Embryology 2: Notochord and Neural Tube

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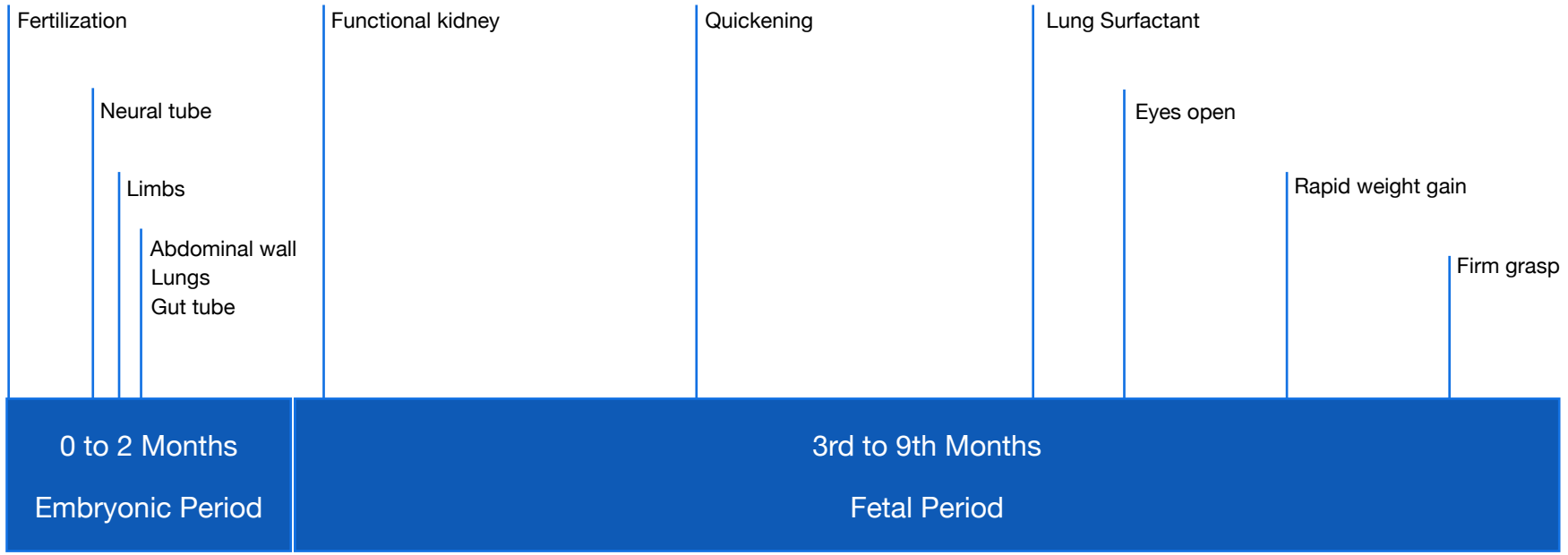
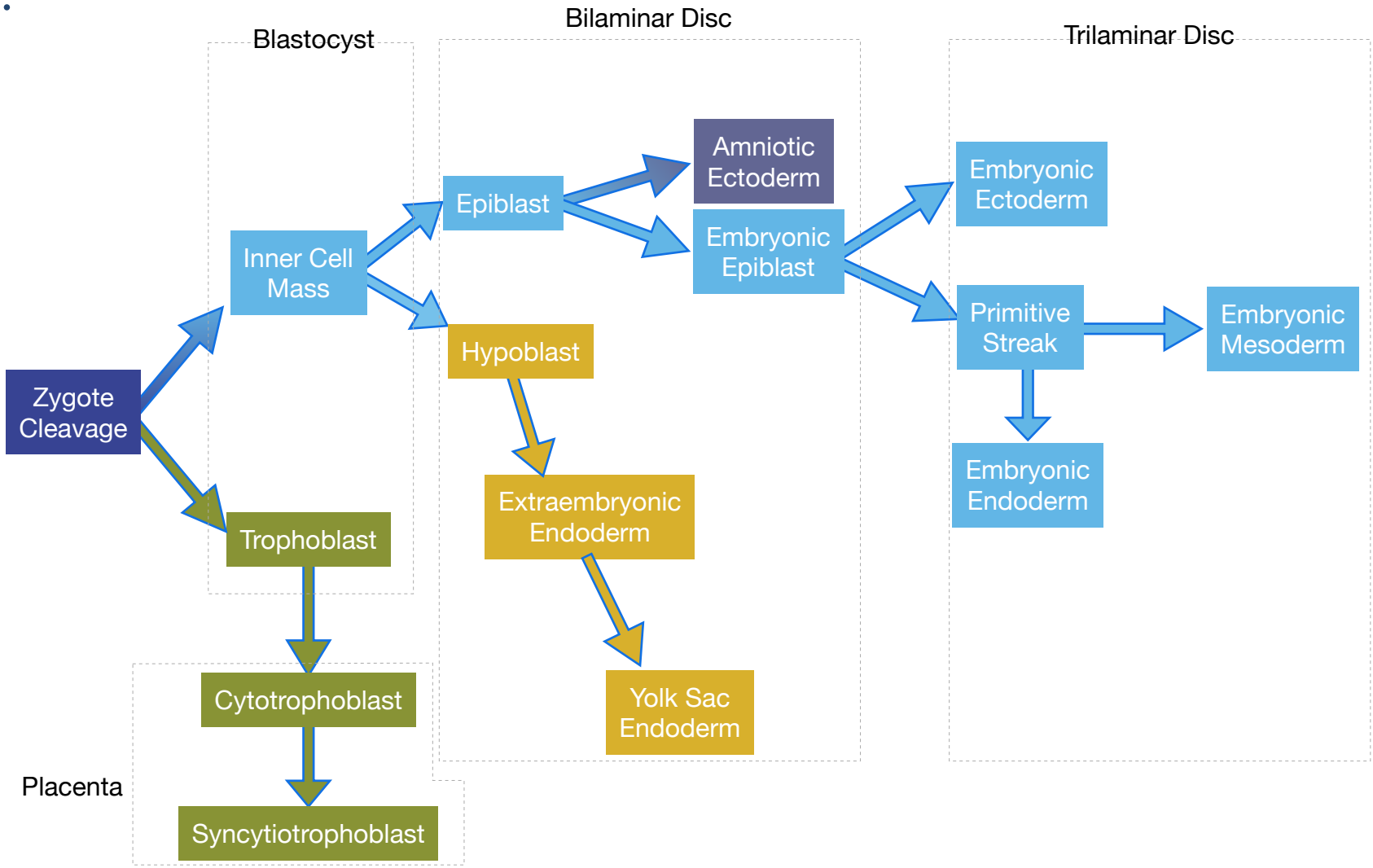
What we'll talk about

- Recap of first lecture and timeline of events
- Convergent extension
- Notochord
- Neural Tube Formation and Closure

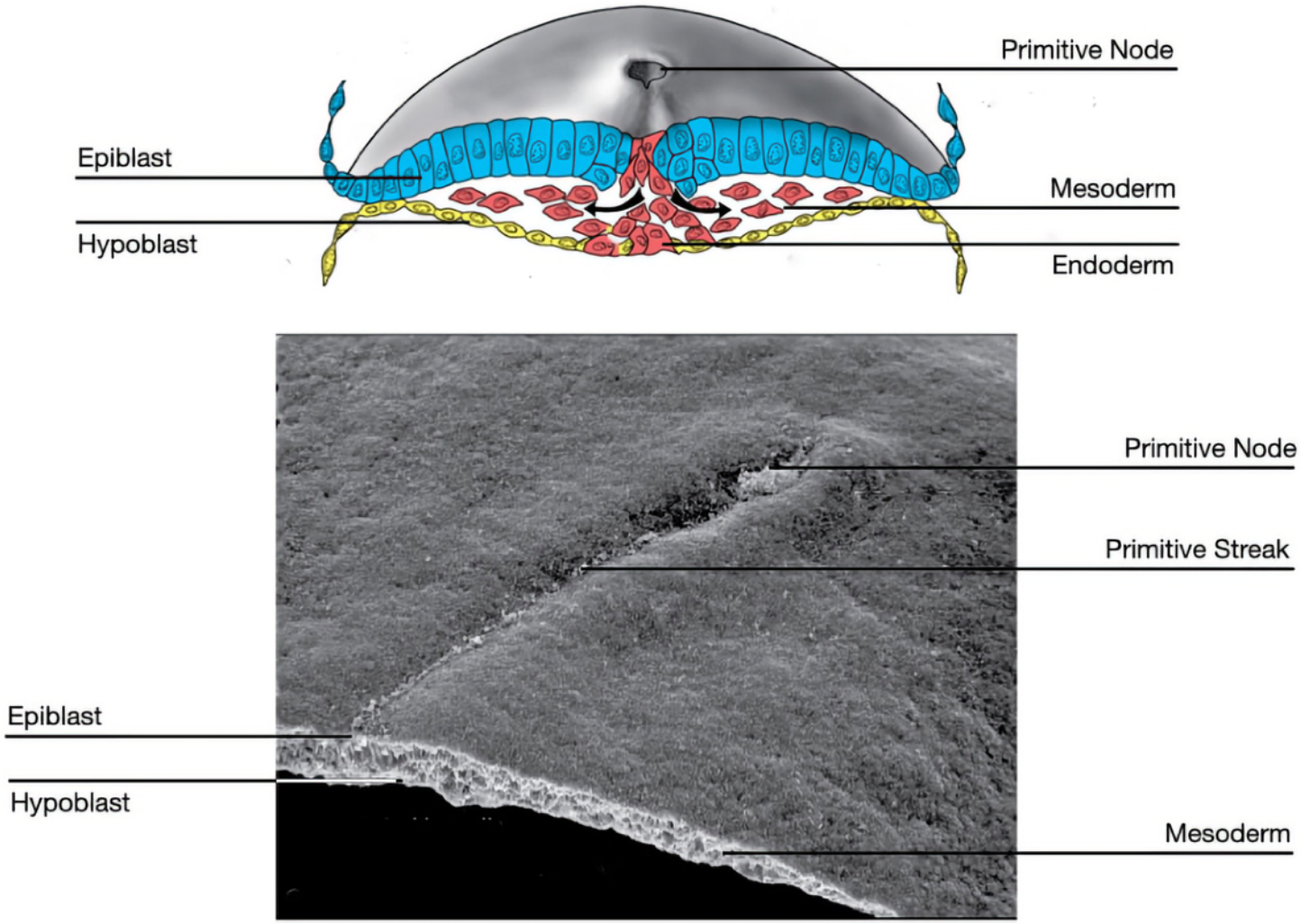
Embryology focuses on the first 8 weeks of development.



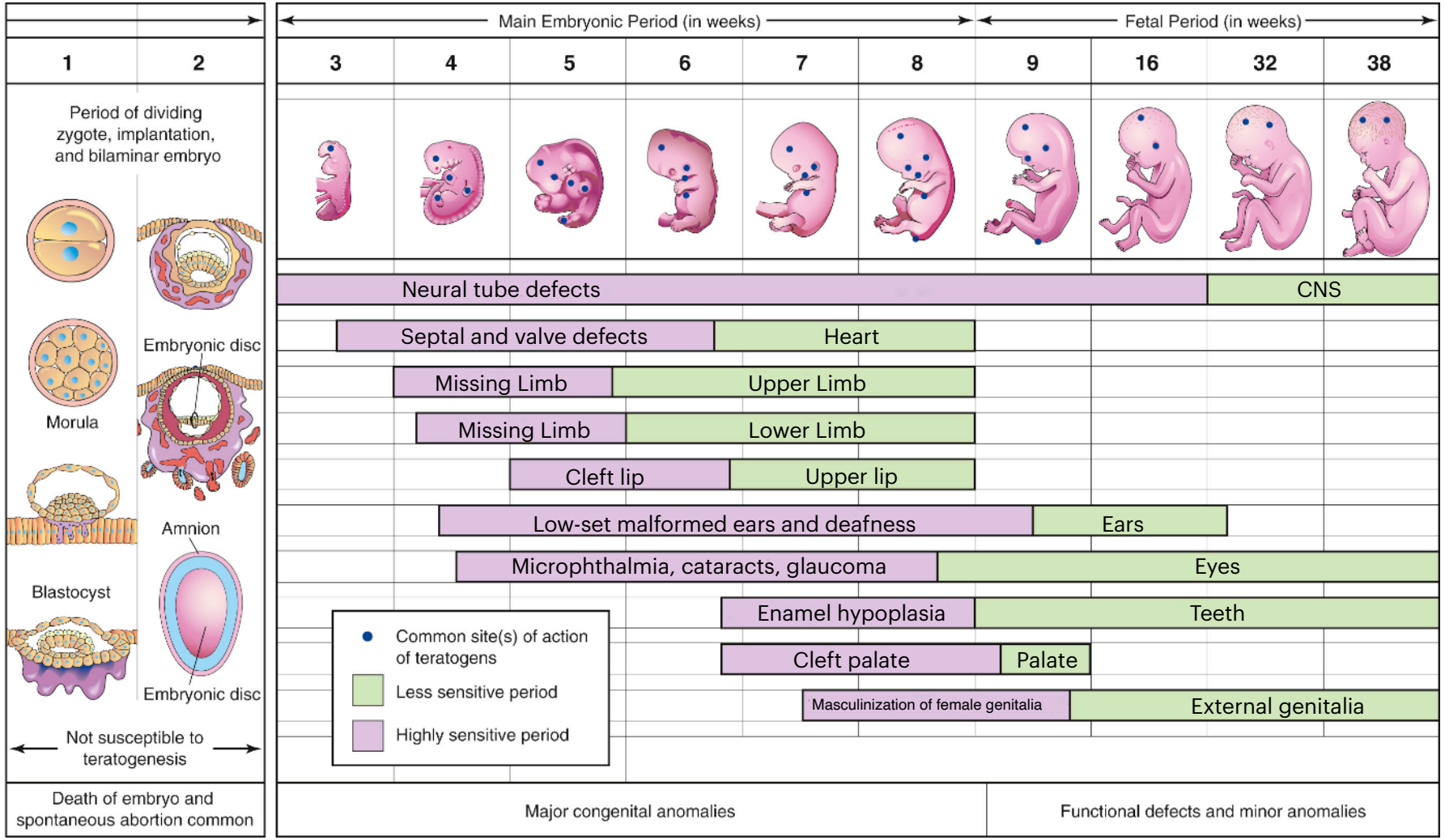
Zygote develops into trilaminar disc and several extra embryonic structures.



Gastrulation generates three germ cell layers.



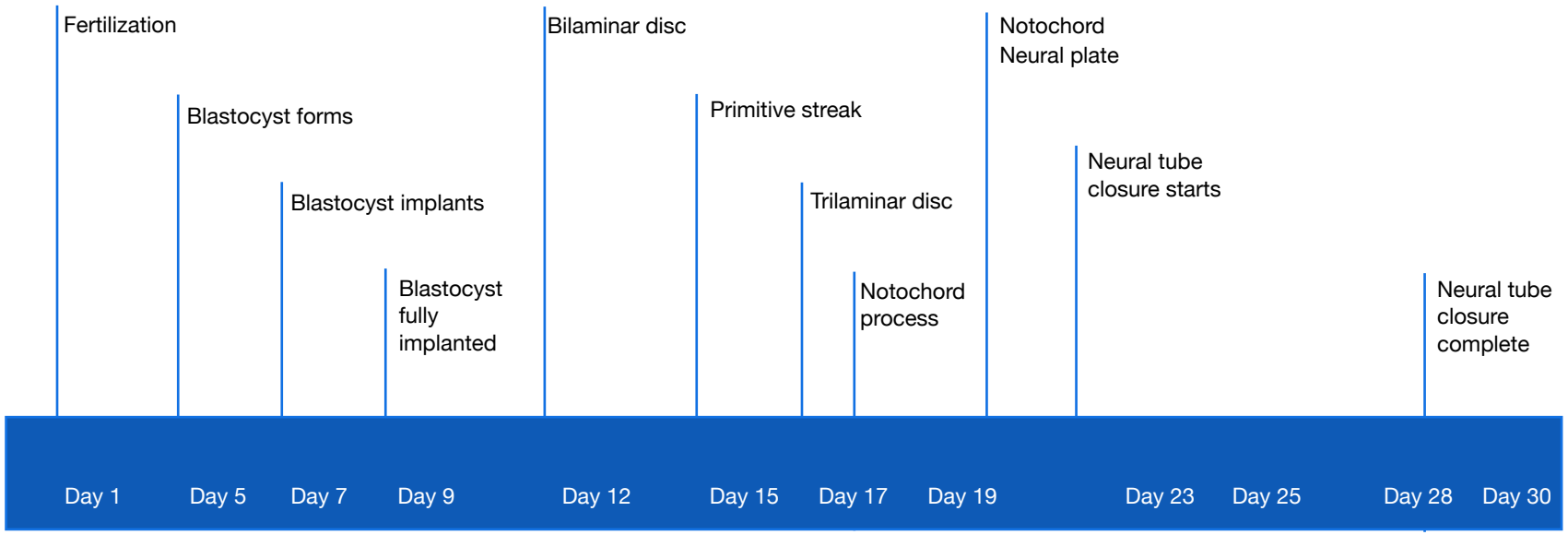
Embryogenesis is the critical period for the development of birth anomalies.



Birth anomalies occur in several different structures and organs.

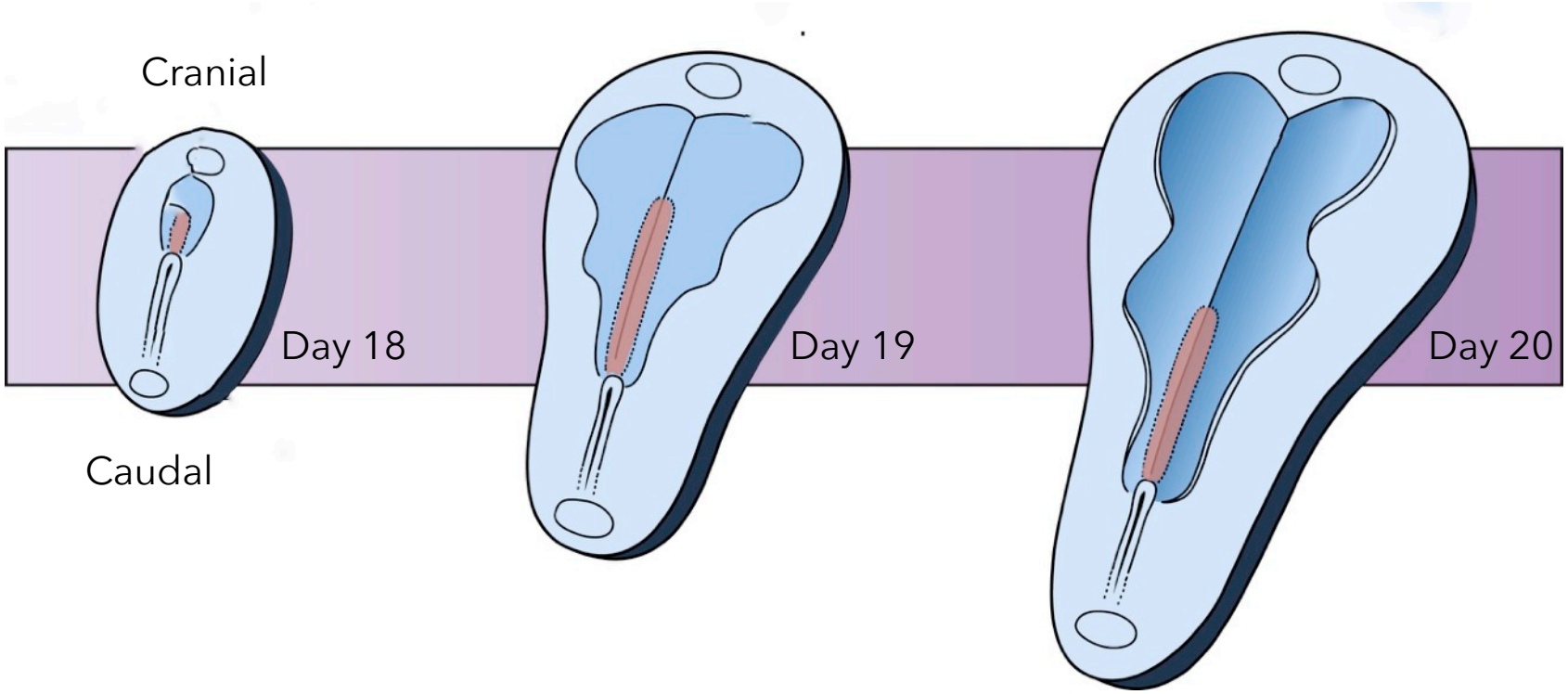
Anomaly	Prevalence (per 10,000)
Anencephaly	2.28
Spina bifida	3.65
Atrioventricular septal defect	5.83
Coarctation of the aorta	5.80
Pulmonary valve atresia and stenosis	10.41
Cleft lip	9.94
Rectal and large intestinal atresia/stenosis	4.59

The neural tube forms shortly after gastrulation.

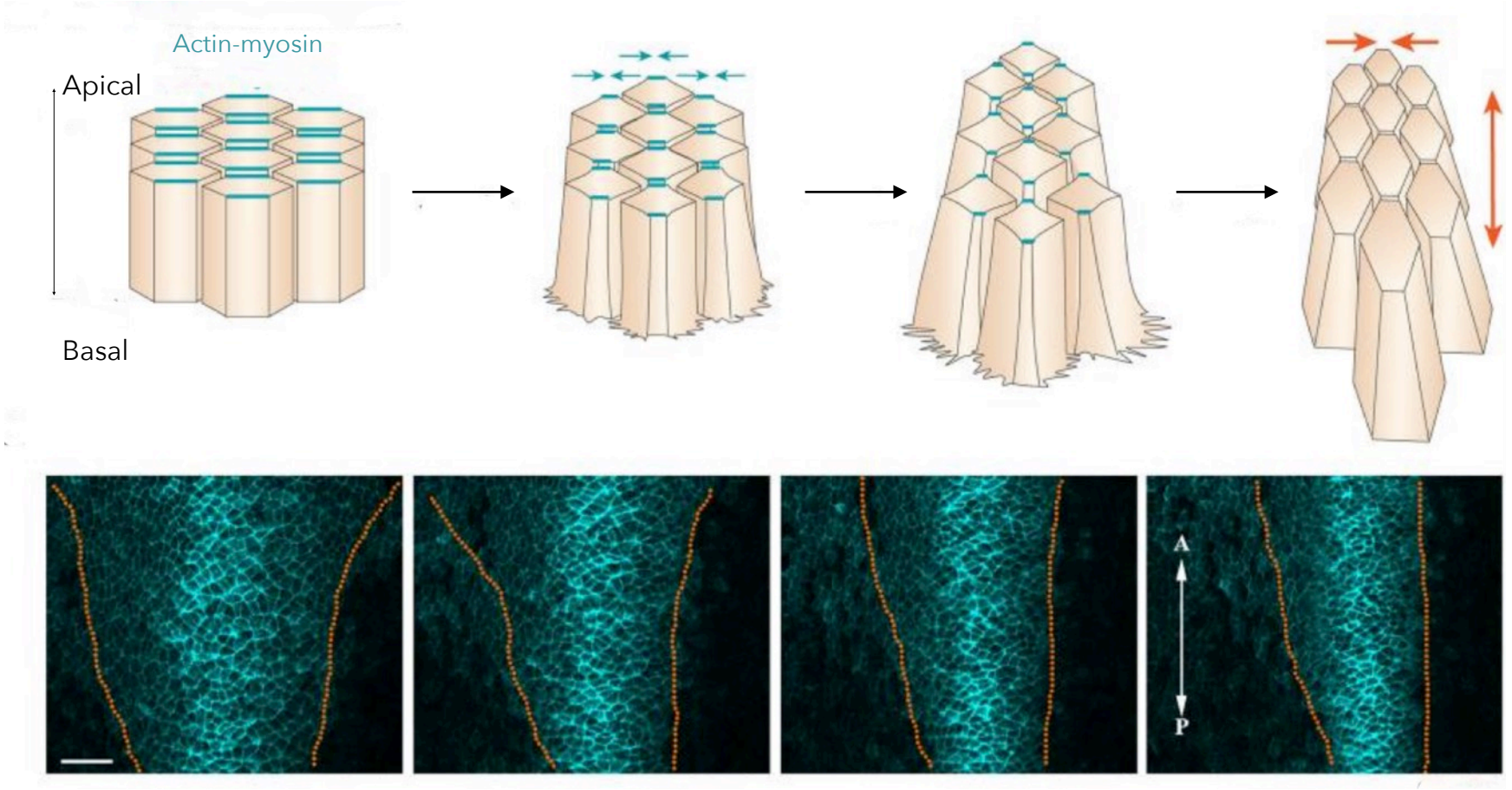


Convergent extension and growth of the embryo

The embryo elongates and narrows during and after gastrulation.

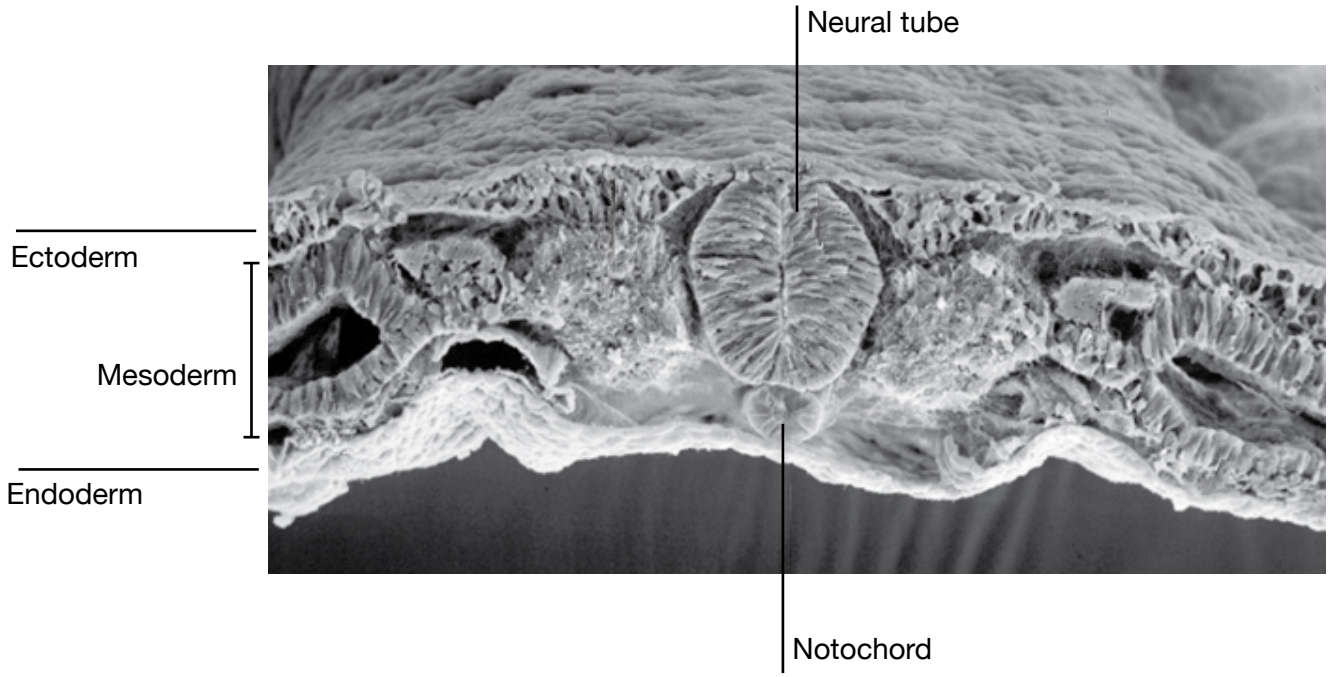


Planar cell polarity and convergent extension help elongate and narrow the embryo.

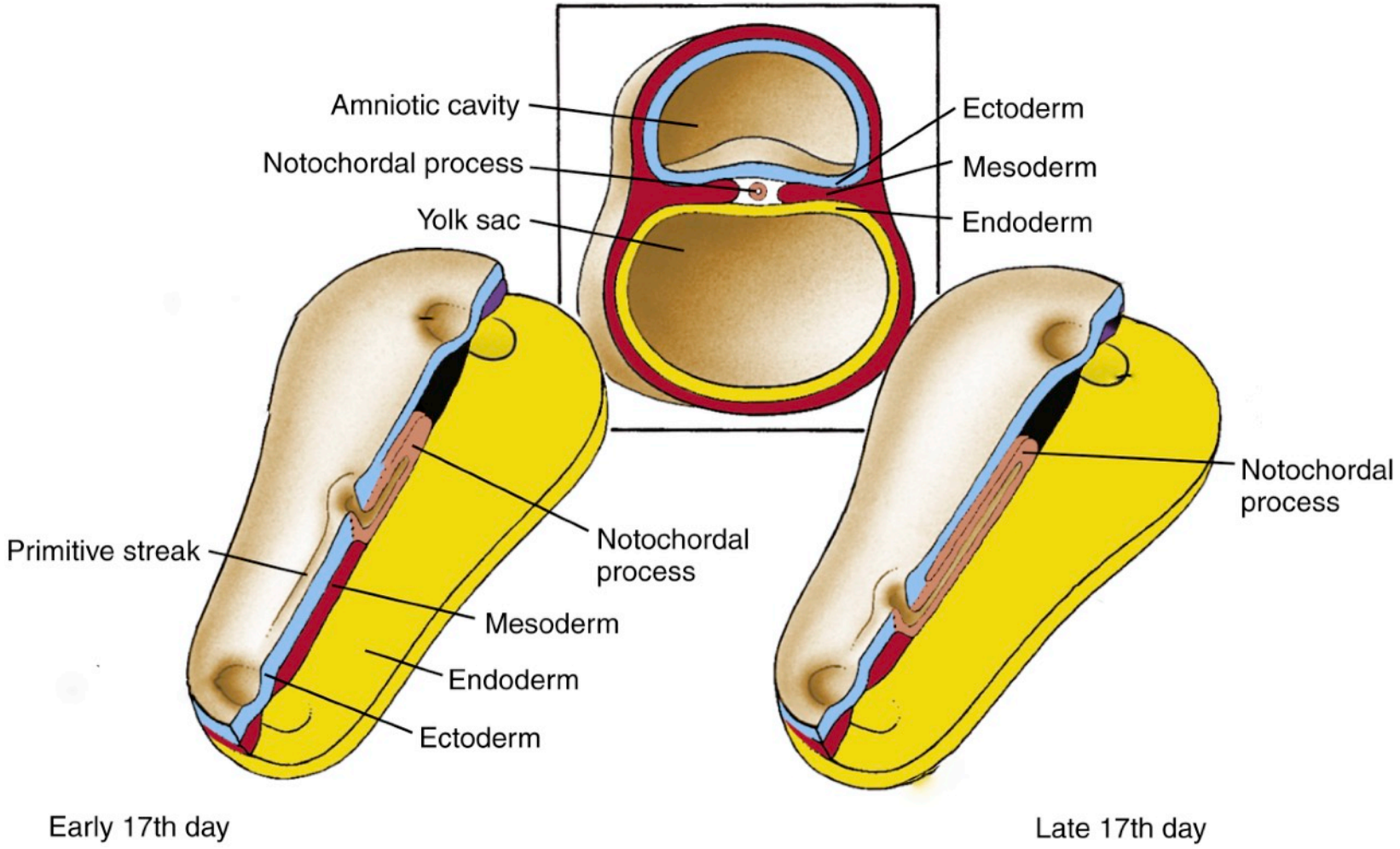


Notochord

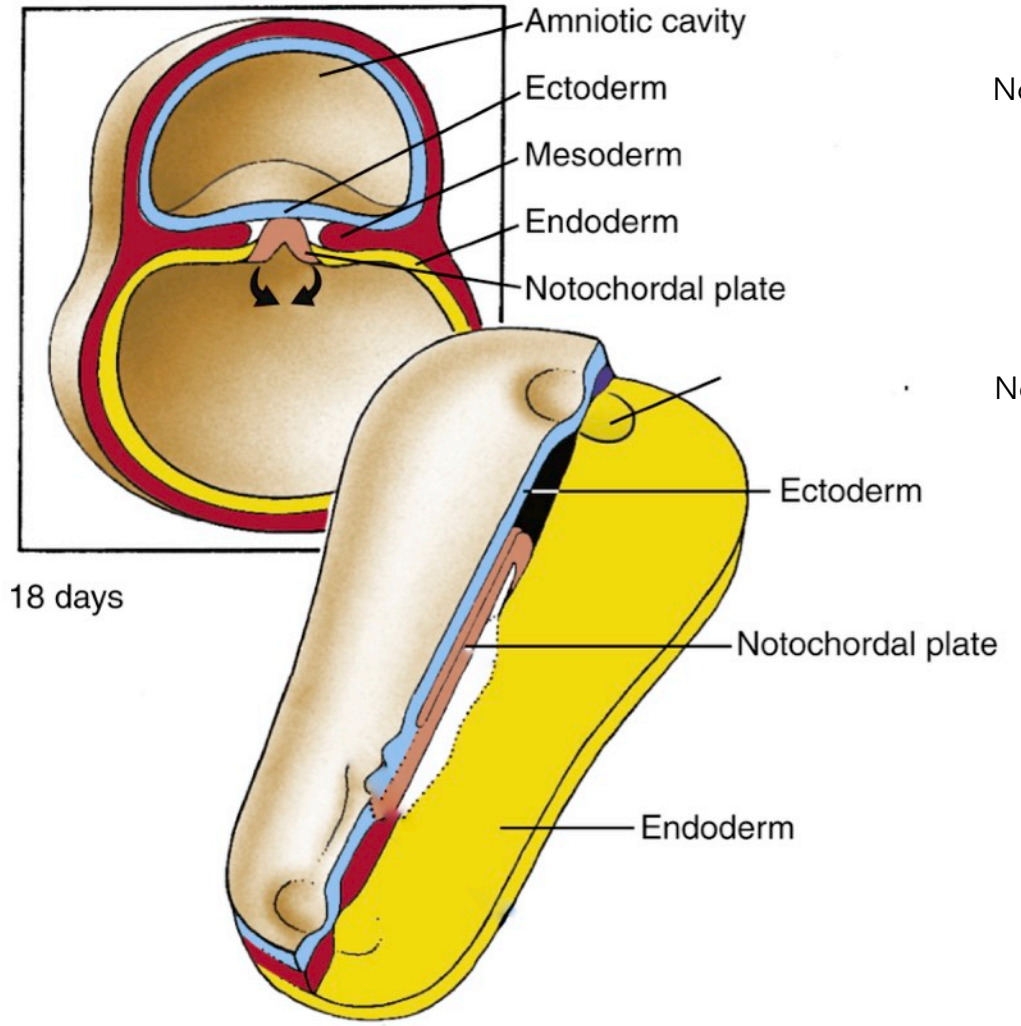
The notochord develops ventrally to the neural tube in the mesoderm.

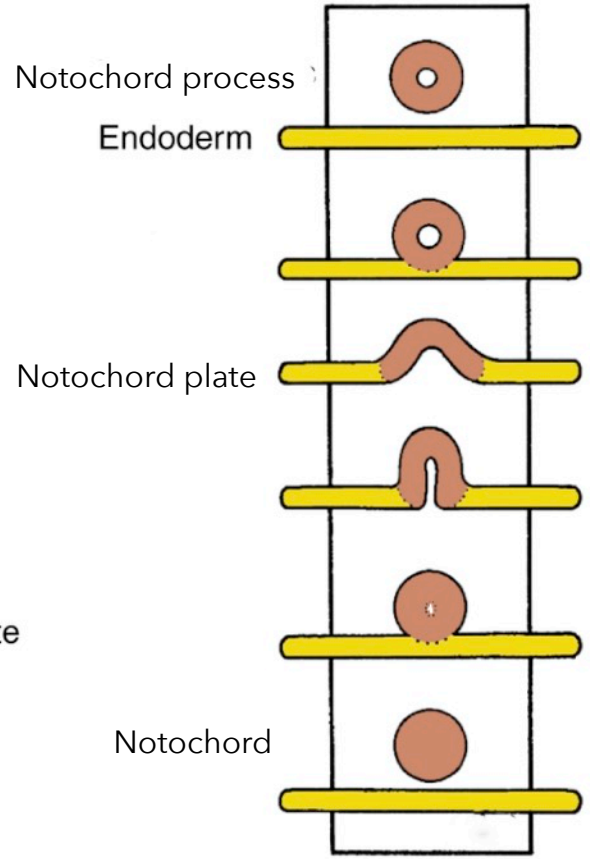


Notochord starts as a tube of cells that descends from epiblast and extends cranially.

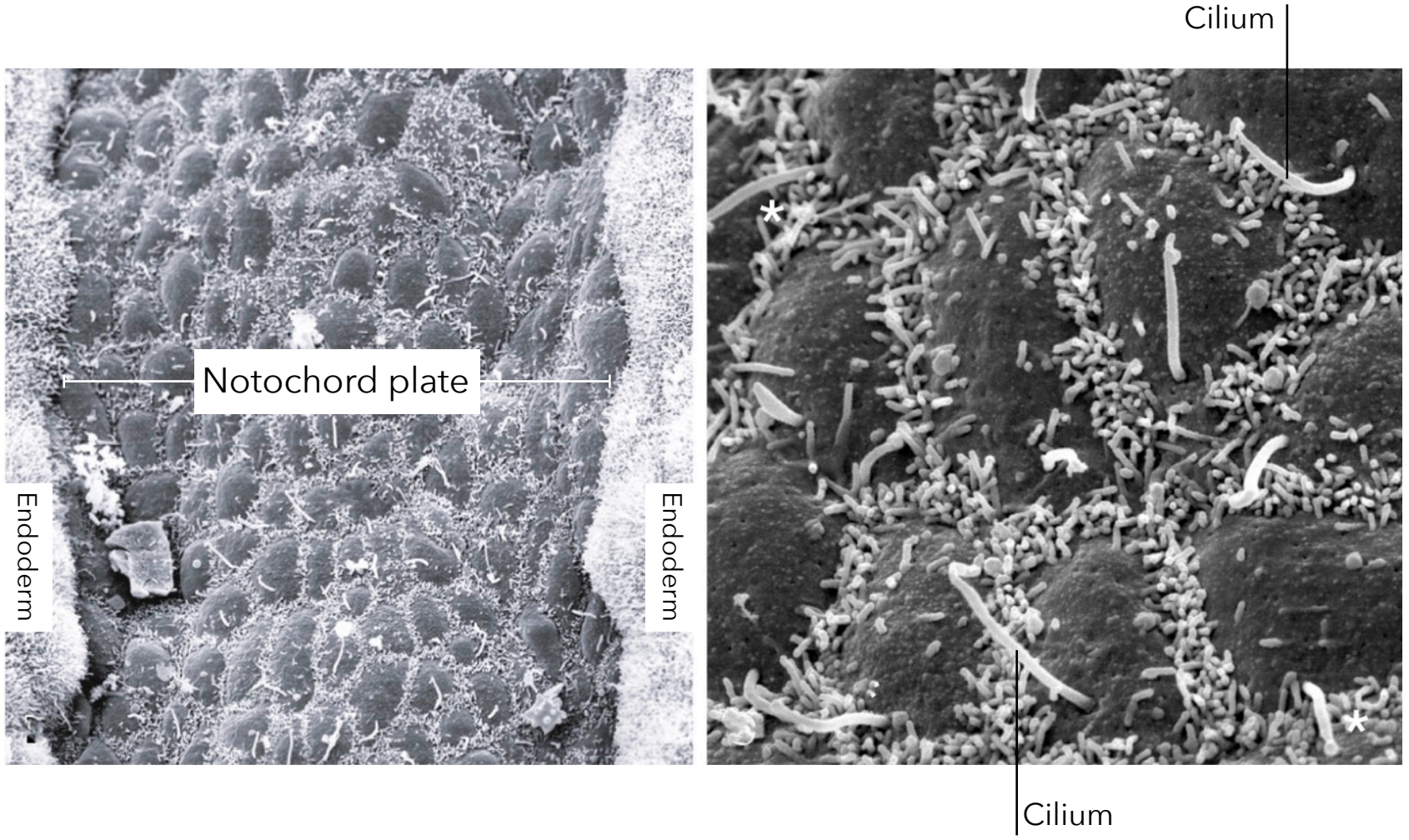


Notochord process fuses with endoderm and then reforms a tube called notochord.

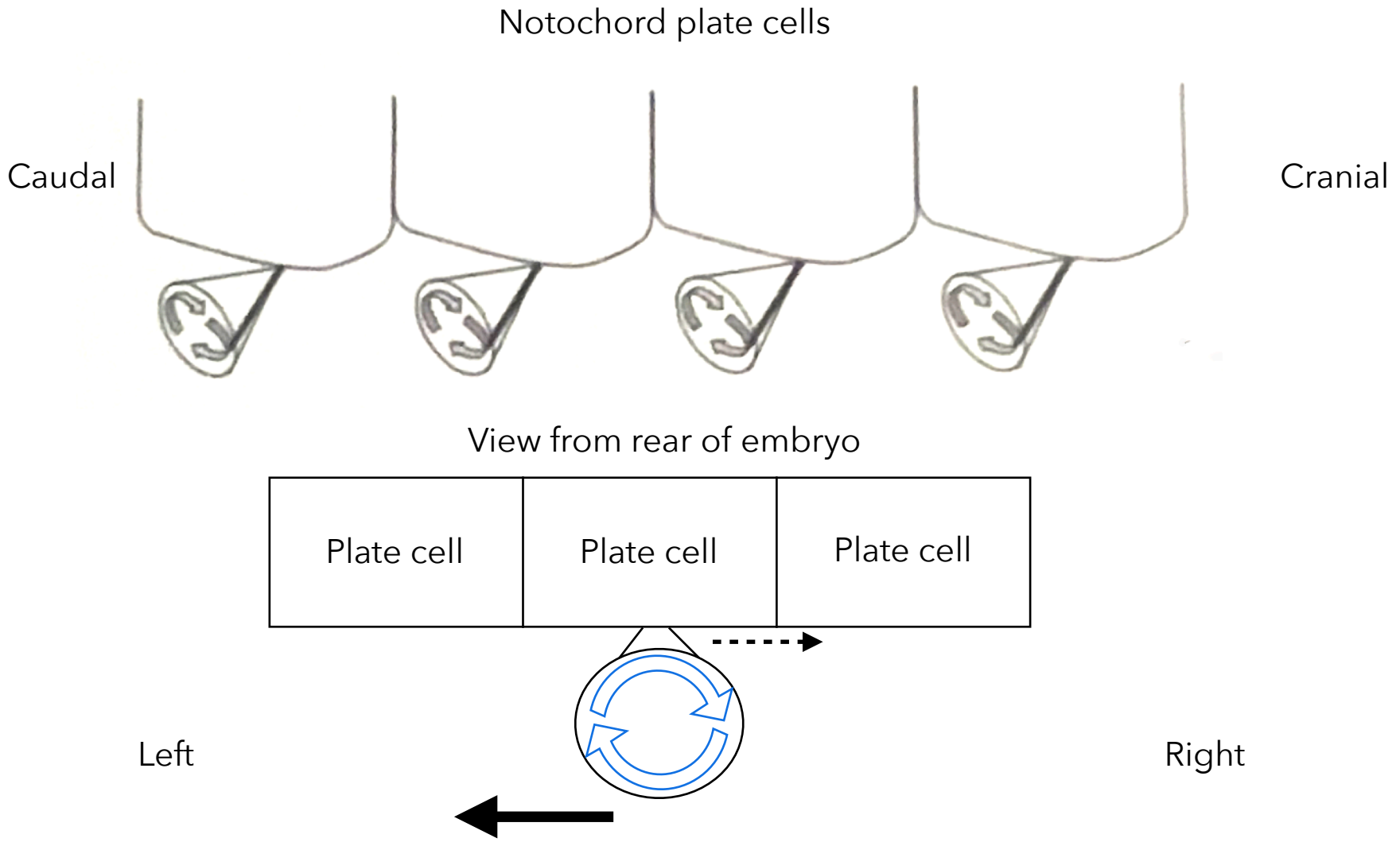




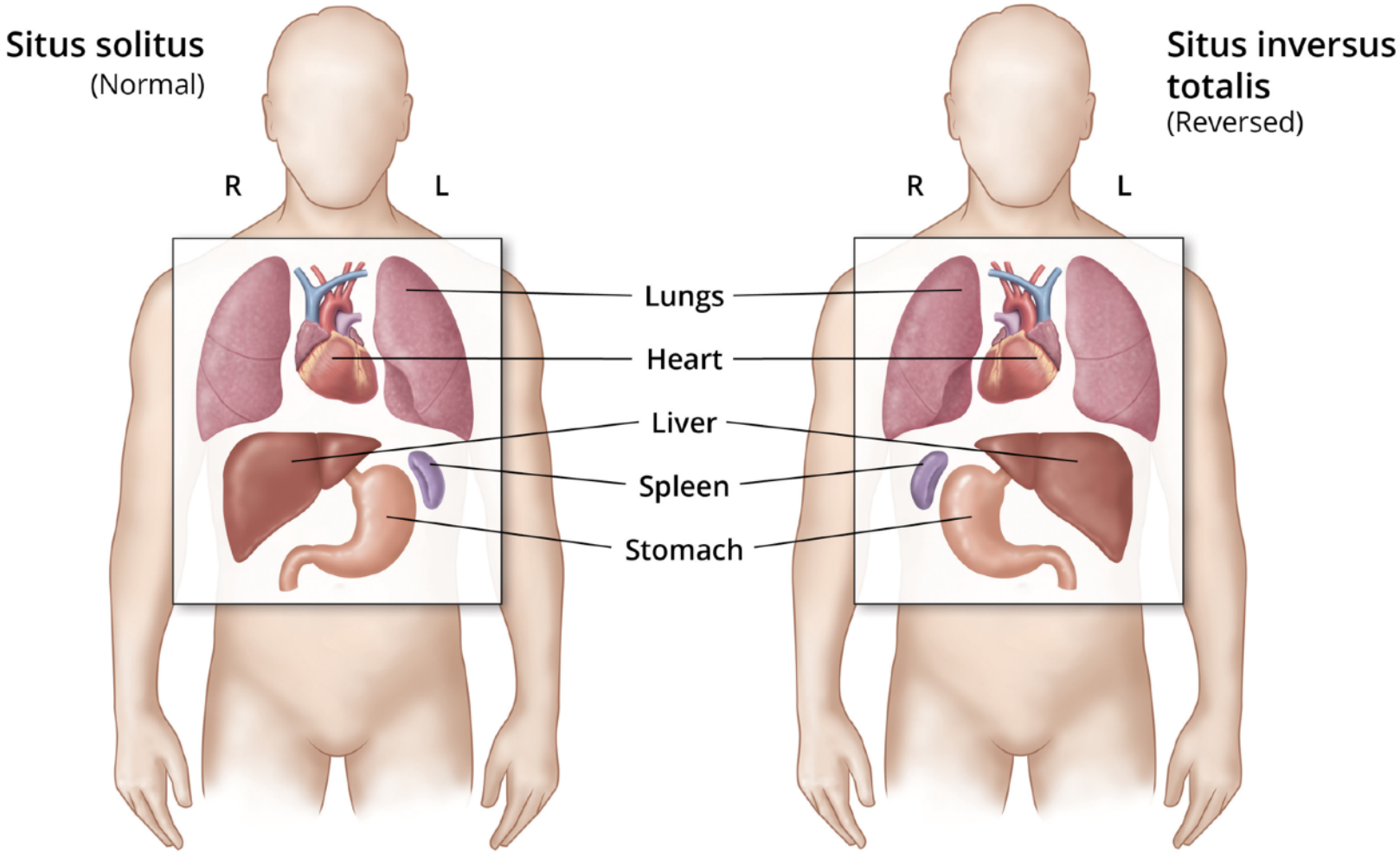
Cells in the notochord plate contain cilia.



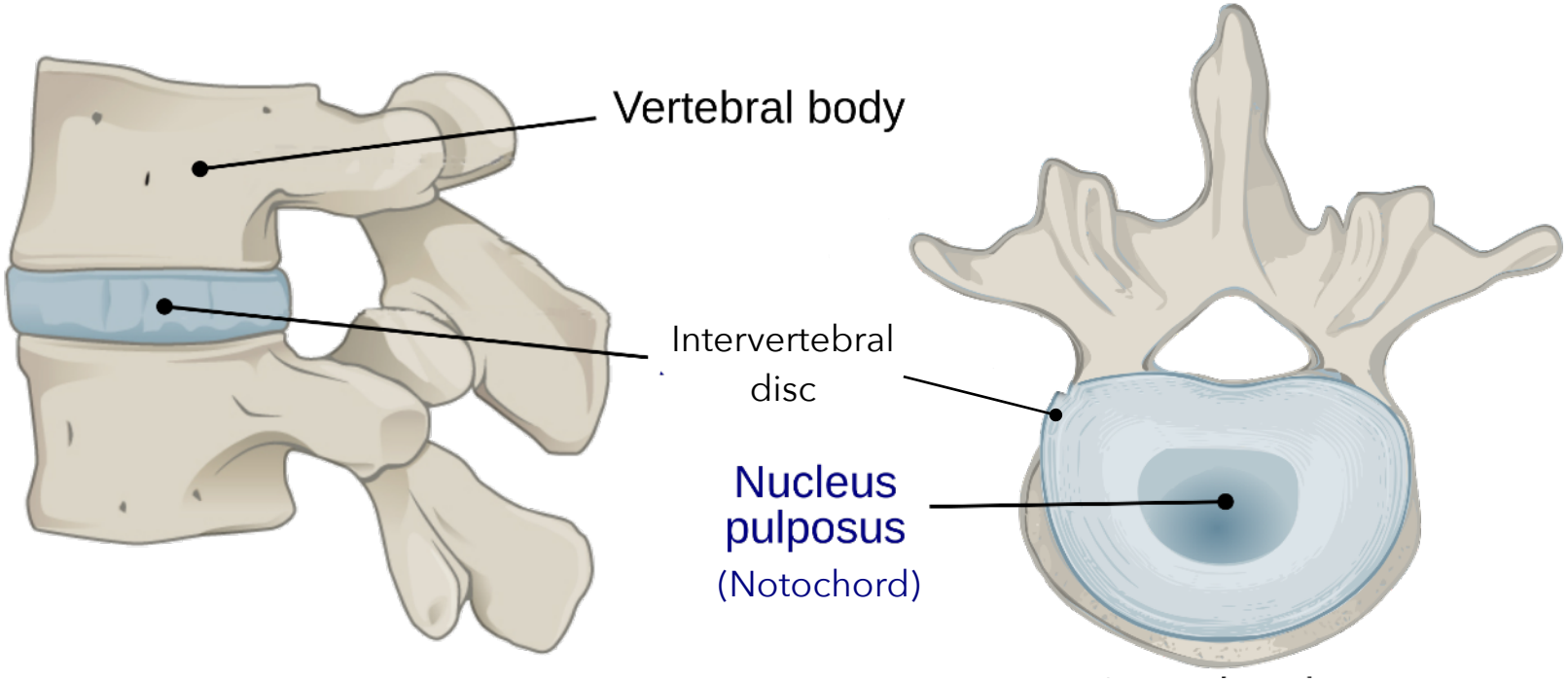
Angle of cilia and clockwise rotation move fluid toward the left side of the embryo.



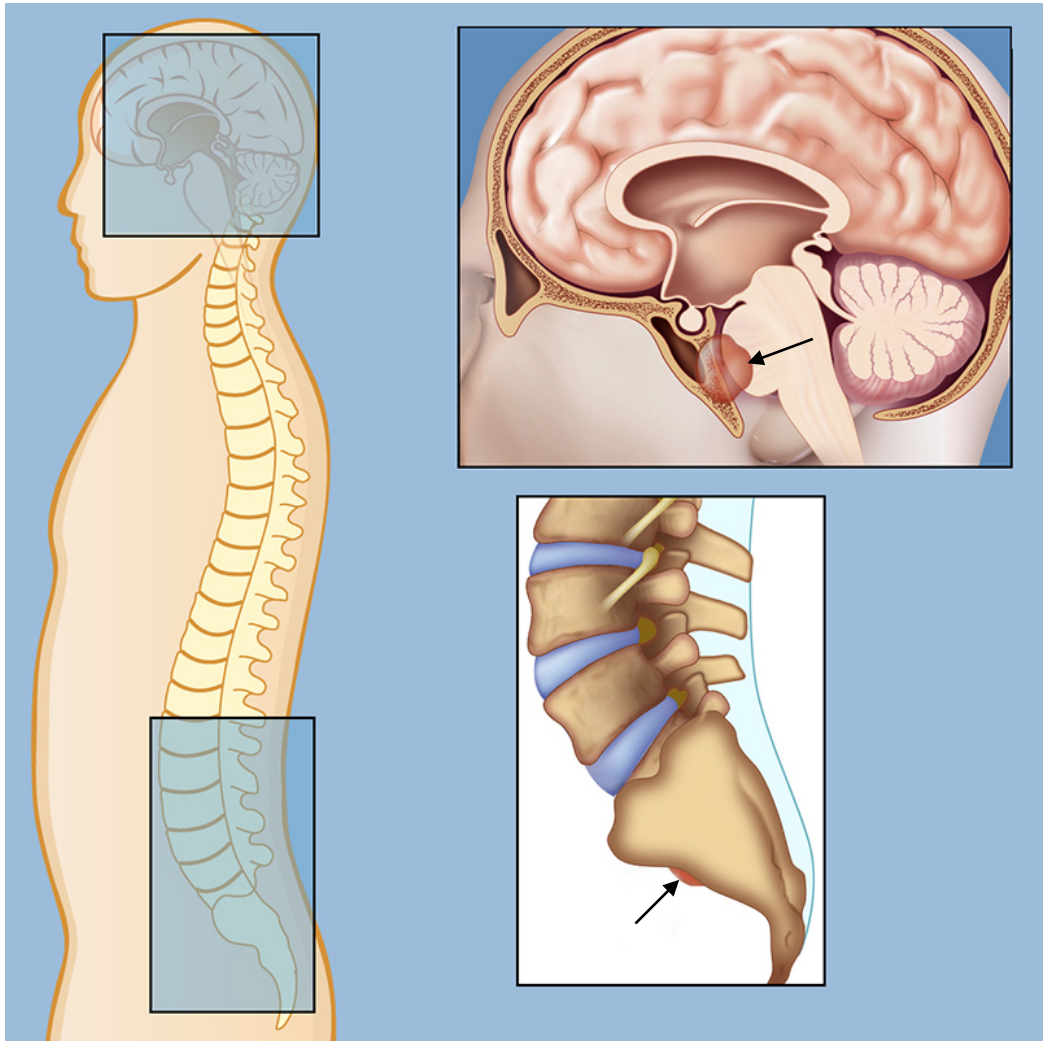
Mutations in notochord cilia lead to situs inversus.



Notochord cells form part of nucleus pulposus in the intervertebral disc.

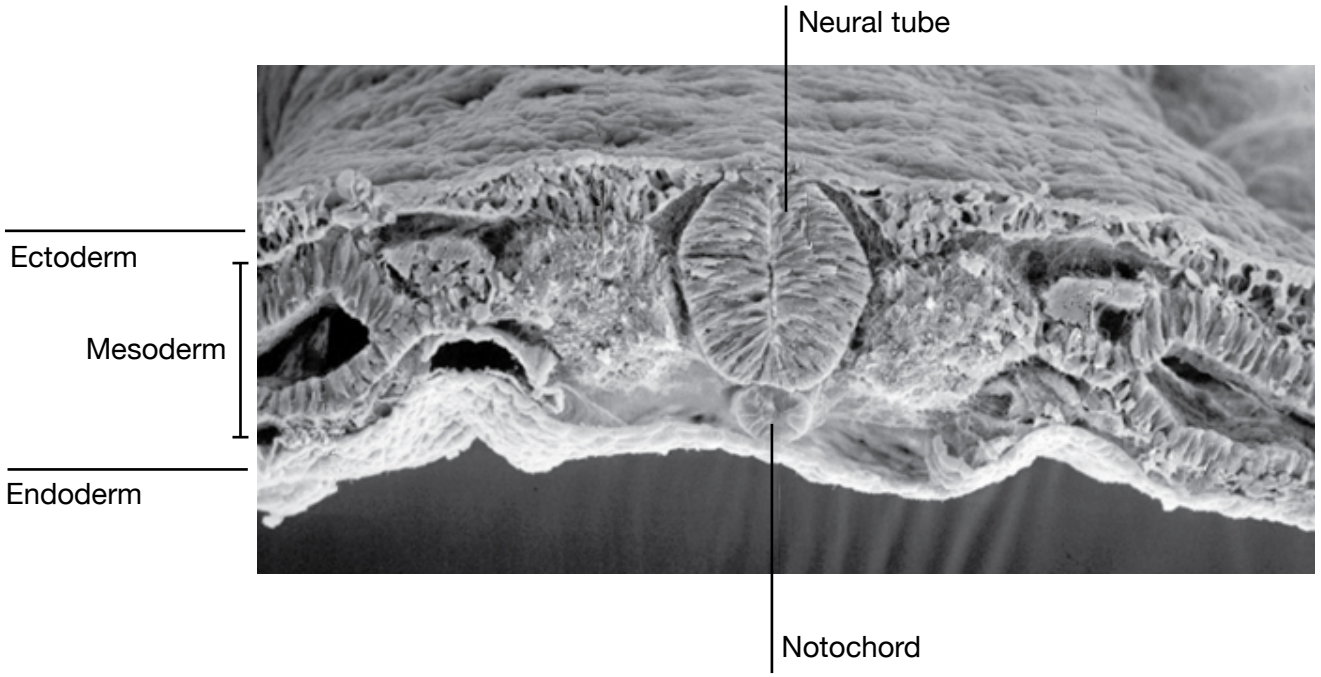


Remnants of notochord can develop into a slow growing tumor called a chordoma.

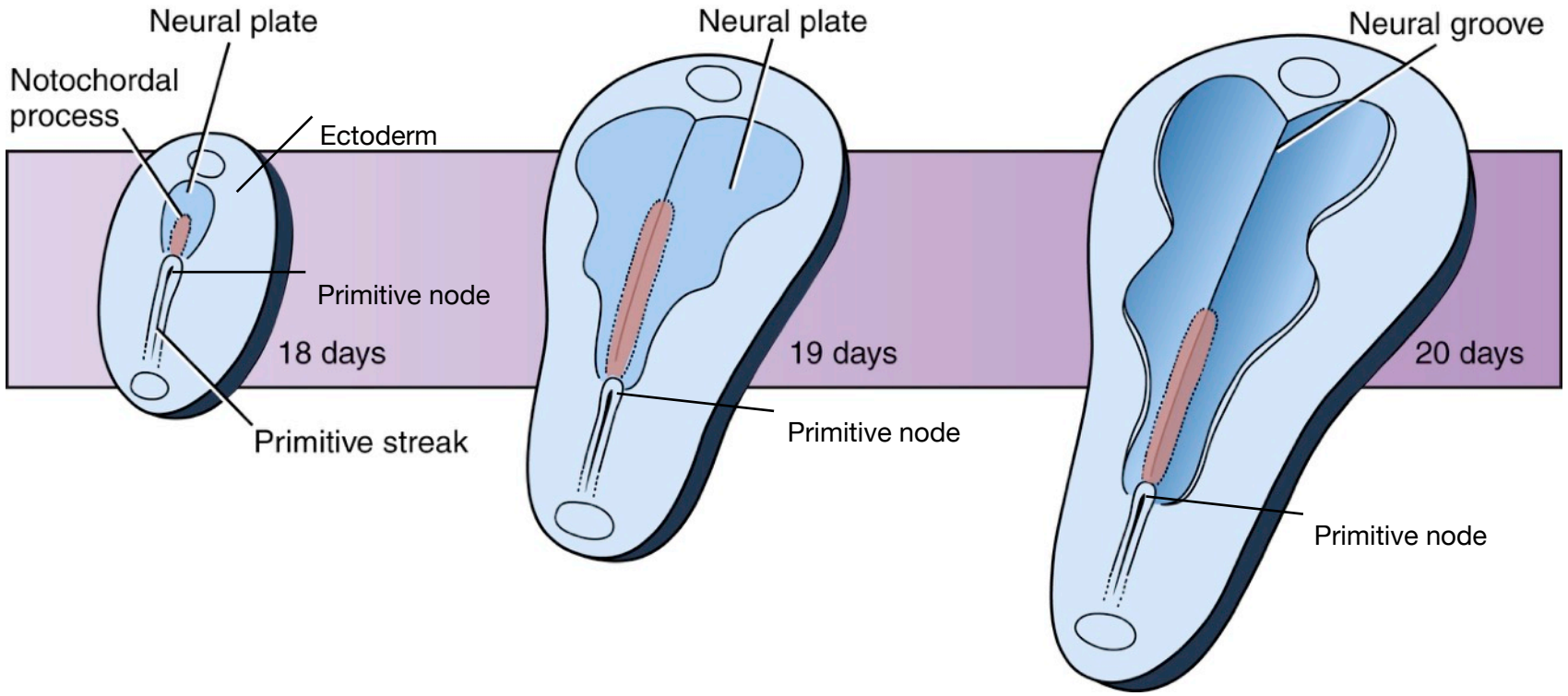


Formation of the Neural Tube

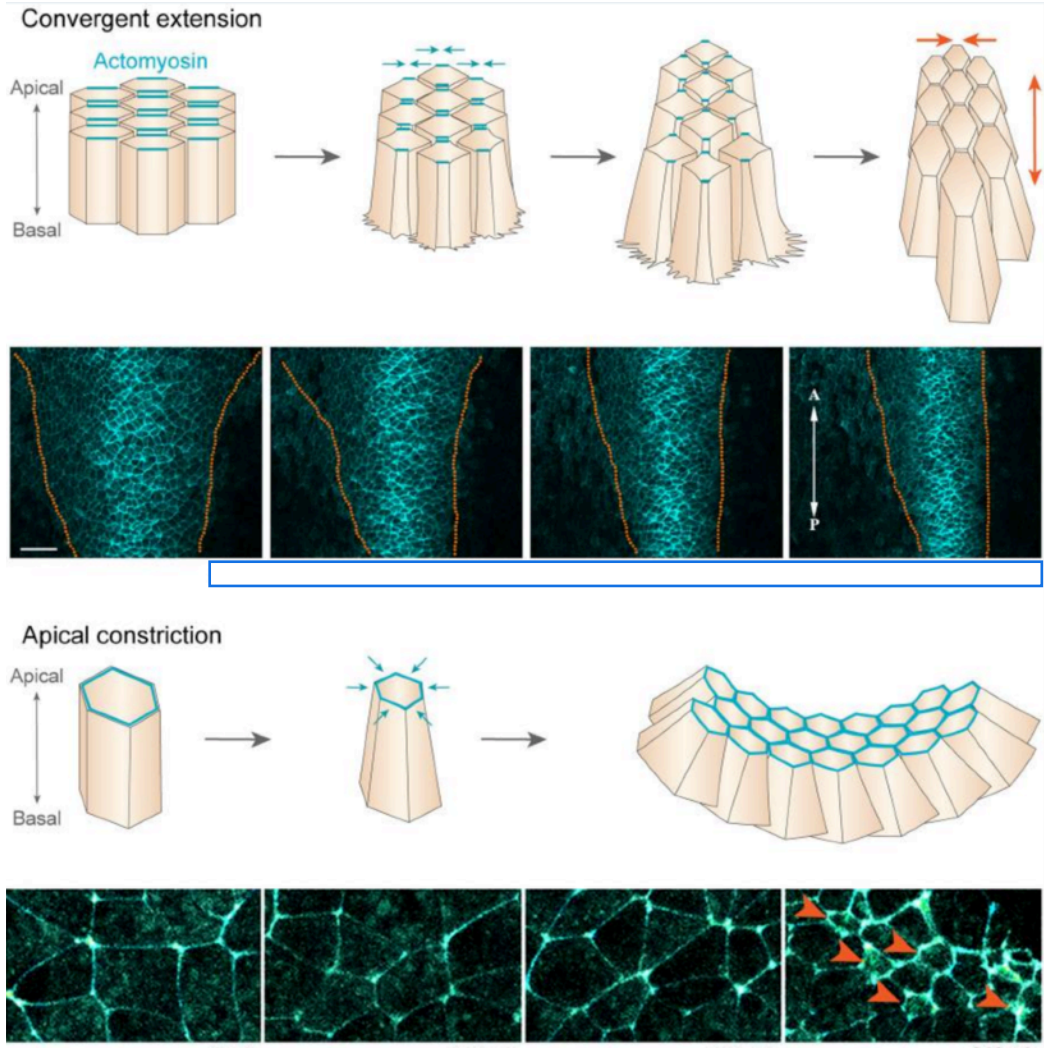
Neural tube forms from ectoderm and is located dorsally to the notochord.



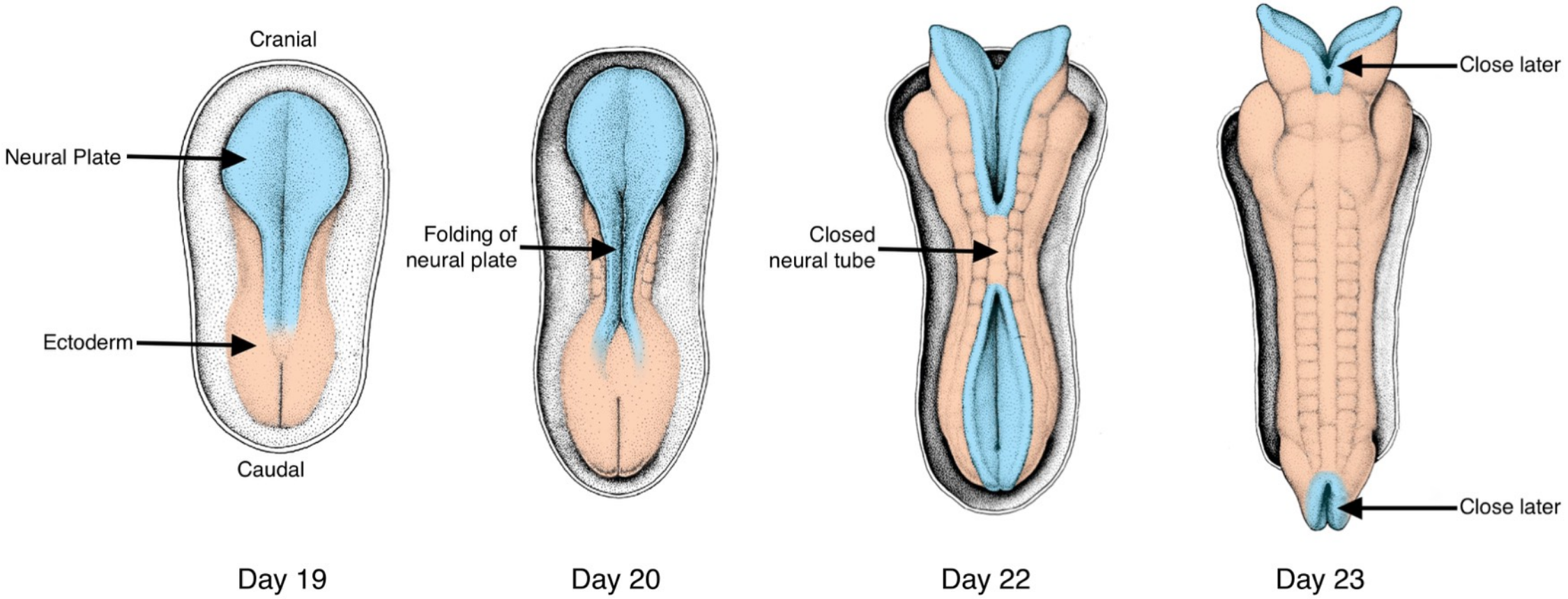
Chordin causes cells in ectoderm to follow a neural fate and form the neural plate.



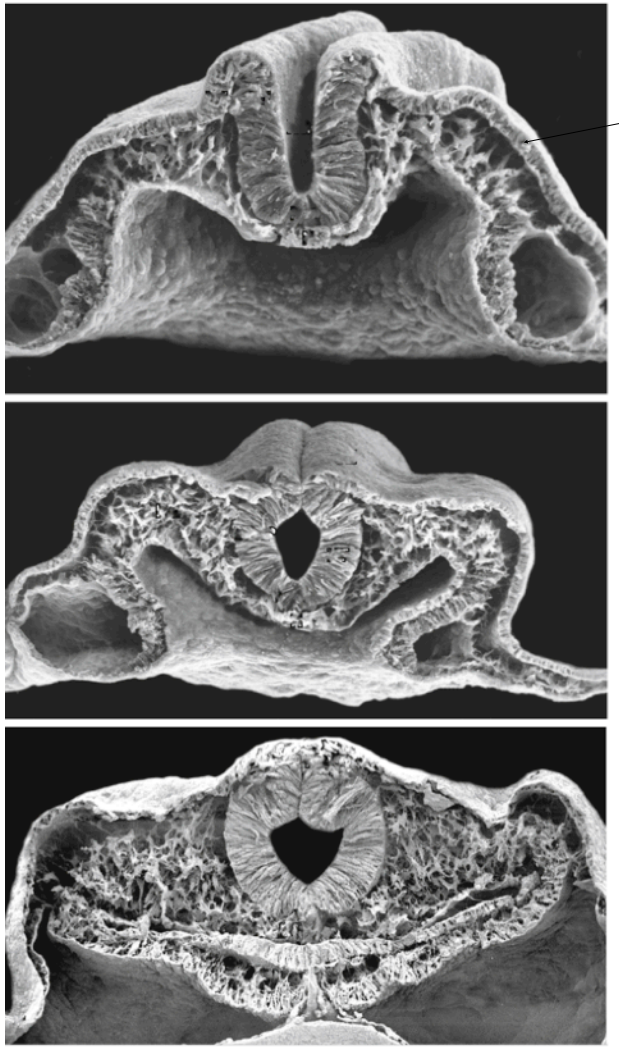
Convergent extension and apical constriction generate formation of the neural tube.

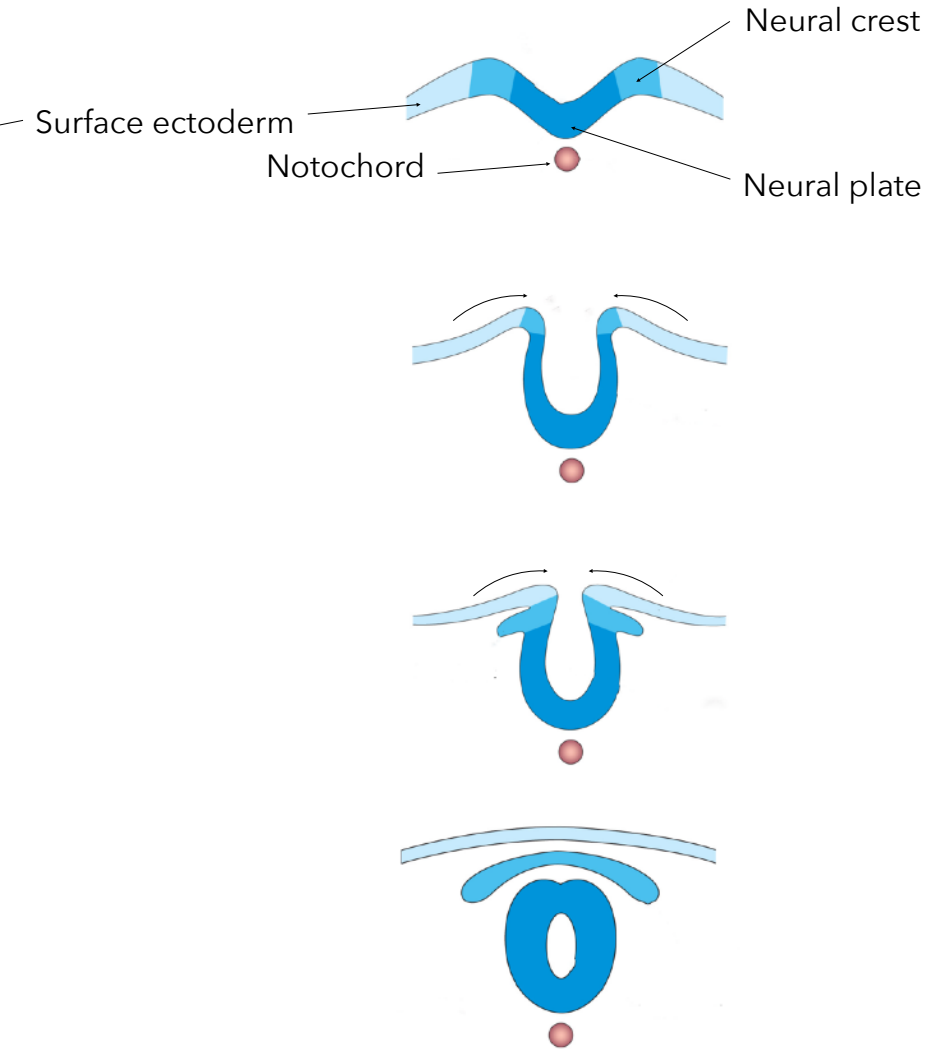


Closure of the neural tube starts in the middle of the embryo and proceeds both directions.

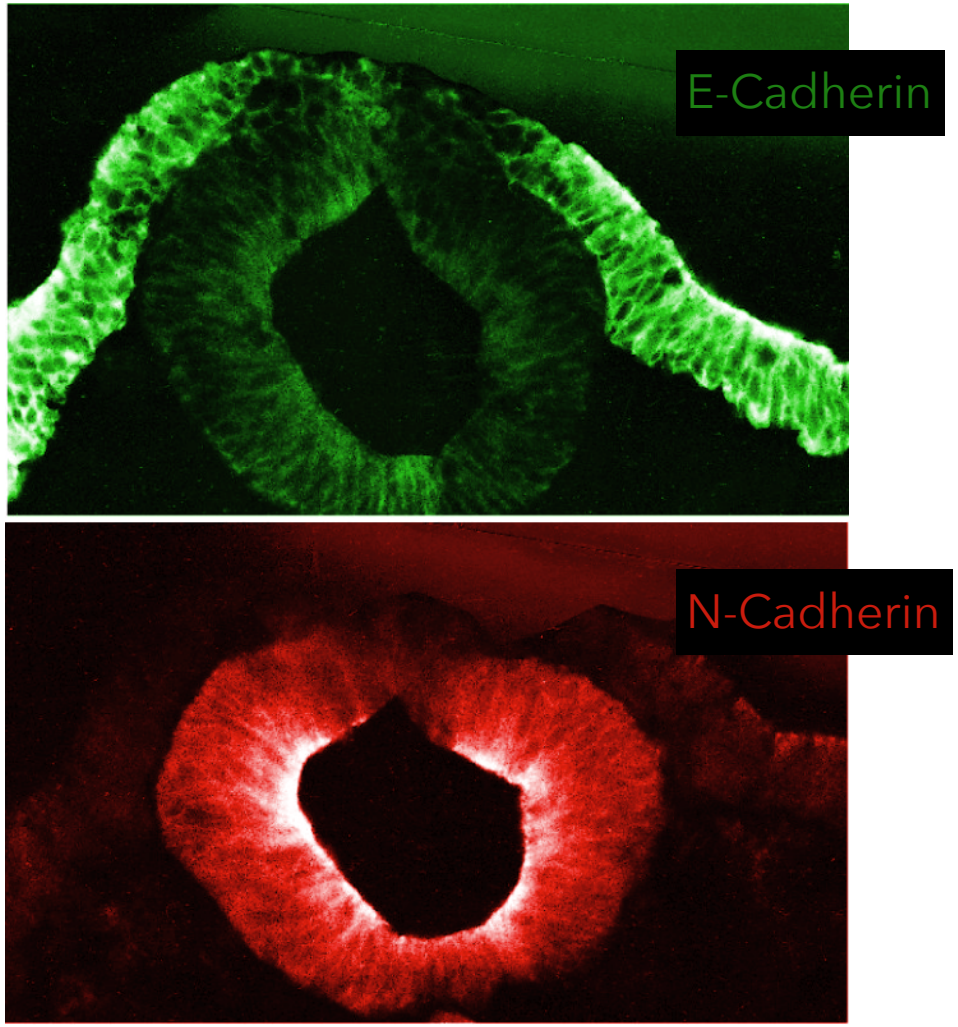


Apical constriction and crawling of surface ectoderm cells push edges of neural plate together.

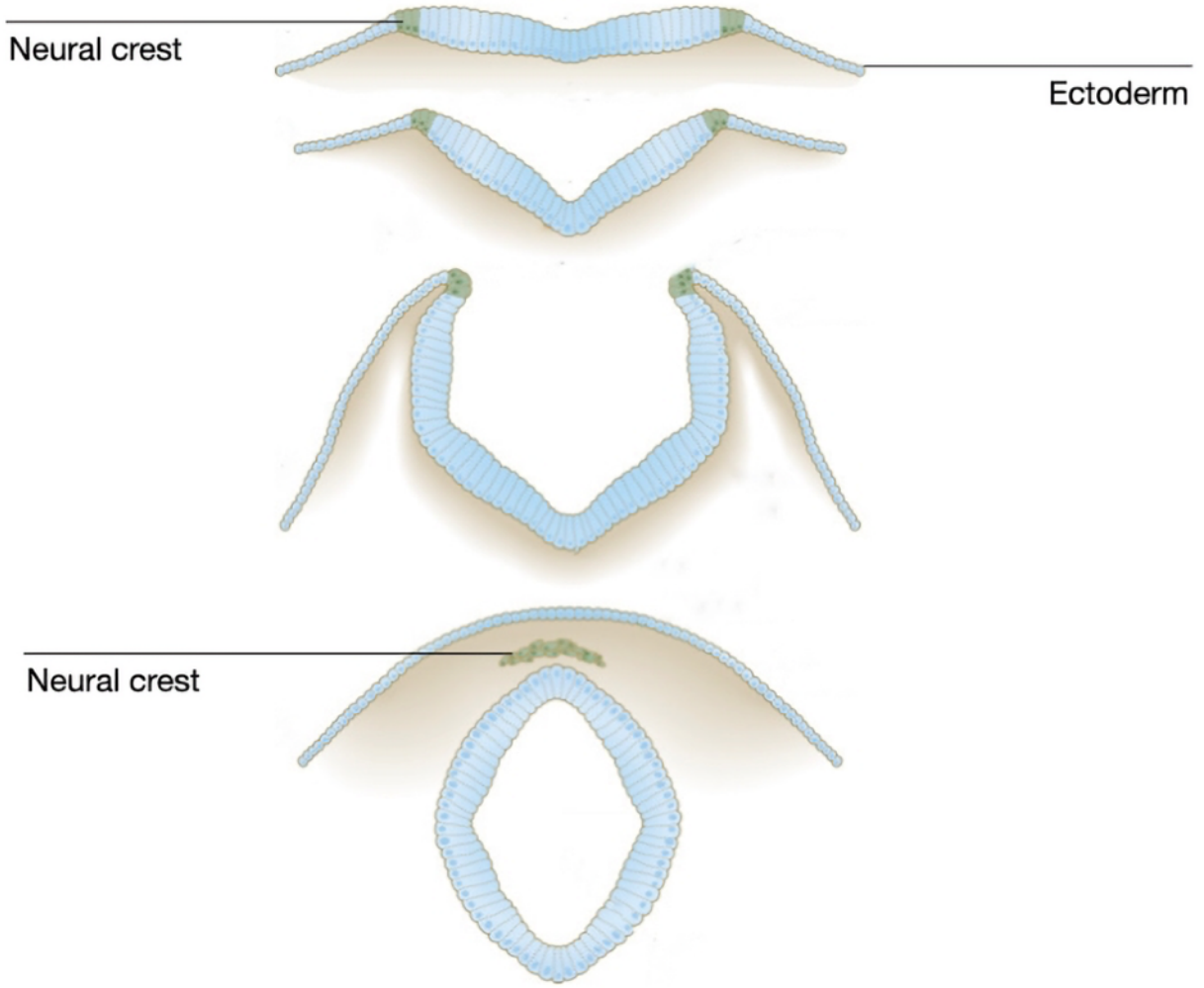




Differential expression of cadherin leads to separation of neural tube from surface ectoderm.



Closure of the neural tube release neural crest cells that will innervate peripheral tissues.



Failure of neural tube closure

Failure of neural tube closure are the most common neural tube defect.

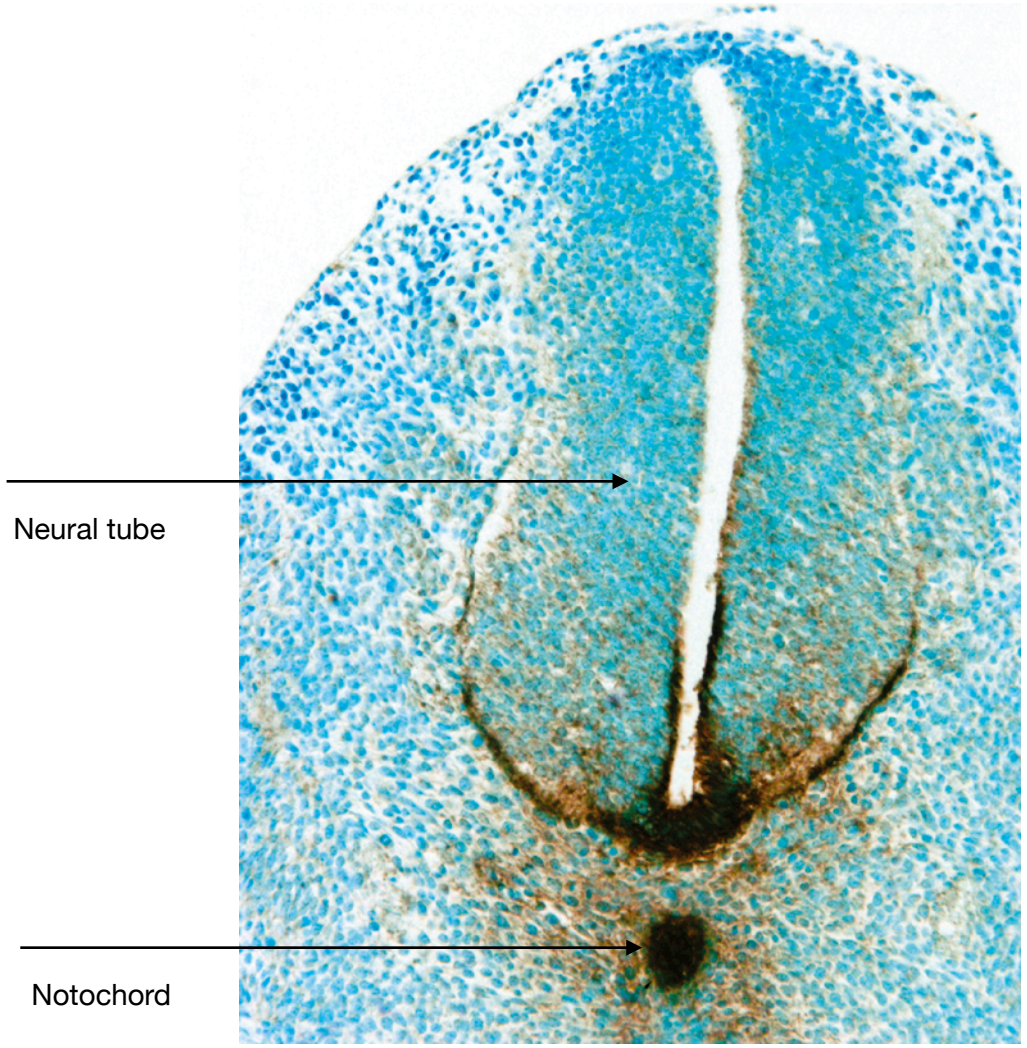
- 0.5 to 10 per 1000 pregnancies worldwide
- Severity depends on location
  - Cranial: anencephaly
  - Caudal: spina bifida

Defects in neural tube closure have both genetic and environmental causes.

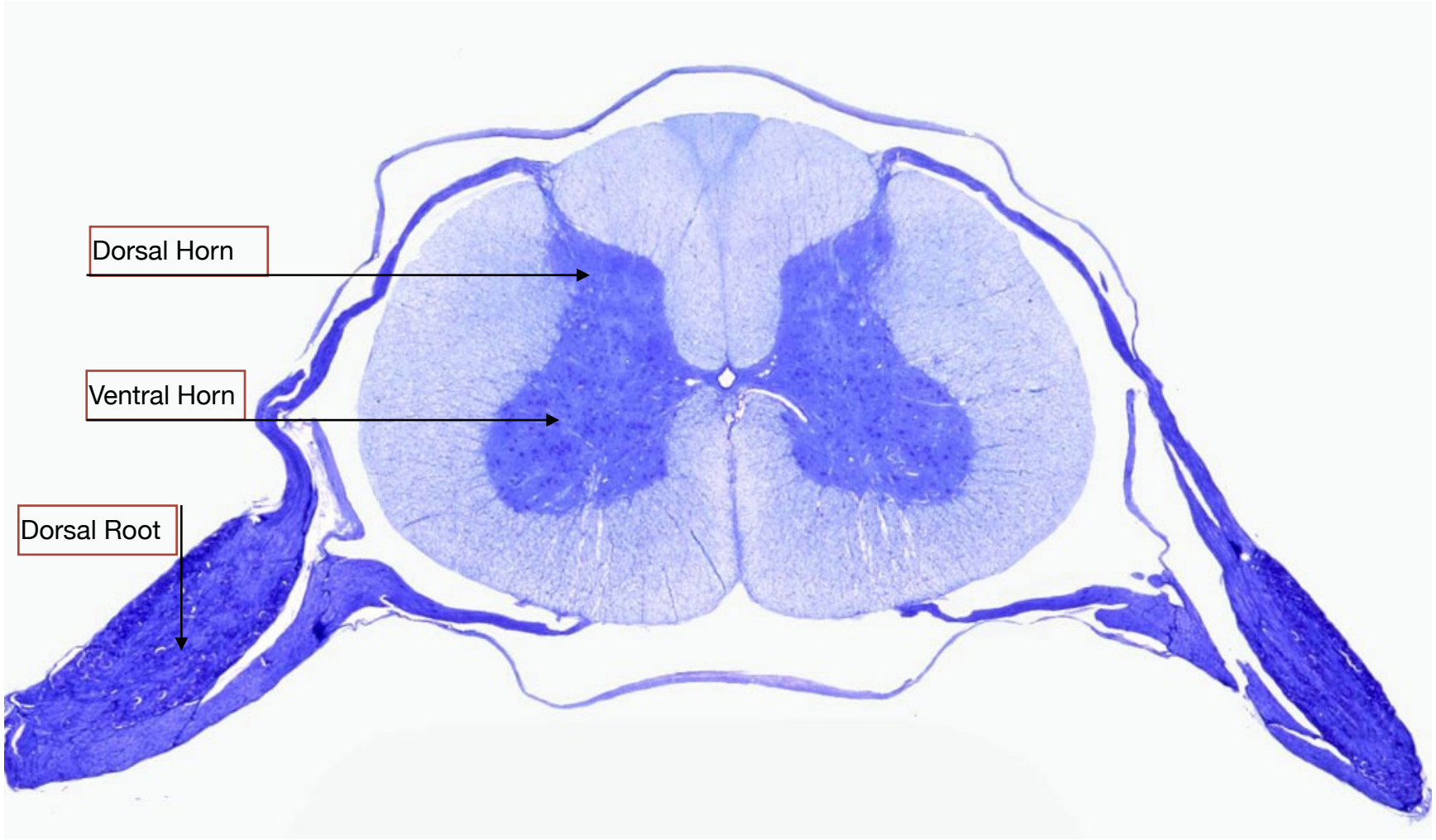
- Concordance higher in same-sex twins than opposite sex twins.
- Candidate genes have been identified
  - Folate metabolism
  - Planar cell polarity
  - Cytoskeleton organization
- Lack of dietary folic acid
- Temperature

Notochord and patterning of the spinal cord

Signaling molecules from notochord determine dorsal-ventral axis of spinal cord.



Motor neurons and sensory neurons develop on opposite sides of the spinal cord.



Take home messages…

- Convergent extension allows tissues to change shape and grow.
- Notochord determines left-right asymmetry in embryo and dorsal-ventral in spinal cord.
- Neural tube differentiates from ectoderm and develops into brain and spinal cord.
- Genetic and environmental factors affect neural tube closure.