Nervous System Development
See pages 4-7

Inner Cell Mass of Blastocyst

- Inner cell mass ("embryonic stem cells")
- Blastocyst cavity
- Trophoblast cells Develop into placenta

Inner cells form 3 layers

- Initially ectoderm forms a flat plate of cells, the "neural plate"

Neural Plate Develops Groove

Neural Tube Progression in Embryos Through the 4th Week

Neural Folds Grow Closer

Neural Tube Progression in Embryos Through the 4th Week
And Closer

Neural Tube Progression in Embryos Through the 4th Week

C

Surface ectoderm
Neural crest
Neural groove

Neural Tube & Neural Crests

Neural Tube Progression in Embryos Through the 4th Week

D

Neural tube
Neural crest

Tube Closed by 4th Week

Neural Tube Progression in Embryos Through the 4th Week

E

Developing epidermis
Developing spinal genglion

Formation of the Neural Tube, seen from above

Anterior Neuropore

Posterior Neuropore

Book Fig. 1.6

Seen in cross-section

- http://learningobjects.wesleyan.edu/neurulation/animation.php

Book Fig. 1.7

Tube Closed by 4th Week
One developmental step stimulates or induces the next.

Vesicles Form at Head End

Neural Tube Bends or Flexes as it Develops

Inside the Tube: Soon Can Distinguish Alar & Basal Plates
Also 3 distinct layers

Also 3 distinct layers

Migration of Neurons From Ependyma Outward

Each step must occur properly for normal development

- Formation of the neural tube
- Cell proliferation
- Cell migration & differentiation
- Growing of neural connections
- Apoptosis or selective cell death or “pruning” of unsuccessful connections
- Myelination of axons and continued formation of synapses

Neural Crest Cells Become:

- Sensory ganglia & incoming sensory nerves
- Autonomic ganglia & nerves to organs
- Parts of endocrine system related to NS (e.g. adrenal medulla)
- Parts of eye and ear; some smooth muscles
- Peripheral glial cells; pigmented cells

Neural Tube Defects (NTD)

- Closure of the neural tube normal induces the normal development of spinal column, skull & overlying skin. If closure does not occur normally, nervous system may remain exposed (“open NTD”).
- In other cases the neural tube may not be exposed to the surface (“closed NTD”), but the spinal vertebrae and skin surrounding the spine may not be completely normal.
Open NTD

Causes

- Has been linked to maternal diet (insufficient folic acid (one of the B vitamins), zinc)
- E-W Geography, anti-seizure meds or alcohol use, fever and illness during pregnancy, age of mom, diabetes, and ethnicity & genetics also play a role.

Improper Closing of the Anterior Neuropore (~ 25 days)

- Anencephaly – forebrain & its coverings fail to develop. Baby has a flattened, open skull. With only hindbrain & midbrain structures intact, survival is brief
- (hours-days).

- [http://www.youtube.com/watch?v=vlCGRbQELNs](http://www.youtube.com/watch?v=vlCGRbQELNs)

Anterior Neuropore Fails to Close Properly

- Sometimes the forebrain develops but the skull does not fuse completely.
- As a result meninges and/or part of the brain (often the occipital region) may bulge out of the opening. This is an encephalocele.

Much More Common: Improper Closing of Posterior Neuropore (~27 days)

- Spina bifida (“open spine”)
- May be so minor you don’t know you have it (“spina bifida occulta”), or may be so severe it causes death or disability
Types of Spina Bifida

As spinal column lengthens but the cord is "stuck" by the protrusion, cord tugs lower brain through foramen magnum, often blocking CSF exit holes in roof of 4th ventricle. This leads to hydrocephalus on top of the original spina bifida.

"Tethered Cord"

Another Variation: Chiari Malformation – rear part of developing skull is too small

Arnold-Chiari malformation

- when the cord is tethered by spinal bifida it can be pulled down through the foramen magnum as the vertebrae lengthen.
Prenatal Diagnosis

- Open NTDs are associated with elevated levels of alpha-fetoprotein in mother’s blood and amnionic fluid (~16-18 weeks)
- Some NTDs are visible on ultrasound
- Some experimental surgeries to repair spinal abnormalities in utero

Healthy Sonogram

Signs of Anencephaly

Signs of Spina Bifida

Cerebral Palsy (~6/1000 live births; 500,000 in US) aka Static Encephalopathy
- Not a single disease or disorder but a category of nonprogressive motor impairments that result from faulty brain development or early brain damage.
- Specific motor symptoms vary, as does severity and presence of other disabilities.
- Once thought to be due to difficult labors/birth injuries but majority of cases due to genetic, developmental malformations, intrauterine factors like infection during pregnancy or premature birth.

Categories of Motor Problems

- 50% Spastic CP – limbs resist movement
  - Spastic hemiplegia (arm & leg) usually due to dev. malformation or early stroke; IQ ok; seizure risk
  - Spastic diplegia (legs) usually related to prematurity; IQ ok
  - Spastic quadriplegia – usually due to severe diffuse damage; severe seizures, retardation
- Physical therapy & medications to deal with spasticity
25% Athetoid CP – involuntary movements; slurring, grimacing – usually due to hypoxia, basal ganglia lesions

http://www.youtube.com/watch?v=lFMLL6A7K0U&feature=related

10% Ataxic CP – uncoordinated, wide based gait, can’t walk straight line, falls
http://www.youtube.com/watch?v=p5VDny7M&feature=related

Fetal Alcohol Syndrome
• Most common variety of drug-related faulty development, causing underdevelopment, distinctive physical features as well as nervous system abnormalities.

Normal vs FAS
Newborn Brain

Also internal abnormalities, like no or misformed corpus callosum, larger ventricles, disorganized neurons