COGS 17 section A02

neural development

section resources repo
week 3 guiding questions
inside folder

reminders

- midterm exam 1 is **tomorrow** (4/21) during class time 3:30 PM - 4:50 PM
  - open book, online, one shot
  - covers material from week 1 - 3
- homework 3 is due **tonight** 11:59 PM!

exam game plan

before the exam

- do the practice homework
    - make sure you don’t just memorize the answers and actually understand the concepts
- study all resources provided in the canvas modules
- read the textbook if you have extra time
    - not required just if you would like more detailed concepts
    - i have a pdf of it if you need lmk

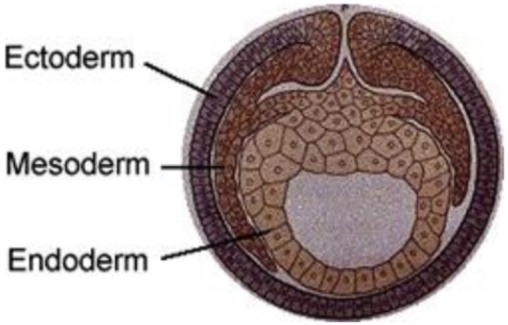
D-0

- please do not pull an all nighter
- pace yourself!
- double check your answers
    - but try to get it right the first time bc you might not have time to revisit them
- have your study notes ready with you

embryonic development

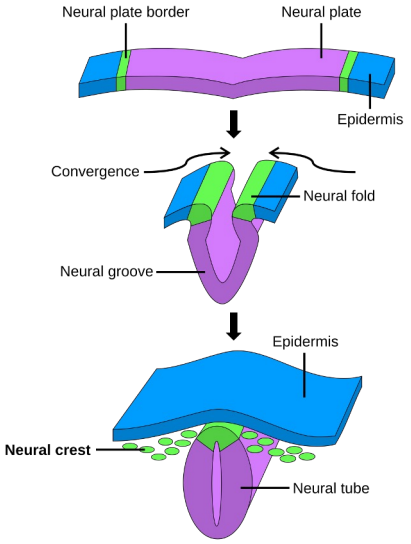
3 layers of cells

- **ecto(outer)derm** → nervous system and skin
- **meso(middle)derm** → bones, muscles, blood vessels
- **endo(inner)derm** → organs, glands



first 2 weeks

- embryo sphere elongates into a “worm”
    - still 3 layers of cells



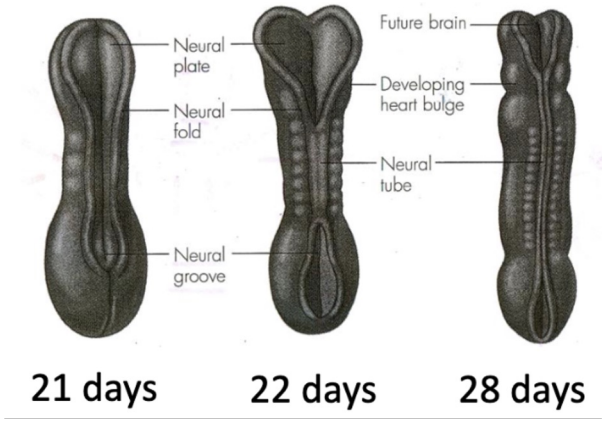
neural plate formation

- dorsal ectoderm thickens into neural plate
- edges form neural folds (ridges) that curl up toward each other and fuse
- failed fusion: spina bifida

embryonic development

week 4: curling and fusing of neural folds complete → neural tube

- becomes central nervous system (CNS)
  - rostral (anterior) end → brain
  - caudal (posterior) end → spinal cord
- surface ridges of neural tube (neural crest) becomes peripheral nervous system
  - hollow center becomes ventricles & central canal

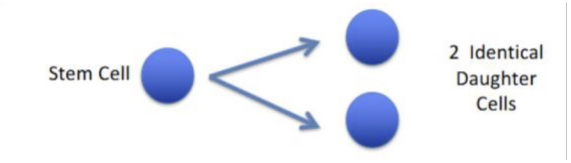


proliferation (growth of new cells)

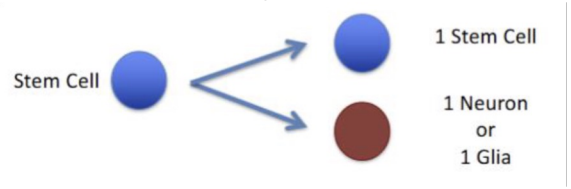
specifically neurons and glia in this context

stem cells: ectodermal cells lining neural tube (ventricular zone)

- early: symmetrical division (increasing size)



- ~week 7: asymmetrical division (produce ~100B neurons in 3 months)



*each brain region proliferates differently depending on their specialized functions!

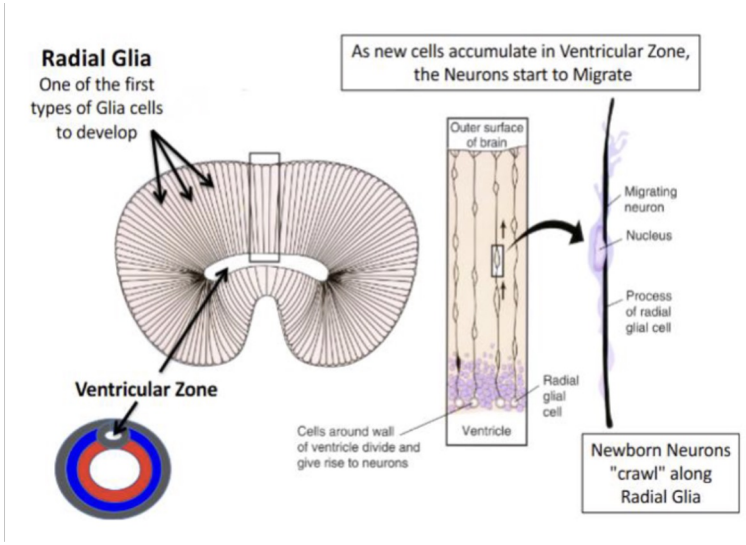
migration and differentiation of cells

some stem cells become radial glia

- extend fibers outwards from ventricular zone, lengthen as cortex expands
- neurons “crawl” on them, aided by glycoproteins
    - some chemical trails (= neurotrophins) secreted by glia or other neurons

differentiation

- neurons develop specific structures and functions
- driven by
    - cell autonomous factors (genetic factors)
    - induction (local chemical signals / environmental conditions)



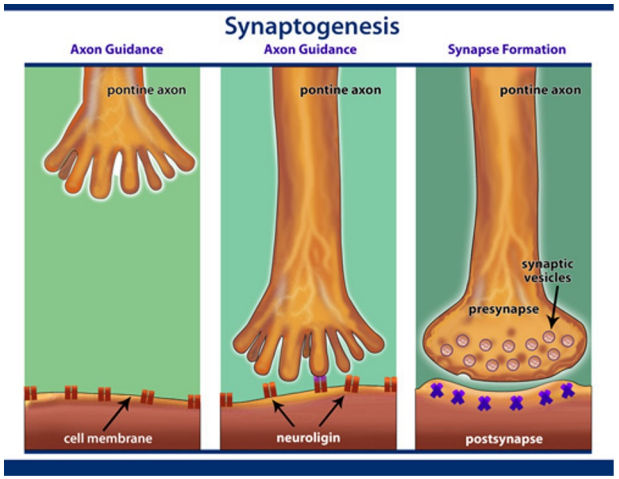
synaptogenesis

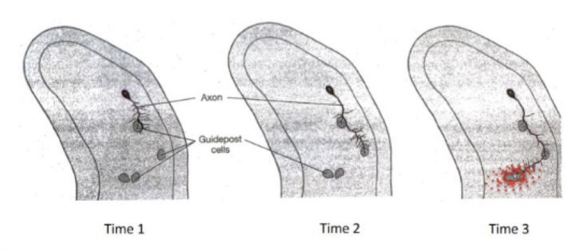
= formation of synapses (cell-to-cell junctions)

- post-migration: neurons settle down; grow axons (outgoing) and dendrites (incoming)
- axons must seek appropriate postsynaptic targets
    - growth cone at axon tip uses filopodia (finger-like extensions) to detect local chemical gradients
    - guided by:
        - guidepost cells (glia): adhere to and direct growing axon to target cell
        - chemical trails (neurotrophins) produced by glia or other migrating neurons/axons

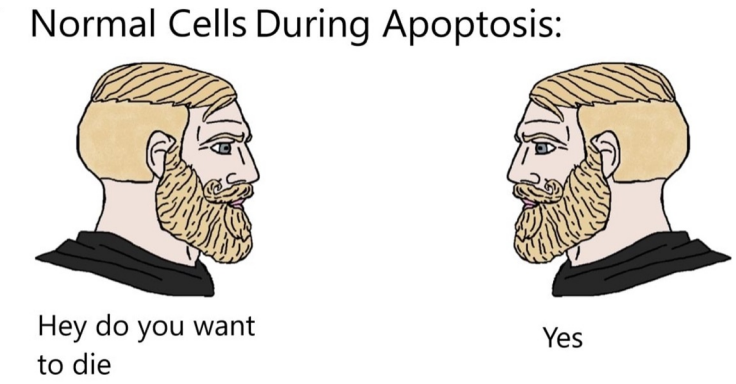
neurotrophins

- attract, repel, and promote neuronal survival & activity
- NGF (Nerve Growth Factor): from muscles/organs ➔ attracts sympathetic NS axons & supports survival
- BDNF (Brain-Derived Neurotrophic Factor): promotes CNS axon survival & branching





apoptosis

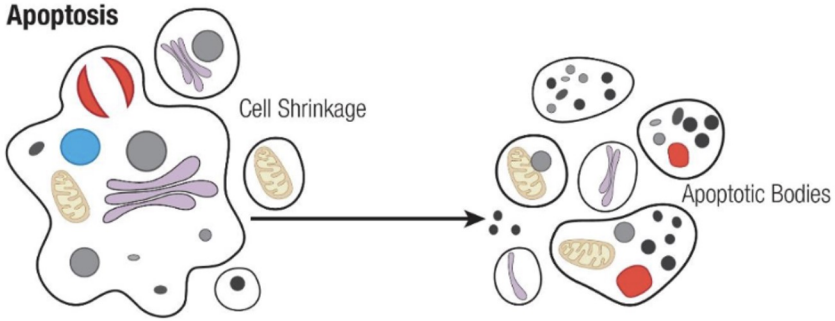


neurons have built-in suicide genes for programmed cell death

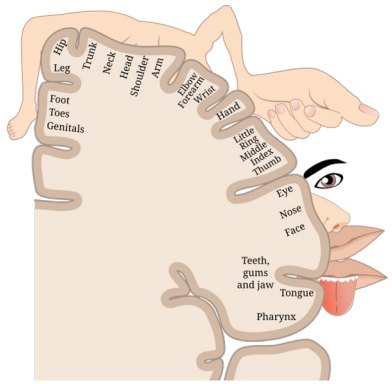
- activation depends on brain chemistry & activity patterns
    - eg. abnormal cell growth, failed connections

massive overproduction of neurons during fetal development (~50% more!)

- axons initially branch widely and connect to multiple sites
    - only few sites are strengthened and maintained over time
- neurons compete for connections and neurotrophic factors
    - “losers” (late arrivals, weak connections) undergo apoptosis

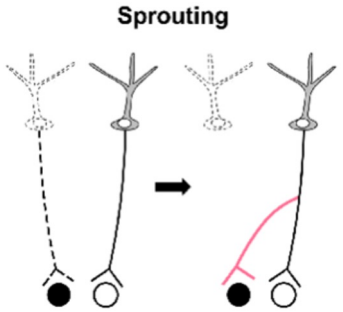


patterns of co activity



CELLS THAT FIRE TOGETHER, WIRE TOGETHER!

- coactivity strengthens connections; inactivity dies off connections
  - presynaptic activity triggers postsynaptic neurotrophin release → supports presynaptic cell survival
- neurotrophin release most effective on active presynaptic cells
  - higher correlation of pre/post activity in a pathway (stronger feedback)→stronger pathway
  - cells w/ less correlated activity are targeted for apoptosis
- collateral sprouting: surviving active cells ("winners") take over losers' synapses
- adjacent neurons co-activate and form topographic maps
  - spatial relationships along receptor surface preserved in brain



further development

brain growth continues post-birth

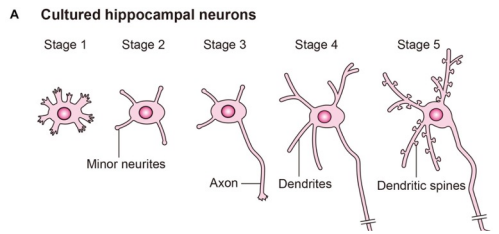
neurons increase in **cell size** and **dendridization** (branching), not in number

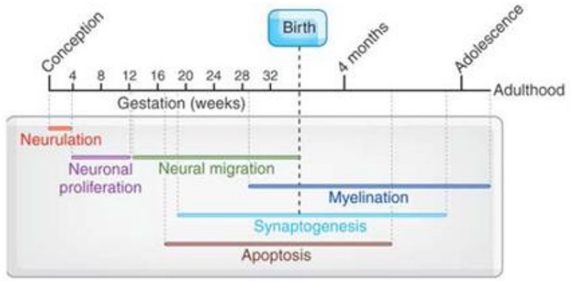
- new neurons are rare

dendritic development

- topographic maps formed during fetal development are continuously shaped by experience after birth
- neuroplasticity: learning / enriched environments → more dendritic spines and connections
- early sensory experiences shape circuits
    - eg. kittens exposed to only vertical lines can't perceive horizontal stimuli as cats
    - eg. violin players trained from childhood show expanded somatosensory map (parietal) in left hand fingers

glial development and differentiation continues (eg. myelination cont. through early adulthood)





k a h o o t

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go study 👊 good luck on your midterm

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