Developmental Zoology
(ZOO 228.1.0)

Neural Tube Formation

Developmental Stages

- Early Development
  - Fertilization
  - Cleavage
  - Gastrulation
  - **Neurulation**
- Later Development
  - Organogenesis
  - Larval molts
  - Metamorphosis
  - Aging

- Invertebrates
  - Echinoderms
    - unusual CNS
  - Arthropods
    - form CNS from region from neural cells that are displaced from the neuroectoderm

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Developmental Stages

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- Vertebrates
  - Dorsal ectoderm is induced by the notochord to become neural tissue
  - Ectoderm turned into neural tissue is called the neural plate
  - Neural plate cells change shape & fold into neural tube

3

Developmental Stages

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- neural crest
  - transition zone between neural plate & ectoderm becomes neural crest
  - crest cells leave dorsal neural tube & migrate throughout embryo differentiating into multiple cell types
    - melanocytes – pigment cells
    - peripheral nervous system – sensory and motor nerves
    - adrenal gland

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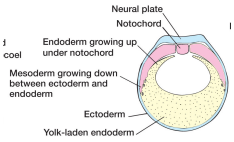
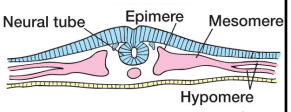
Major Tissue Regions After Gastrulation

- The embryo has three primary layers that undergo many interactions in order to evolve into organ, bone, muscle, skin or neural tissue.
  - The outside layer is the ectoderm
    - (skin, neural tissue),
  - the middle layer is the mesoderm
    - (skeleton, cardiac) and
  - inner layer is the endoderm
    - (digestion, respiratory).

Major Tissue Regions After Gastrulation

- Skin ectoderm
- Neural ectoderm
- Notochordal mesoderm
- Lateral mesoderm
- Endoderm

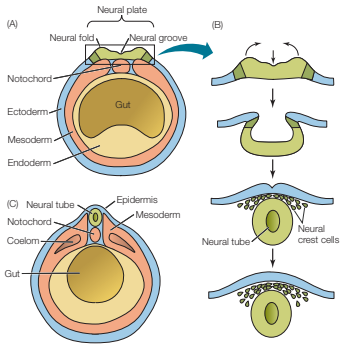




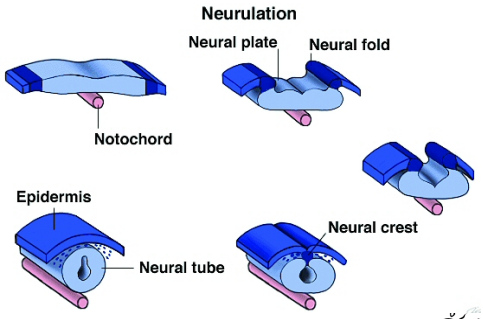
Nurulation

- Development of brain and neural tubes
- Primary neurulation occurs in the anterior region
- Secondary neurulation occurs in the posterior part of the embryo

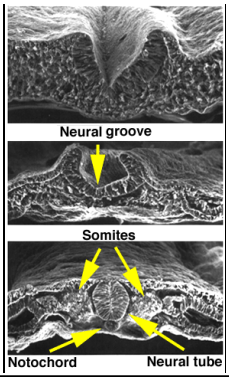
Nurulation



Nurulation



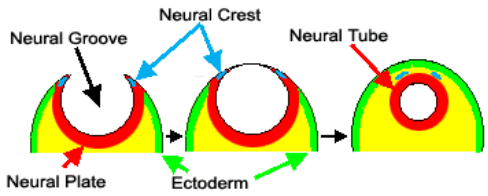
Nurulation



Nurulation

- The skin and neural tissue arise from a single layer, known as the ectoderm
  - In response to signals provided by an adjacent layer, known as the mesoderm.
  - A number of molecules interact to determine whether the ectoderm becomes neural tissue or develops in another way to become skin

Nurulation



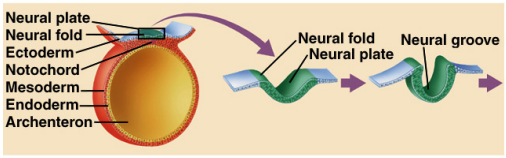
Nurulation

Neurulation

- the cells above the notochord roll into a tube that pinches off
  - = the neural tube (becomes the spinal cord)

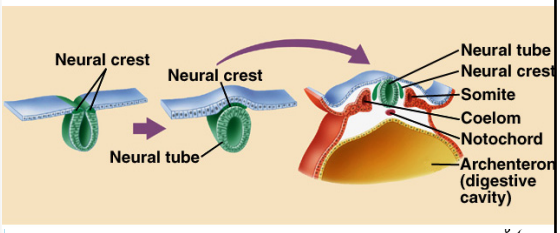
Nurulation

Neural Tube Formation (1)



Nurulation

Neural Tube Formation (2)



Neural Tube Formation of the Amphioxus

1. Folding up of tissue at junction of future skin ectoderm and neural ectoderm areas; the two tissues separate as this fold forms

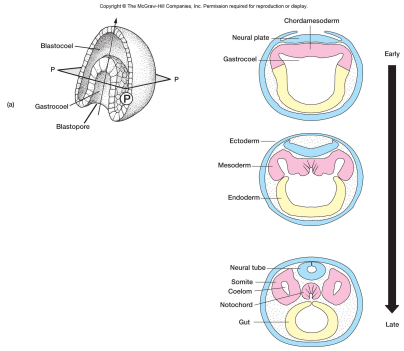
1. Skin ectoderm grows over the top of neural ectoderm

Neural Tube Formation of the Amphioxus

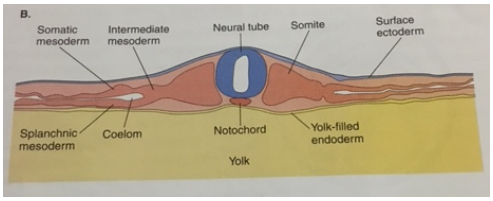
3. Beneath "skin," lateral margins of neural ectoderm grow upward and together to form tube

4. Tube first closes at midpoint, progresses anteriorly and posteriorly. Anterior end opens to surface as *neuropore*, posterior end forms common opening with blastopore (becomes anus) forming *neurenteric canal*.

Neural Tube Formation of the Amphioxus



Neural Tube Formation of the Vertebrates



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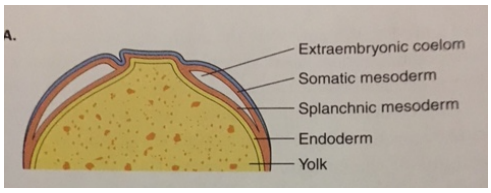

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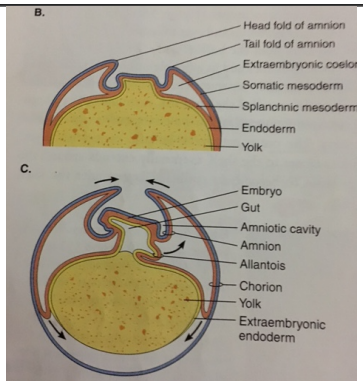

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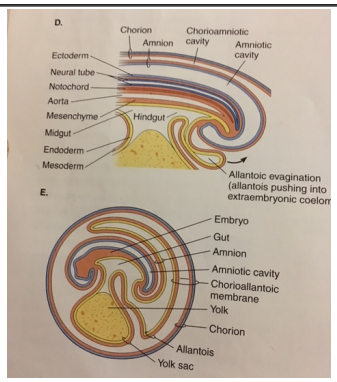
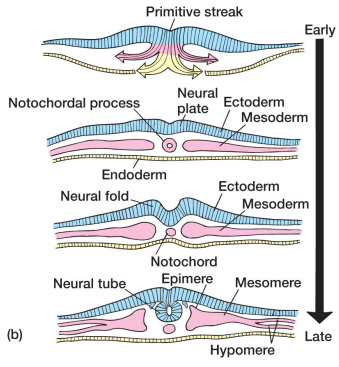


Neural Tube Formation of the Vertebrates

1. Formation of neural folds along margins of skin-neural ectoderm
2. Mid-dorsal meeting of folds, simultaneous with joining of skin ectoderm
3. During folding, high crests of tissue are formed on either side = *neural crest cells*

Neural Tube Formation of the Vertebrates



Gastrulation and Neurulation in Mammals

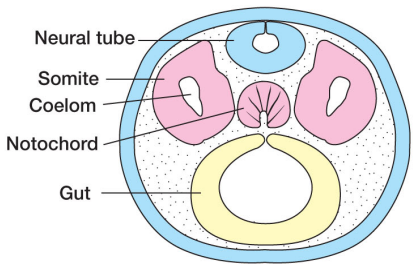
Neural Tube Formation of the Vertebrates

- Majority of body structures are mesodermal in origin.
- *Notochordal Mesoderm* rapidly rounds up and separates from lateral mesoderm, forming a discrete cylinder = *notochord*.
  - Notochord is much reduced or obliterated in most adult vertebrates, but forms the center around which vertebral formation occurs.

Neural Tube Formation of the Vertebrates

- *Lateral Mesoderm* – Amphioxus
  - Mesoderm forms paired series of segmentally arranged blocks = *somites*.
  - From their initiation, somites have a cavity inside = *coelomic cavity*.

Neural Tube Formation of the Vertebrates



Notochordal and lateral mesoderm in Amphioxus

Mesoderm Development

- **Lateral Mesoderm** – Vertebrates
- Initially there is no segmentation of mesoderm; instead forms as a continuous sheet without a central cavity.
- Mesodermal differentiation occurs from dorsal midline outward into 3 divisions, each extending the entire length of the body trunk.

Mesoderm Development

- Differentiation always occurs head-to-tail
- The 3 divisions are:

1 Next to neural tube and notochord = *Epimere* (somites). Thicken and subdivide on either side to form longitudinal rows of blocks. This is the first indication of segmentation in vertebrate embryos. Proliferation and differentiation occurs within somite forming:

Mesoderm Development

- *Sclerotome* = portion surrounding notochord and neural tube
- *Dermatome* = outermost portion near skin ectoderm
- *Myotome* = middle portion between and ventral to sclerotome and dermatome

Mesoderm Development

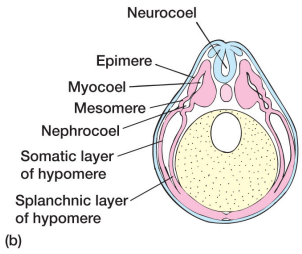
2. Lateral and ventral to somites is a relatively small region of mesoderm, known as intermediate mesoderm or *Mesomere*. This may show segmentation similar to somites.

Mesoderm Development

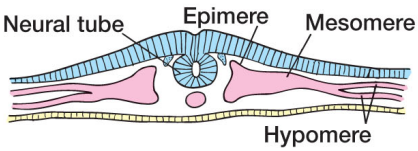
3. Beyond mesomere region, extending ventrolaterally is a sheet of mesoderm known as *lateral plate mesoderm or Hypomere*.

– Apart from cyclostomes, there is no segmentation in this region. Coelomic cavity forms within lateral plate mesoderm, dividing it into:

- *Somatopleure* = external mesoderm + ectoderm
- *Splanchnopleure* = internal mesoderm + endoderm



Mesoderm divisions in Amphibians and Mammals



Mesoderm Development

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TUTORIAL

Shortly after fertilization, the zygote undergoes a series of rapid cell divisions. This is called

- Meiosis
- Gastrulation
- Organogenesis
- Cleavage

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

During cleavage, each cell in the embryo is called a

- Blastula
- Morula
- Gastrula
- Blastomere

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

The solid ball of cells that results from cleavage is called

- Blastula
- Morula
- Gastrula
- Blastomere

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

A fluid filled space called the blastocoel forms inside the embryo - at this point it is a

- Blastula
- Morula
- Gastrula
- Blastomere

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

The stage that results in three germ layers and a primitive gut is the

- Blastula
- Morula
- Gastrula
- Blastomere

Sorry!

- **That is incorrect.**
- Try again!

Congratulations!

- You are correct!

Which of the following is not one of the three primary germ layers formed during gastrulation?

- Endoderm
- Myoderm
- Mesoderm
- Ectoderm

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

The difference in gastrulation found in different types of animals is due primarily to

- The amount of yolk present
- The size of the blastomeres
- Development in different species is completely unrelated
- None of the above

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

Suites of Developmental Characters

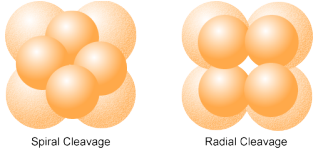
- Two major groups of triploblastic animals:
  - **Protostomes** include flatworms, annelids and mollusks
  - **Deuterostomes** include echinoderms and chordates.

Suites of Developmental Characters

- **Protostomes & deuterostomes are differentiated by:**
  - Spiral vs. radial cleavage
  - Mosaic vs. regulative cleavage
  - Blastopore becomes mouth vs. anus
  - Schizocoelous vs. enterocoelous coelom formation.

Spiral vs Radial Cleavage

- **Spiral cleavage** – occurs in most protostomes.
  - Some ecdysozoans show radial or superficial (insects) cleavage.
- **Radial cleavage** – is found in most deuterostomes.
  - Tunicates and mammals have specialized cleavage patterns.



Spiral Cleavage | Radial Cleavage

Mosaic vs Regulative Development

- **Mosaic development** – cell fate is determined by the components of the cytoplasm found in each blastomere.
  - An isolated blastomere can't develop.
  - Protostomes
- **Regulative development** – the fate of a cell depends on its interactions with neighbors, not what piece of cytoplasm it has.
  - A blastomere isolated early in cleavage is able to from a whole individual (e.g. twins).
  - Deuterostomes

Fate of Blastopore

- Protostome means "first mouth".
- **Blastopore** becomes the mouth.
  - The second opening will become the anus.
- Deuterostome means "second mouth".
- The **blastopore** becomes the anus and the mouth develops as the second opening.

Coelom Formation

- The **coelom** is a body cavity found in many triploblastic organisms that is completely surrounded by mesoderm.
- Not all protostomes have a true coelom.
  - **Pseudocoelomates** have a body cavity between mesoderm and endoderm.
  - **Acoelomates** have no body cavity at all other than the gut.

Coelom Formation

- In protostomes that have a coelom, a mesodermal band of tissue forms *before* the coelom is formed.
- In the process of coelom formation called **schizocoely,** this mesoderm splits to form a coelom.
- In **enterocoely**, the coelom forms as outpocketing of the gut.
- Typical deuterostomes have coeloms that develop by enterocoely.
  - Vertebrates use a modified version of schizocoely.

Radial cleavage is found primarily in which group?

- Protostomes
- Deuterostomes
- Both groups show radial cleavage
- Neither group shows radial cleavage

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

This figure shows

- Radial cleavage
- Spiral cleavage
- A four-cell stage embryo
- A blastula

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

Early in cleavage, a blastomere becomes isolated. It grows into an entire separate individual. This is an example of _____ development found in _____.

- Mosaic, protostomes
- Mosaic, deuterostomes
- Regulative, protostomes
- Regulative, deuterostomes

Sorry!

- **That is incorrect.**
- Try again!

Congratulations!

- You are correct!

The blastopore will become the mouth in

- Protostomes
- Deuterostomes
- All animals
- Neither – it forms something else

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

"Coel" is a word-part that we see frequently. The blastocoel is the space inside the blastula, the coelom is a mesoderm-lined body cavity. What will you find associated with "coel" words?

- An organ like the heart
- A proliferation of cells
- A cavity or space
- It indicates a developmental stage

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

Most protostomes show this type of coelom formation where a band of mesoderm splits to form the coelom.

- Enterocoely
- A modified version of enterocoely
- Schizocoely
- A true coelom is never found in protostomes

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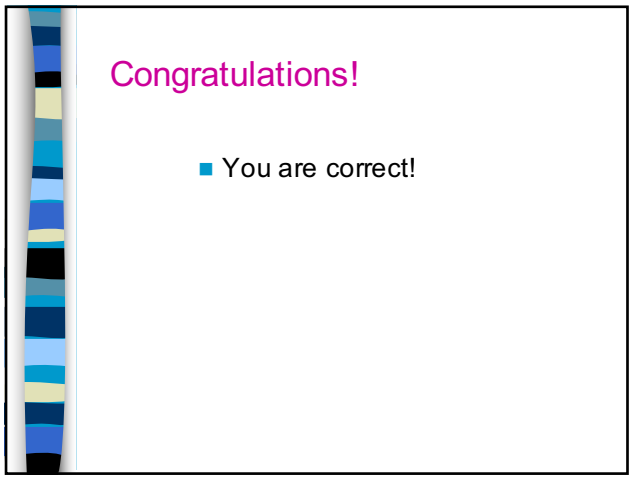
- That is incorrect.
- Try again!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