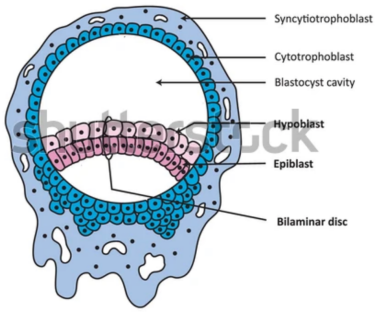
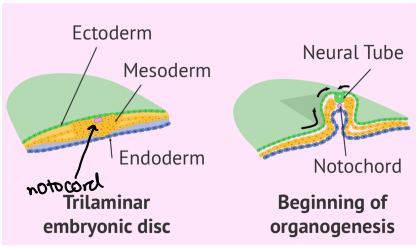
Neuroembryology

1. Fertilization – after fertilization cells rapidly divide. Cyst forms so all cells have access to nutrients. the morula forms shortly after
2. 5-6 days after fertilization: blastocyst implants into wall of uterine lining
    - Blastocyst contains two layers of undifferentiated cells
        - inner cell mass ⟶ becomes embryo
        - outer cell mass ⟶ becomes cells that nourish the embryo
3. Weeks 1-2: inner cell mass forms bilaminar disk
    - epiblast → outer layer
    - hypoblast → inner layer
    - basement membrane separates epi/hypoblast
    - the bilaminar disk contains embryonic stem cells that are pluripotent and could give rise to ecto, meso, or endoderm



4. 2 weeks post fertilization: bilaminar disc becomes trilaminar disc. Cells are no longer pluripotent at this stage
    - ectoderm - becomes skin, brain, and some glands (epithelial and neural stem cells)
    - mesoderm - becomes everything else (muscles, bones, blood vessels, connective tissues, etc.)

- endoderm - forms hollow structures such as gut, lining of vessels (viscera)



5. Weeks 2-3: Neurulation - neural plate forms folds and crests → derived from mesoderm
   - notocord stimulates neurulation in the ectoderm by causing cell differentiation + division
   - neural groove and crest form due to differing rates of cell division
   - neural tube forms from neural ectoderm by fusing neural fold, while epithelial ectoderm forms above the neural tube

6. Weeks 3-4
   - neural tube first closes in the middle, and neuropore remains open until end of week 4
   - the neural tube separates from neural crest once both sides of neural plate fuse
     - neural tube forms CNS
     - neural crest forms PNS
   - nervous system sinks into mesoderm, nervous system surrounded by muscles, bones, etc.
   - neural tube forms two regions
     1. alar plate: sensory structures
     2. basal plate: motor structures

7. Week 4: anterior and posterior neuropores close
   - mesoderm forms somites which has dermatomes, myotomes, and sclerotomes (form bones)
   - motor function → neurons in basal plate form axons that travel to myotomes
   - sensory function → neurons in neural crest form two projections
     1. to dermatome (periphery) that will eventually detect pressure + temperature
     2. connects to alar plate neurons to form synaptic connections

Vesicle formation

Primary vesicles	Secondary Vesicles	Adult Structures
prosencephalon	telencephalon	cerebral hemispheres, lateral ventricles, cortex, basal ganglia
	diencephalon	thalamus, hypothalamus, retina, 3rd ventricle
mesenchephalon	mesencephalon	midbrain, cerebral aqueduct, colliculi, substantia nigra
rhombencephalon	myelencephalon	pons + cerebellum
	metencephalon	medulla

flexures: occur due to differential rates of cell division

- cephalic flexure - between mesencephalon and rhombencephalon

- Pontine flexure - between metencephalon (pons + cerebellum) and myelencephalon (medulla)
- cervical flexure - between rhombencephalon and spinal cord

Internal Brainstem Anatomy

Distinguishing between levels of the brainstem

1. Closed (caudal) Medulla - Pyramidal decussation level
   - pyramidal fibers crossing, resulting in lopsided ventral median sulcus
2. Closed (caudal) Medulla - Sensory decussation level
   - central canal still present
   - dorsal motor nucleus of vagus present
3. Caudal Open Medulla - middle medulla
   - presence of 4th ventricle
   - distinct olivary nucleus
   - bigger hypoglossal nucleus
   - presence of nucleus ambiguous
4. Rostral open Medulla - rostral medulla
   - cochlear nuclei present on lateral sides
   - presence of inferior cerebellar peduncles
5. Caudal Pons
   - bulbous structure on ventral side
   - presence of abducens nucleus
6. Middle Pons
   - presence of superior cerebellar peduncles
   - trigeminal motor nucleus and principle trigeminal sensory nucleus
7. Rostral Pons
8. Midbrain
   - hole in ventral side → interpeduncular fossa
   - presence of oculomotor nucleus
   - superior colliculus

Functional Components of Spinal + Cranial Nerves

Somatic Motor (GSE)

- project to skeletal muscles from somites
- LMN in the spinal cord + brainstem

Nuclei:

- hypoglossal nucleus (CN12) → in medulla
- abducens nucleus (CN6) → in pons
- trochlear nucleus (CN4) → in midbrain
- oculomotor nucleus (CN3) → in midbrain

Cranial Nerves: 3, 4, 6, 12

Brachial Motor

- LMNs in brainstem
- project to skeletal muscles not from somites, but from brachial arches in embryos neck
- swallowing, mastication, speaking, facial expressions
- Nuclei
  - spinal accessory nucleus (CN11) → Medulla
  - nucleus ambiguous (CN9, 10) → Medulla
  - Facial nucleus (CN7) → pons
  - Trigeminal motor nucleus (CN5) → pons
- Cranial Nerves: CN 5, 7, 9, and 10 (maybe 11)

Visceral Motor (GVE)

- project to visceral motor ganglia
  - Sympathetic visceral MNs in spinal cord → lumbosacral level
  - parasympathetic visceral MNs in spinal cord → sacral level
  - Parasympathetic visceral MNs in brainstem
- controls smooth muscle, cardiac muscle and glands
- Nuclei
  - nucleus ambiguous (CN10) → medulla
  - dorsal motor nucleus of vagus (CN10) → medulla
  - Salivitory nucleus inferior (9) superior (10) → pons
  - edinger-westphal nucleus (CN3)
- Cranial Nerves: 3, 7, 9, 10

General Sensory (GSA)

- sensory neurons in spinal cord (dorsal horn) and brainstem
- sensation from cutaneous (skin) and musculotendinous (muscles and tendons) receptors

Special Sensory (SSA)

- vision + hearing

Nuclei:

- vestibular nuclei (CN8) → pons + medulla
- cochlear nuclei (CN8) → pons + medulla

- Cranial Nerves: 2, 8

Visceral Sensory (GVA + SVA)

- sensation from receptors in organs (CN 9, 10)
- sensation from receptors in tongue and nose (CN 1, 7, 9, 10)

Nuclei: nucleus of the solitary tract