Neurulation

SUMMARY

NEURULATION

Definiton

• The process of neurulation involves the formation of the neural plate and the folding of the neural plate into the neural tube.

Key Points

• The notochord induces the overlying ectoderm to develop into the neural plate.

• The neural plate folds into the neural tube and as it closes, the neural crests are pinched off.

• The neural tube derives the central nervous system (the brain and spinal cord).

• The neural crest cells derive the peripheral nervous system (eg, ganglion cells and Schwann cells) and also select other cell types (eg, melaoncytes).

THE DEVELOPING EMBRYO

Trilaminar germ disc

Three layers of the trilaminar germ disc.

• Ectoderm (and amniotic cavity)

• Mesoderm

• Endoderm (and yolk sac)

THE NOTOCHORD

The prochordal knot

• A strand of cells that extends toward the cranial end of the prochordal knot.

- The prochordal knot lies within the mesoderm (in between the ectoderm and endoderm).

ASSOCIATED EMBRYONIC STRUCTURES

Key associated embryonic structures:

• The primitive streak exists within the ectodermal layer of the germ disc; it dimples along the embryonic disc.

• The primitive node (aka primitive knot, Hensen's node) lies at the cranial end of the primitive streak.

• The prochordal knot lies farther cranially.

NOTOCHORD DEVELOPMENT

• The notochord develops cranially, (towards the head of the embryo) and because it is blocked at the prochordal plate, it also develops caudally (towards the tail of the embryo) as the primitive streak regresses. There are multiple stages of notochord development, which we omit, here, for simplicity.

Key notochord actions:

• Forms the embryonic central axis,

• Induces neural plate formation,

• Establishes the central column of the spine and then degenerates to become the nucleus pulposus of the intervertebral discs.

DAY 17 OF EMBRYOGENESIS

• Early regression of the primitive streak.

• Development of the neural plate.

• The notochord lies within the mesoderm (it induces neural plate formation).

DAY 18 OF EMBRYOGENESIS

• The primitive streak has regressed.

• The neural plate invaginates to form the neural groove (the dip, centrally) and the neural folds (the peaks, laterally). The neural crests lie at the tips of the neural folds.

• Within the mesoderm, somites develop.

Somite differentiation

• Sclerotome (which derives bone and cartilage),

• Dermatome (which derives dermis),

• Myotome (which derives skeletal muscle).

DAY 21 OF EMBRYOGENESIS.

• The primitive streak has nearly completely regressed and the neural groove starts to fully fold to form the neural tube, which enters the mesoderm.

• It closes off in the center first, with the cranial and caudal ends still open at this point, and resides within the mesoderm.

• The neural crest cells have pinched off and reside in the ectoderm layer.

DAYS 23 - 26 OF EMBRYOGENESIS

• The anterior (cranial) neuropore closes at approximately Day 24.

• The posterior (caudal) neuropore closes at approximately Day 26.

• The somites form ridges underneath the ectoderm.

• The neural crests migrate to within the mesoderm.

SELECT CONGENITAL NEURO-EMBRYOLOGICAL DISORDERS

• Chordoma

• Chiari Malformation

• Dandy Walker Malformation

• Encephalocele

• Holoprosencephaly

• Lissencephaly

• Schizencephaly

• Septo-Optic Dysplasia

• Zellweger Syndrome

FULL TEXT

OVERVIEW

Neurulation

• Here, we'll learn the process of neurulation, which involves the formation of the neural plate and the folding of the neural plate into the neural tube.

Definitions

To begin, start a table.

• Denote that via neurulation, the notochord induces the overlying ectoderm to develop into the neural plate.

• Next, the neural plate folds into the neural tube and as it closes, the neural crests are pinched off.

• The neural tube derives the central nervous system (the brain and spinal cord).

• The neural crest cells derive the peripheral nervous system (eg, ganglion cells and Schwann cells) and also select other cell types (eg, melaoncytes).

DEVELOPING EMBRYO

Developing Embryo

To begin, let's draw the developing embryo that we left off with from the germ cell tutorial.

• Indicate that we'll show the three layers of the trilaminar germ disc.

• Draw its mesoderm.

• Then, its endoderm and label the yolk sac, give this cavity three-dimensionality.

• Draw the ectoderm and show the amniotic cavity, again, give the cavity three-dimensionality.

• Specify the ectodermal layer of the germ disc.

• Next, draw the primitive streak, which dimples along the embryonic disc.

Developing Embryo: Downward View

• Now, draw an expanded superior view of a section of the germ disc: looking down on the ectoderm.

• Label the head and tail of the disc.

• Then, draw the primitive streak.

• Then, the primitive node (aka primitive knot, Hensen's node) (within which lies the primitive pit).

• And also establish the prochordal knot, cranially.

• Show that the primitive node derives the notochord: a strand of cells that extends toward the cranial end of the prochordal knot.

- Although not discernable in this view, the notochord lies within the mesoderm (in between the ectoderm and endoderm).

- Because the notochord is blocked at the prochordal plate, cranially, (towards the head of the embryo) it also develops

caudally (towards the tail of the embryo), as well, as the primitive streak regresses.

- There are multiple stages of notochord development, which we omit, here, for simplicity.

• Establish the plane of our upcoming cross-section.

Developing Embryo: Coronal View

• Now, show the boundaries of our coronal section.

Show that the trilaminar germ disc comprises (from top to bottom), the:

• Amniotic cavity and ectoderm,

• Mesoderm,

• Endoderm and yolk sac.

• Also, show the notochord, which resides in the mesoderm.

Write that it:

• Forms the embryonic central axis,

• Induces neural plate formation,

• Establishes the central column of the spine and then degenerates to become the nucleus pulposus of the intervertebral discs.

DAY 17 EMBRYOGENESIS

Day 17 Embryogenesis: Downward View

Next, re-draw the germ cell layer at approximately Day 17 of embryogenesis.

• Indicate that there is:

• Early regression of the primitive streak.

• Development of the neural plate.

Day 17 Embryogenesis: Coronal View

Establish the plane of our upcoming cross-section.

• Then, re-draw our coronal section in similar fashion to the prior section but here include the neural plate, centrally, along the ectoderm.

• Again, show the notochord within the mesoderm, which induces neural plate formation.

DAY 18 EMBRYOGENESIS

Day 18 Embryogenesis: Downward View

• Next, draw the embryo at approximately Day 18 of embryogenesis.

• Show that the primitive streak has regressed.

• Show, now, that the neural plate invaginates to form the neural groove (the dip, centrally) and the neural folds (the peaks, laterally).

Day 18 Embryogenesis: Coronal View

Establish the plane of our upcoming cross-section.

• Re-draw our coronal section.

• Along the ectoderm, draw the neural groove, centrally, and the neural folds laterally.

• Indicate the neural crests at the tips of the neural folds.

• Within the mesoderm, show the development of the somites.

Write that the somites will go on to differentiate into three main tissue categories:

• Sclerotome (which derives bone and cartilage),

• Dermatome (which derives dermis),

• Myotome (which derives skeletal muscle).

DAY 21 EMBRYOGENESIS

Day 21 Embryogenesis: Downward View

• Next, draw the embryo at approximately Day 21 of embryogenesis.

• Show that the primitive streak has nearly completely regressed, and, as we'll see, the neural groove starts to fully fold to form the neural tube, which enters the mesoderm.

• Show that it closes off in the center first, with the cranial and caudal ends still open at this point.

Day 21 Embryogenesis: Coronal View

Establish the plane of our upcoming cross-section.

• Re-draw our coronal section, show that the neural tube is closed (at this slice) and resides within the mesoderm.

• Show the neural crest within the dorsum of the closed neural tube.

• Redraw the somites for reference.

DAYS 23 - 26 EMBRYOGENESIS

Day 23 Embryogenesis: Downward View

• Then, redraw the embyronic disc at approximately Day 23.

• Show that much more of the neural tube has closed, but there remains open:

- **The anterior (cranial) neuropore, which ultimately closes at approximately Day 24.**

- **And also the posterior (caudal) neuropore, which closes at approximately Day 26.**

• Also, show that the somites form ridges underneath the ectoderm.

Day 23 Embryogenesis: Coronal View

Establish the plane of our upcoming cross-section.

• Re-draw our coronal section.

• Show that the neural crests abut along the dorsal surface of the neural tube and migrate into the mesoderm.

- We learn the neural crest cell migration and differentiation elsewhere.

- They produce biological mediators: bone morphogenetic proteins (BMPs) and Wnt, which signal the dorsal neural tube to form the roof plate.

- Elsewhere we learn that the roof plate then uses these same mediators to form the bilateral alar plates.

• Next, show the floor plate of the neural tube: the notochord signals the base of the neural tube to form the floor plate via sonic hedgehog.

- Elsewhere we learn that the floor plate uses this to signal formation of the bilateral basal plates.