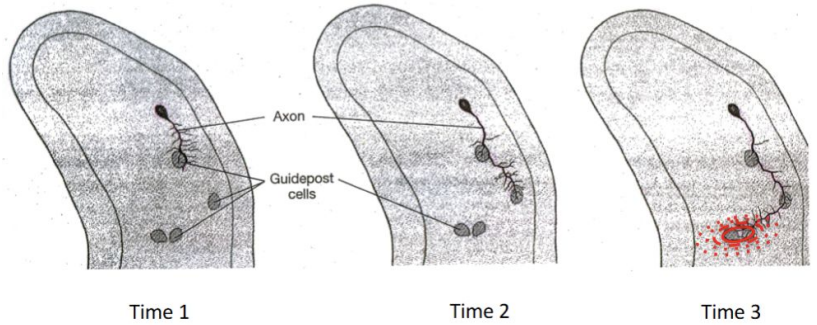
- Neurons grow Axons and Dendrites once they've settled down after migration and form the critical connections b/w neurons

- Axons must seek out appropriate target post-synaptic cells ("who do I communicate with?)

    1. Filopodia (= cilia) on the growth cone at the end of the axon can detect local chemical gradients

    2. "Guidepost cells" (type of Glia cell) attracts the growth cone, allowing stepwise guidance of axon

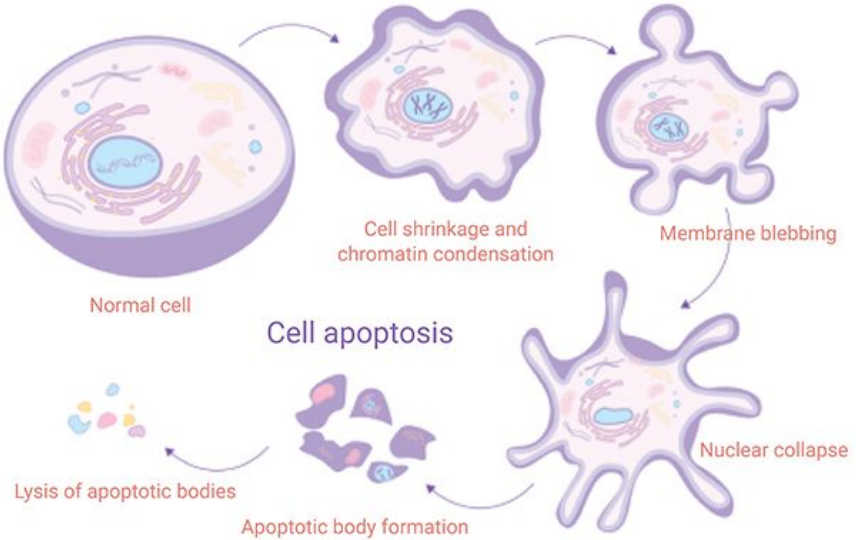




Apoptosis

Suicide Gene Programmed **cellular death**

- Activated when certain conditions are met (abnormal cellular growth or failed connections)
- During development, the NS **massively overproduces** cells (50% more than present at birth) and then “losers” in the race selectively die off (only the most fit, best-connected persist)



Patterns of Co-Activity

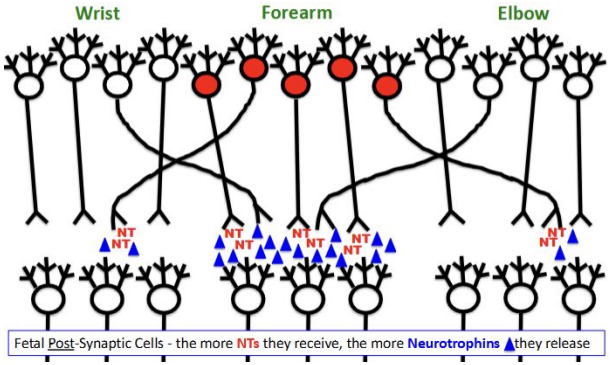
- *"Cells that Fire Together, Wire Together"*

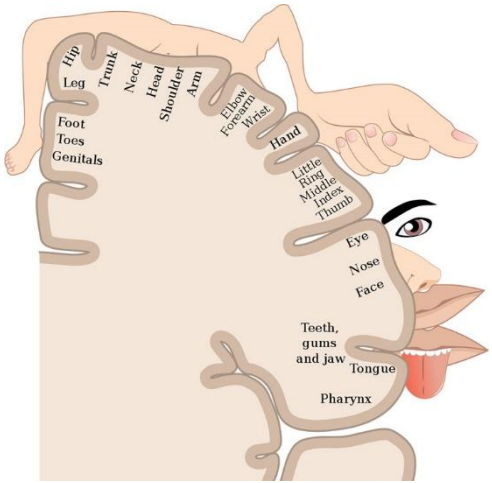
- NT release by developing presynaptic cell. In response, postsynaptic cell releases neurotrophins (chemical feedback) to promote the presynaptic cell survival

- 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

- This makes connections to adjacent targets, forming a topographic map (e.g., Penfield map) where spatial relationships are preserved



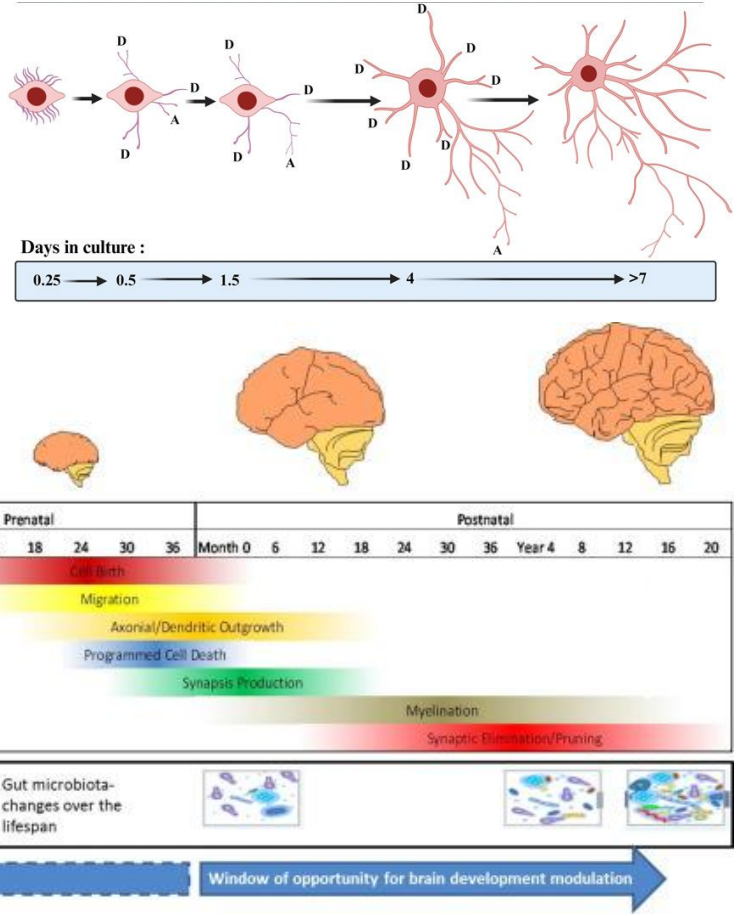


Further Development

- Brain growth continues after birth, mainly due to the increase in <u>cell size and branching</u> (dendritization, x new cells!)
  - 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



Effects of Experience

- Post-natal experience continues to shape Synaptogenesis, esp. in infancy

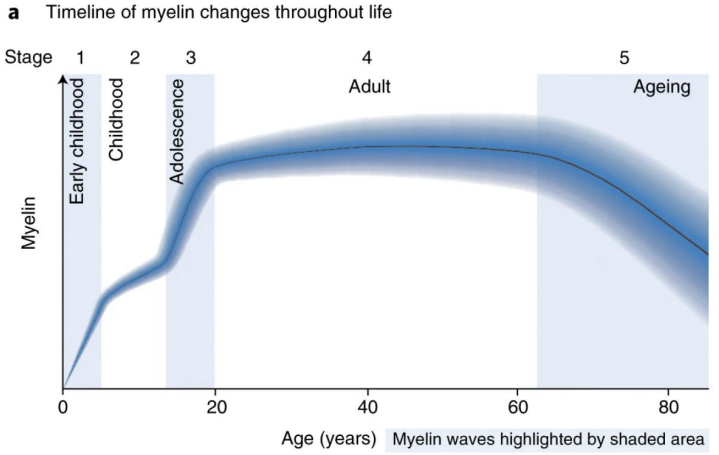
  e.g., Kittens, exposed to only vertical lines during their critical period, could NOT detect horizontal lines (cells normally responding to horizontals were out-competed)

BUT…

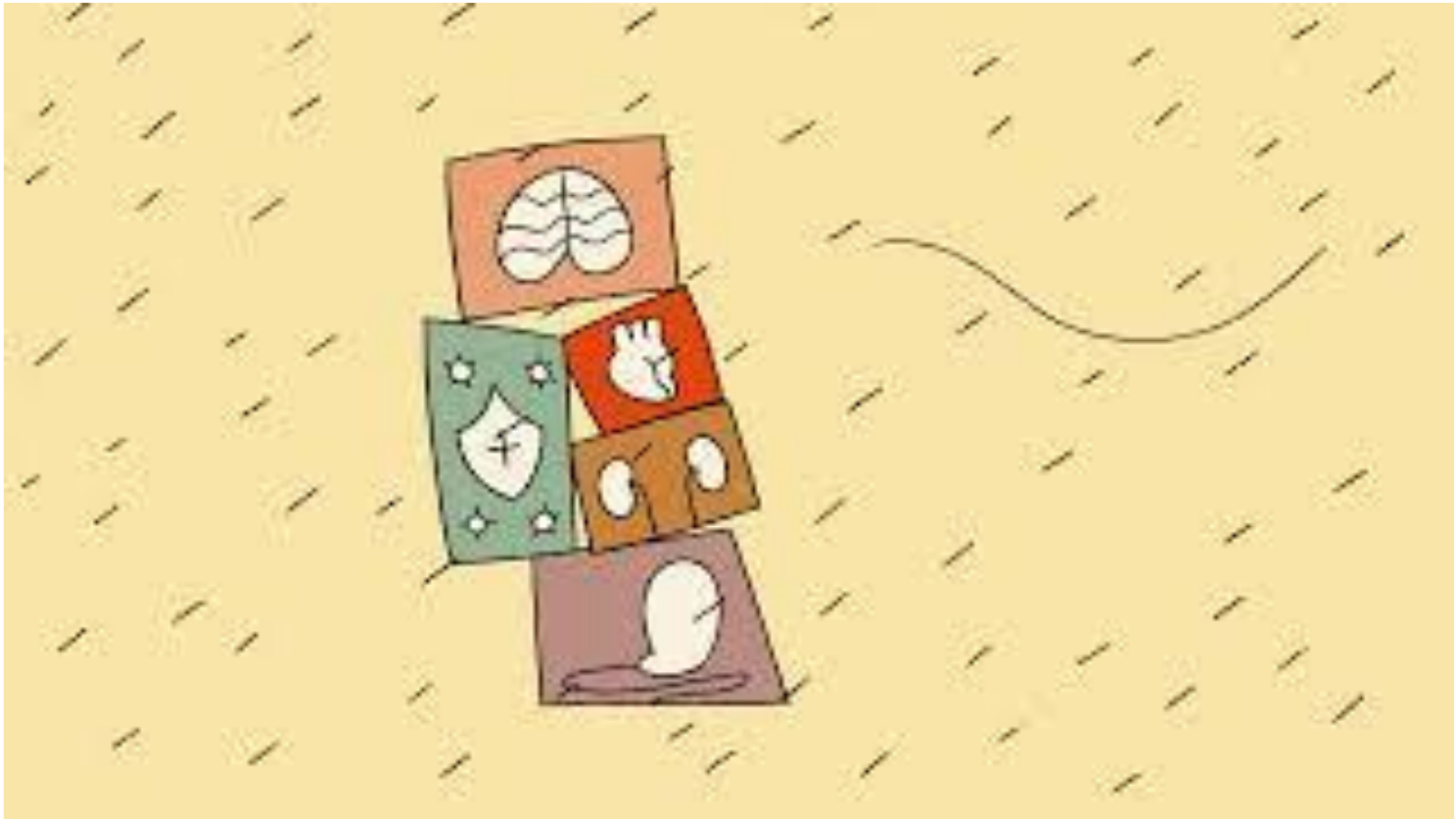
- Other areas of visual cortex continue to be modified throughout life

  e.g., Fusiform gyrus (inferior temporal area, end of "Ventral pathway"): circuitry changes every time you learn to recognize a new face

- Myelination continues through adulthood (~20 yo)



Effects of Experience



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

When you use 100% of your brain