BIOPSYCH REVISION

WEEK 1: INTRO TO UNIT/DEVELOPMENT OF THE NERVOUS SYSTEM

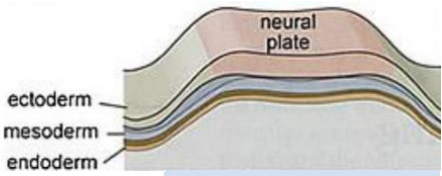
LEARNING OBJECTIVE 1: Describe pre and postnatal development of the brain

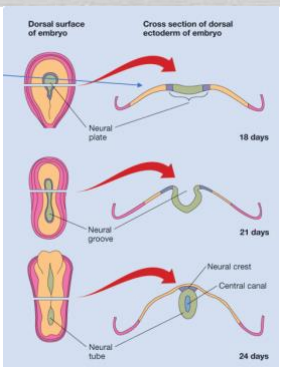
- Neuroplasticity is greatest during early development
    - Positive: child has brain injury then the brain can adjust
    - Negative: brain has a program of events in its development, if one goes astray, can put all following off schedule
- **NEURODEVELOPMENT**:
    - Follows a sequence of events influenced by: genetics, environmental, biochemical and physical events
    - **PRENATAL: FEATAL DEVELOPMENT**:
        - Zygote (first cell) → 2 daughter cells (X chromosomes)→ 4 cells → 8 cells etc. → eventually embryo
        - The cells must:
            - differentiate- become neurons, muscle cells etc.
            - form connections with other cells to establish functional capacity
        - cell specialization (first **stem cells** and then can identify into different cell types)
            - totipotent: cells that can change into any cell (neurons, blood cells etc.)
            - pluripotent: cells that can be turned into diff cells (used in stem cell research)
            - multipotent: capacity to self-renew (dividing)
            - unipotent: differentiate along one lineage
            - neurogenesis: when a stem cell becomes a neuron
    - **POSTNATAL**:
        - **Synaptogenesis**: connections form in brain
            - Continues throughout life
            - Varies across brain related to emergence of functions
            - Prefrontal cortex synaptogenesis steady, peaking at 24 months
        - **Myelination**: myelin sheet wraps around axon – helps transmission of information/impulse from the cell body to the axons
            - Increases speed of axonal conduction
            - Rate of myelination varies across brain- related to functional development
                - Sensory regions myelinate in first few months
                - Motor regions myelinate soon after
                - Myelination of higher-order association regions continues throughout adulthood
        - **Dendritic branching**: dendrites become more complex
            - Not just growing but also regressive events: apoptosis, dendritic pruning

- **PREFRONTAL CORTEX**: most prolonged period of development
    - Role: cognition and emotional function, working memory, planning ability, inhibition, following social rules etc.
    - Last region to develop
- **Fine tuning**: final stage of neurodevelopment
    - Dependent on environmental exposures – enhances efficiency of brain systems

LEARNING OBJECTIVE 2: Understand the development of the neural plate into the neural tube, and the term stem cell

- **PHASES OF NEURODEVELOPMENT (PRENATAL)**:

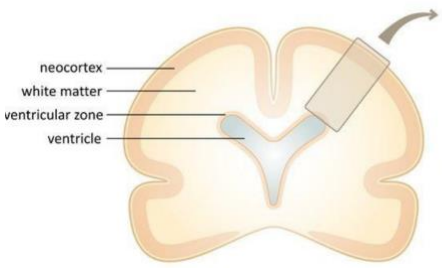


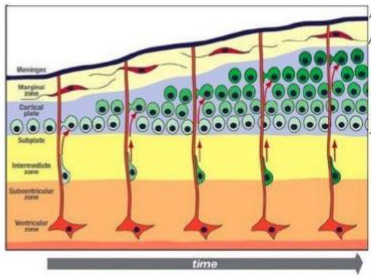


1. **INDUCTION OF THE NEURAL PLATE**:
    - Embryo has three layers: endoderm, mesoderm, **ectoderm**- becomes skin and nervous system
    - Neural plate begins to fold to form the neural groove
    - Neural groove fuses to form neural tube
    - Neural tube becomes the brain and spinal cord
    - Neural tube has different vesicles: prosencephalon (forebrain), mesencephalon (midbrain) and rhombencephalon (hindbrain) and continues to develop

LEARNING OBJECTIVE 3: Describe the process of neural proliferation, and identify the two organizer areas

2. **NEURAL PROLIFERATION**
    - Proliferation: rapid cell division/formation
    - Occurs rapidly after neural tube is formed in ventricular zone
    - Cells migrate away from ventricular one to form the cortex – travelling to their ultimate positon
    - Controlled by chemical signals





LEARNING OBJECTIVE 4: Describe the process of migration and aggregation

3. **Migration and Aggregation**
    - **Migration**: process by which cells travel to their target destination
    - Migrating cells are immature (yet to specialize)
    - Process governed by time and location
        - Proliferation in different regions of the neural tube occur at different times
    - **Two types of migration**:
        - Radial: ventricular zone outward to outer wall

- Tangential: parallel to outer wall
- Combination: to get right destination both radial and tangential migration are required

- **Methods of migration**:
  - Somal translocation: cells grow an extension (like a little arm) that explores the environment for attractive and repulsive cues
  - Glia mediated migration: during proliferation, radial glial cells emerge at the walls of the neural tube. Radial glial cells extend from the ventricular zone to the outer wall and then neurons travel along this matrix (ladder) to go to their destination. Radial glial cells are pluripotent and following migration some develop into neurons
- For both migration methods, there are guidance molecules that have chemicals to attract or repel them
- Migration occurs in an orderly pattern:
  - progressing from deeper layers to more superficial layers (layer 6, then 5, then 4 etc.)
  - each wave of cells need to pass through lower layers of cortex before reaching the destination
  - inside-out migration
- **Aggregation**: once migrated, neurons align themselves with other neurons to form CNS structures
  - Through cell-adhesion molecules: ability to recognise molecules on other cells and adhere to them
- If something goes wrong in this stage of the brain, there will be disastrous effects- many disorders

LEARNING OBJECTIVE 5: Describe the process of axon growth and synapse formation

4. Axon growth and synapse formation

- **Axon growth**:
  - Axons (the long nerve fibre of a neuron) searches for other cells and dendrites (branch extension from a neuron) connects with other neurons
  - Growth cones on the tips of axons/dendrite: extend and retract helping figure out where it wants to connect with
    - Pioneer growth cones: identifies correct route by interacting with guidance molecules along the way
    - Subsequent axons follow same route: fasciculation
- Axon development theories:
  - **Chemoaffinity hypothesis:**
    - postsynaptic surface (dendritic arms) release specific chemical label which attracts selective growing axons to target

        - used during development and regeneration
        - if this theory was correct the axon should grow directly to the dendrite BUT axons do not always go directly to the target- often circuitous route is taken
    - **Chemoaffinity hypothesis revised:**
        - Growing axon NOT attracted to target by a single chemical released at the target site
        - Axonal growth cones are influenced (positively and negatively) by series of signals along the route
- **Synapse formation**:
    - **Synaptogenesis**: formation of a synapse (nerve impulse passed from one neuron to the other)
    - Exchange of chemical signals between presynaptic and postsynaptic neurons
    - Requires coordinated activity between 2 neurons
    - Astrocytes important for survival of synapses: nutritional role
    - Developing neurons are promiscuous (form connections with lots of different cells): synapses will be eliminated if not active or functionally important

LEARNING OBJECTIVE 6: Describe the processes of neuron death and synapse rearrangement

5. **Neuron death and synapse rearrangement**
    - **Apoptosis**:
        - Normal and important: removes excess neurons (50% more than required)- microglia attracted to site and removes waste- prevents inflammation as a result of cell content spilling into extracellular fluid
    - **Synapse rearrangement**:
        - Space created when neurons suicide – filled by sprouting axon terminals
        - Unproductive synapses are removed, resulting in neurons connecting with a smaller number of targets

LEARNING OBJECTIVE 7: Explain the different effects of deprivation vs. enrichment on neurodevelopment

- Neurodevelopment: dependent on environmental experiences
- **Critical period of development**: periods in which the brain systems are dependent on environmental stimuli
    - E.g. binocular vision: eye patch between 3-6 months – eye will lose its connections to the visual cortex
- **Sensitive period of development**: time period in which environmental exposures have greater influence on brain systems than other time periods
    - e.g. language prior to 7 years

- **Deprivation:**
    - E.g. human infants with cataracts develop severe vision deficits, but vision is normal if removed 1-9 months
- **Enrichment**:
    - E.g. rats raised in group enclosures have thicker cortex, more dendritic spines and synapses than those raised in isolation
- **Competitive nature of experience**:
    - Depriving one eye of input during a sensitive period of development, has lifelong effects on function of that eye: ability of the eye to activate visual cortex is reduced, while ability of the other eye is increased
        - Synapses of the other eye will takeover the place in the brain where synapses of the covered eye would've been

LEARNING OBJECTIVE 8: Understand autism spectrum disorder and Williams syndrome and attempts to identify their neural mechanisms

- **AUTISM SPECTRUM DISORDER**:
    - Symptoms: reduced capacity for social interaction and communication, restricted repetitive behaviours
    - Likely triggered by several genes interacting with environment
    - Intellectual and educational disability
    - Heterogeneous disorder (many genes producing disorder)
    - Brain imaging studies show disparities in frontal cortex, cerebellum and amygdala
    - Savants: show remarkable abilities
        - 10-30% have savant ability
        - atypical development of certain parts of the brain
- **WILLIAMS SYNDROME**:
    - Genetic condition that alters neurodevelopment
    - 1 in 7500
    - sociable, empathetic, talkative
    - symptoms: low IQ, severe attentional problems, poor spatial abilities, distinctive facial features, short, cardiac problems
    - strengths: language, music, face recognition
    - brain imaging studies: thinning of cortex, orbitofrontal and parietal/occipital boundary, increased cortical thickness in superior temporal gyrus