

Lecture - Mesoderm Development

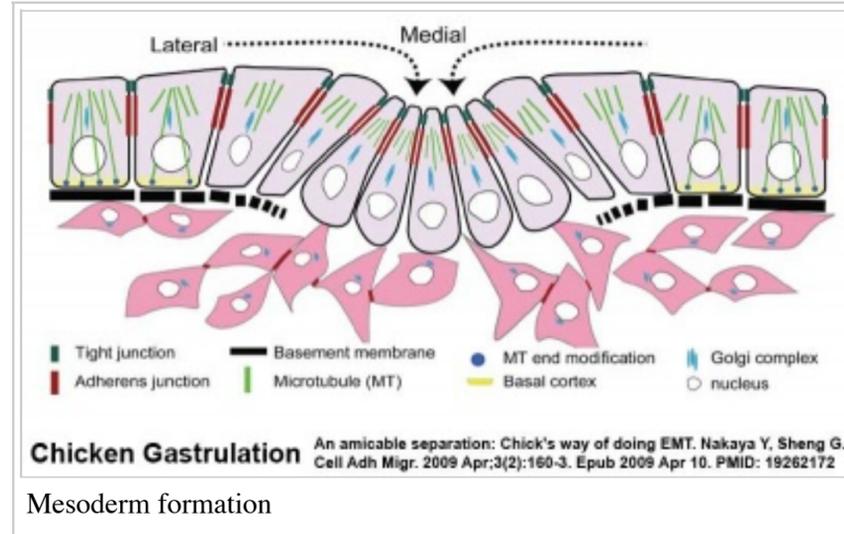
From Embryology

Contents

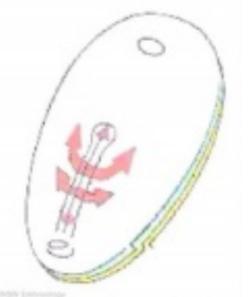
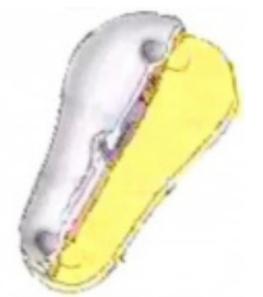
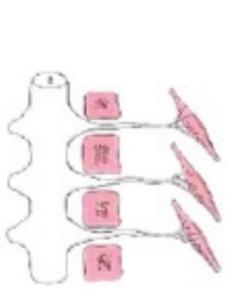
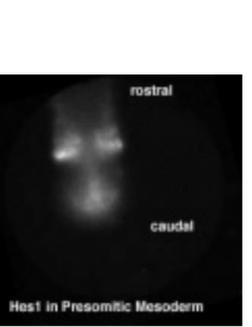
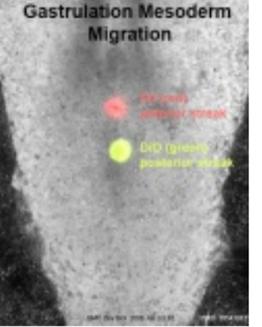
Objectives

- Understanding of events during the third week of development
- Understanding the process of early somite development
- Understanding the process of body cavity formation
- Brief understanding of the future fate of mesoderm components
- Brief understanding of early heart formation

Lecture Resources



Movies [Collapse]

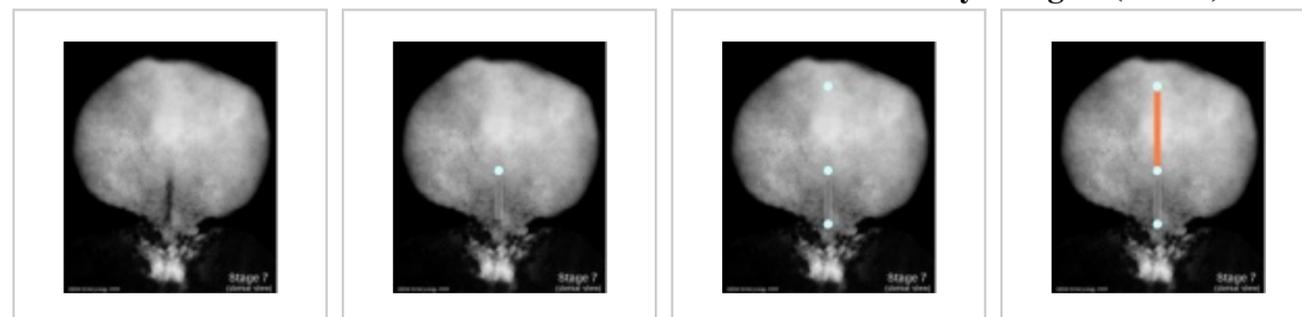
 <p>Week 3 Mesoderm Page Play</p>	 <p>Week 3 Notochord Page Play</p>	 <p>Week 3 Notochord Page Play</p>	 <p>Vertebra Page Play</p>	 <p>Musculoskeletal Page Play</p>
 <p>Somitogenesis Page Play</p>	 <p>Mesoderm Move Page Play</p>			

 <p>Hill, M.A. (2014). <i>UNSW Embryology</i> (14th ed.) Retrieved August 17, 2014, from http://php.med.unsw.edu.au/embryology</p>	<ul style="list-style-type: none"> ▪ Week 4 Mesoderm Somitogenesis ▪ Lecture Archive: 2011 (http://php.med.unsw.edu.au/embryology/index.php?title=Lecture_-_Mesoderm_Development&oldid=61931) 2012 (http://php.med.unsw.edu.au/embryology/index.php?title=Lecture_-_Mesoderm_Development&oldid=97926) 2013
 <p>Moore, K.L., Persaud, T.V.N. & Torchia, M.G. (2011). <i>The developing human: clinically oriented embryology</i> (9th ed.). Philadelphia: Saunders.</p>	<p>The following chapter links only work with a UNSW connection.</p> <ul style="list-style-type: none"> ▪ Chapter 4 – Third Week of Human Development (http://er.library.unsw.edu.au/er/cgi-bin/eraccess.cgi?url=http://www.mdconsult.com/books/page.do?eid=4-u1.0-B978-1-4377-2002-0..00004-7&isbn=978-1-4377-2002-0&uniqId=330028653-2#4-u1.0-B978-1-4377-2002-0..00004-7) ▪ Chapter 5 – Fourth to Eighth Weeks of Human Development (http://er.library.unsw.edu.au/er/cgi-bin/eraccess.cgi?url=http://www.mdconsult.com/books/page.do?eid=4-u1.0-B978-1-4377-2002-0..00005-9&isbn=978-1-4377-2002-0&uniqId=330028653-2#4-u1.0-B978-1-4377-2002-0..00005-9) ▪ Chapter 15 - Muscular System (http://er.library.unsw.edu.au/er/cgi-bin/eraccess.cgi?url=http://www.mdconsult.com/books/page.do?eid=4-u1.0-B978-1-4377-2002-0..00015-1&isbn=978-1-4377-2002-0&uniqId=330028653-2#4-u1.0-B978-1-4377-2002-0..00015-1)
 <p>Schoenwolf, G.C., Bleyl, S.B., Brauer, P.R. & Francis-West, P.H. (2009). <i>Larsen's human embryology</i> (4th ed.). New York; Edinburgh: Churchill Livingstone.</p>	<p>The following chapter links only work with a UNSW connection.</p> <ul style="list-style-type: none"> ▪ Chapter 3 - Third Week: Becoming Trilaminar and Establishing Body Axes (http://www.mdconsult.com/books/linkTo?type=bookPage&isbn=978-0-443-06811-9&eid=4-u1.0-B978-0-443-06811-9..10003-X) ▪ Chapter 4 - Fourth Week: Forming the Embryo (http://www.mdconsult.com/books/linkTo?type=bookPage&isbn=978-0-443-06811-9&eid=4-u1.0-B978-0-443-06811-9..10004-1) ▪ Chapter 8 - Development of the Musculoskeletal System (http://www.mdconsult.com/books/linkTo?type=bookPage&isbn=978-0-443-06811-9&eid=4-u1.0-B978-0-443-06811-9..10008-9)

ECHO360 Recording [Expand]

Notochord (Axial mesoderm)

Embryo Stage 7 (dorsal)



Stage 7 embryonic disc

Primitive node and streak

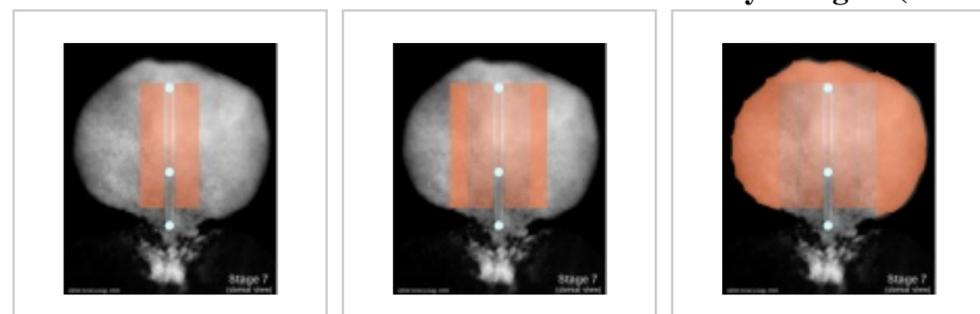
Oral and cloacal membranes

Axial process

Mesoderm

- generated from epiblast cells migrating through the primitive streak
- epiblast cells expressing fibroblast growth factor (FGF2)
- forms a layer between ectoderm and endoderm with notochord down midline
- present before neural tube formation
- divides initially into 3 components

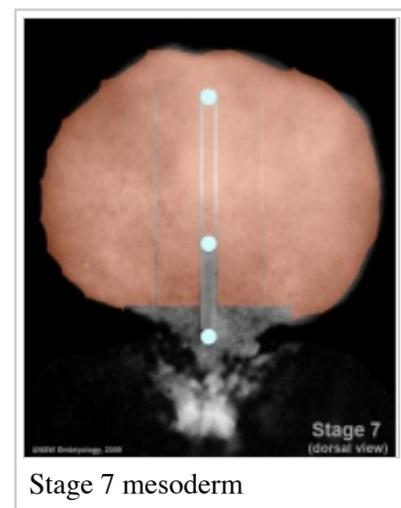
Embryo Stage 7 (dorsal)



paraxial mesoderm

intermediate mesoderm

lateral plate



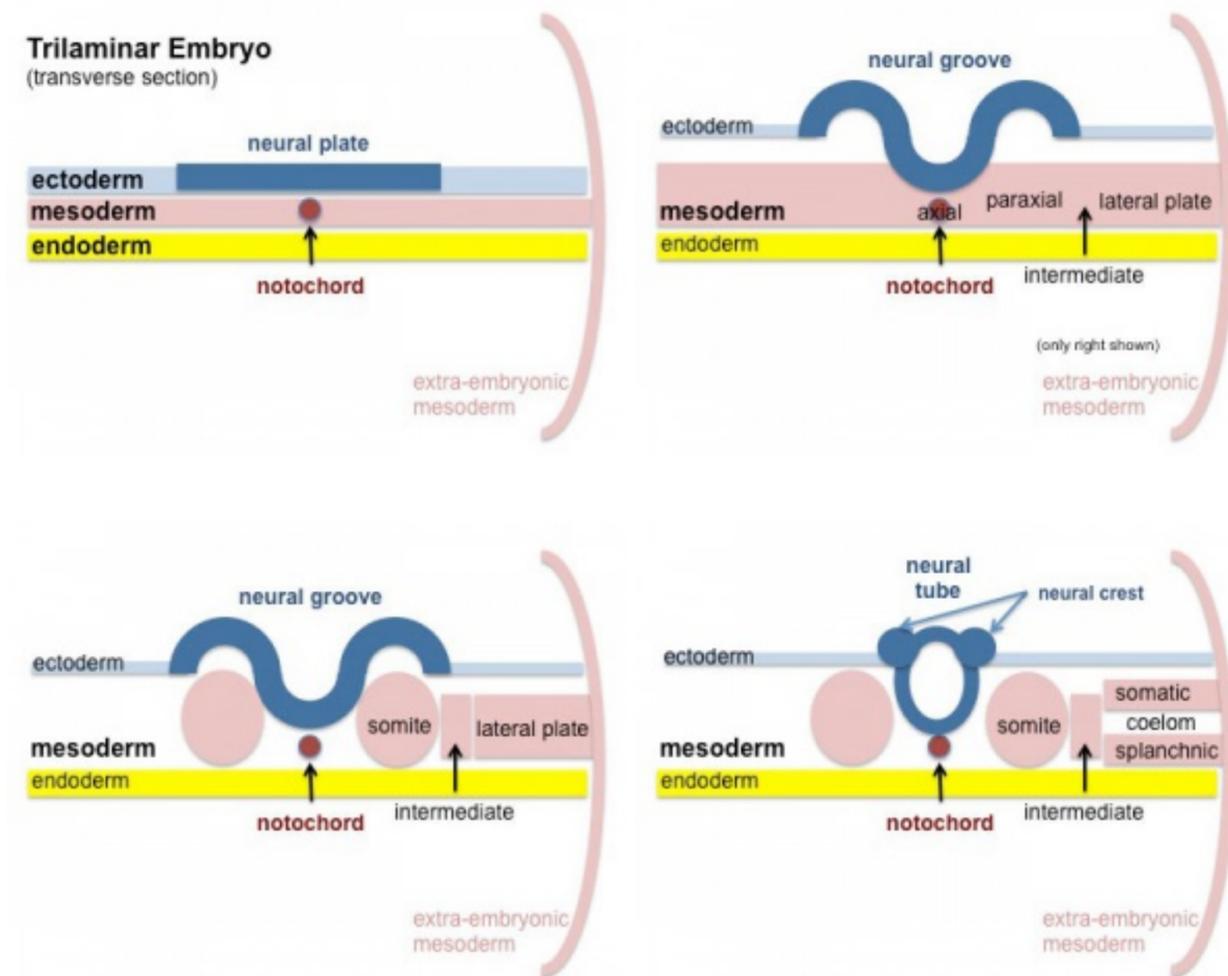
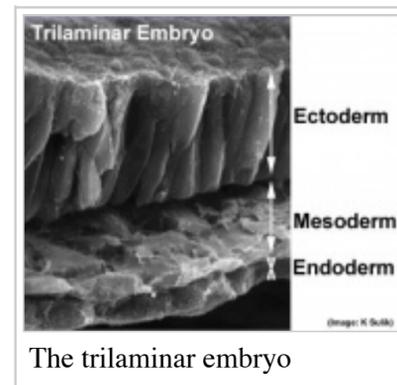
Stage 7 mesoderm

- **Paraxial mesoderm** - somites - musculoskeletal structures
- **Intermediate mesoderm** - urogenital (kidney and genital)
- **Lateral plate mesoderm** - body wall, body cavities, cardiovascular and GIT structures

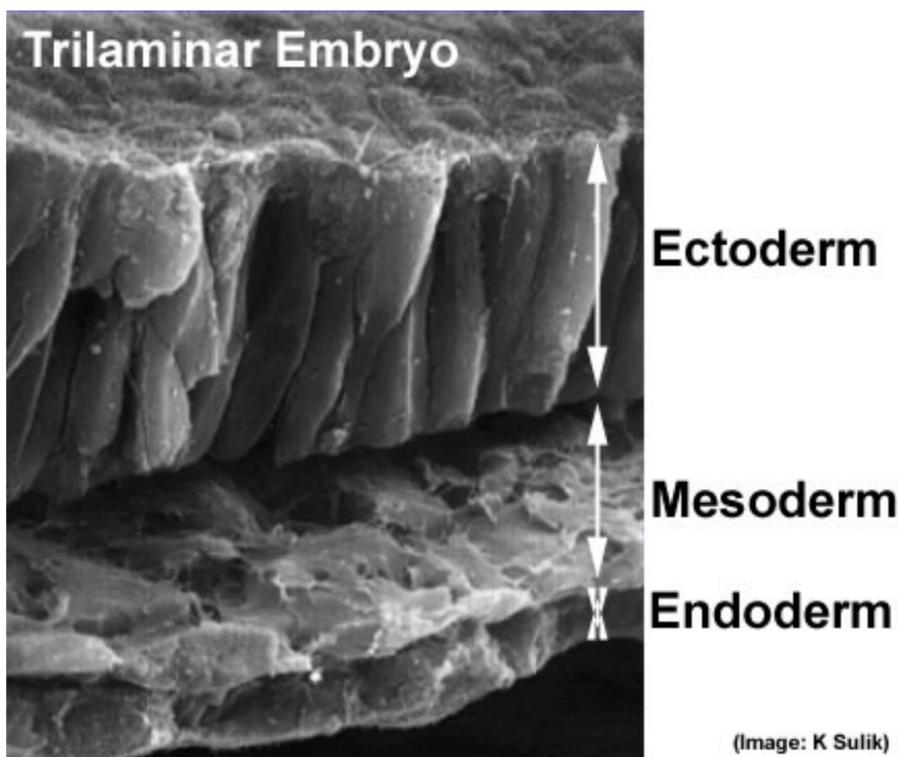
[File:Mesoderm-cartoon1.jpg]

Mesoderm Development

The four images below beginning at week 3 show cross-sections of the trilaminar embryo and the sequence of mesoderm development.



Mesoderm Overview



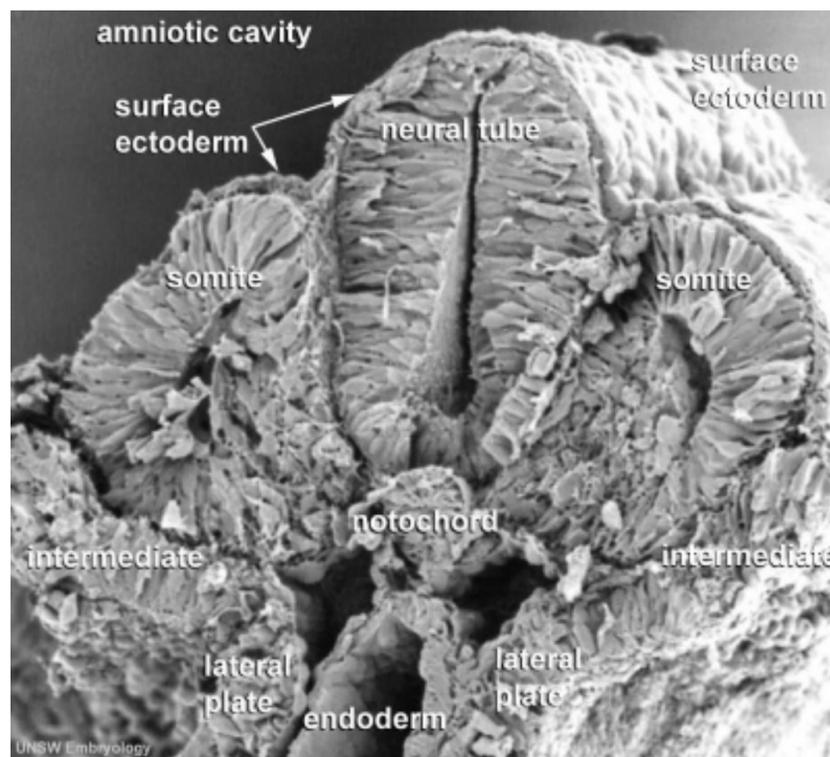
Week 3

Trilaminar embryo

Compare this week 3 trilaminar embryo with the week 4 embryo.

- **Mesenchyme** - embryonic connective tissue, describes the cell morphology (developmental transitions: epithelial to mesenchymal, mesenchymal to epithelial)

(Note - 2 these images are not to scale)



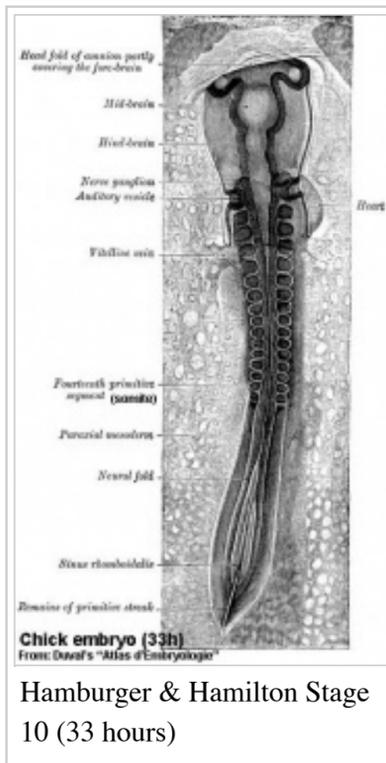
Week 4

Scanning electron micrograph of a cross-section of a human embryo at week 4 (stage 11).

Note the mesoderm structures now present and their relative position and size within the embryo.

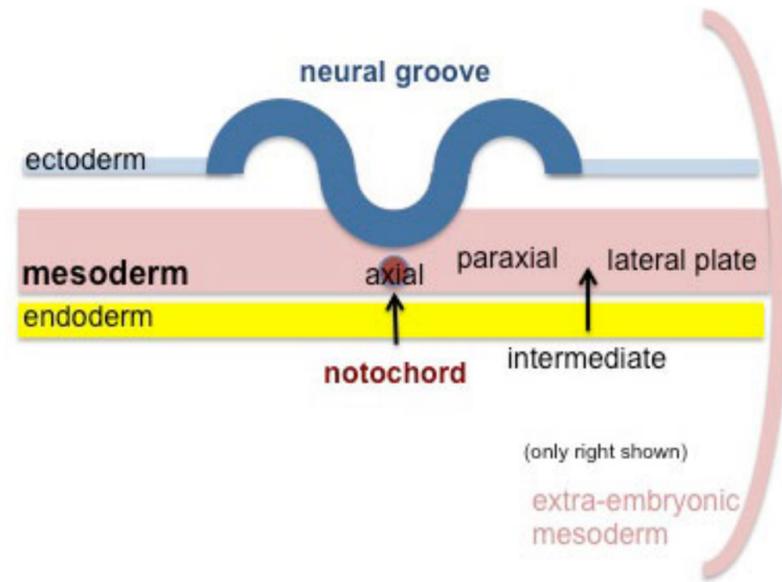
Compare the mesoderm structures to those formed by ectoderm (neural tube and epidermis) and endoderm (epithelia of developing gastrointestinal tract).

Paraxial Mesoderm



Hamburger & Hamilton Stage 10 (33 hours)

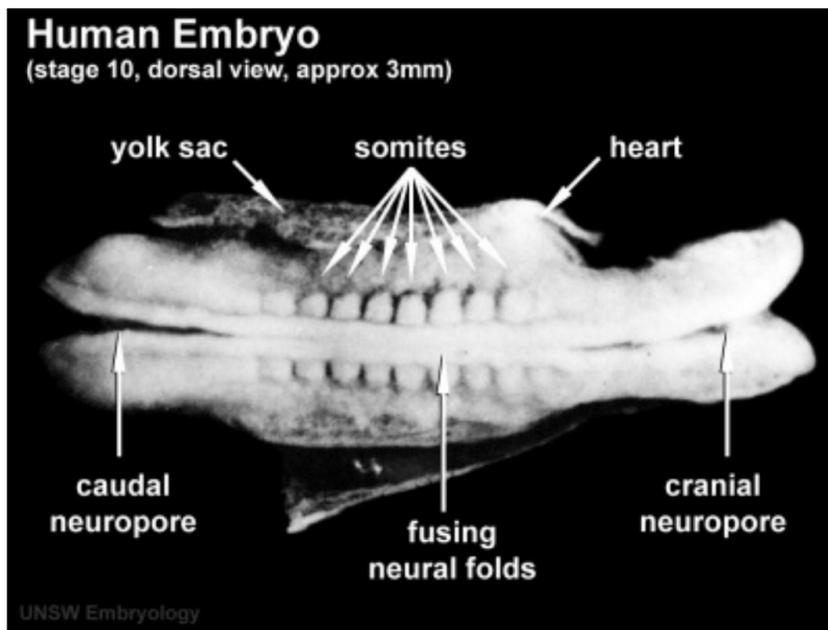
- lies adjacent to axial mesoderm (notochord) and forms 2 components:
 - Head - unsegmented paraxial mesoderm
 - Body - segmented paraxial mesoderm
- Generates trunk muscles, skeleton, dermis of skin, blood vessels, connective tissue



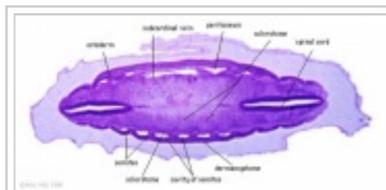
Segmented Paraxial Mesoderm

- segments called **somites** - transient embryonic structures.
- first pair of somites (day 20)
- segmentation imposes a pattern on nerves, vasculature, vertebra....
- somites appear in ordered sequence cranial to caudal
- appearance so regular used to stage the embryo (Hamburger & Hamilton 1951-chicken)
 - thought to be generated by a "clock" (1 pair every 90 minutes)
 - neural tube begins to close at 4th somite level, 44 pairs of somites

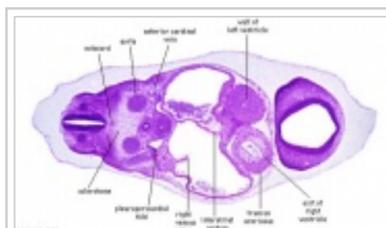
Somite Formation



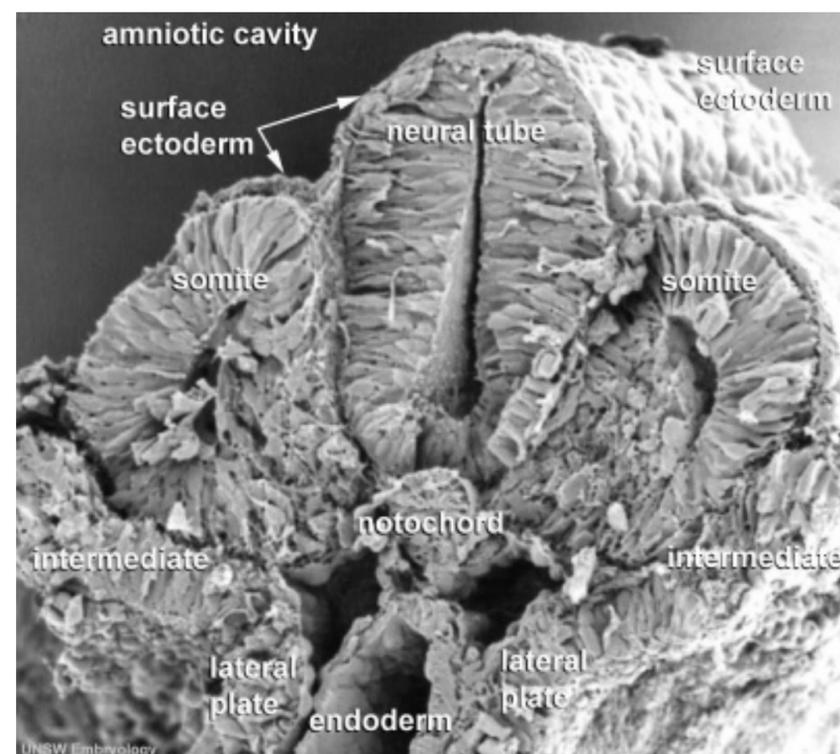
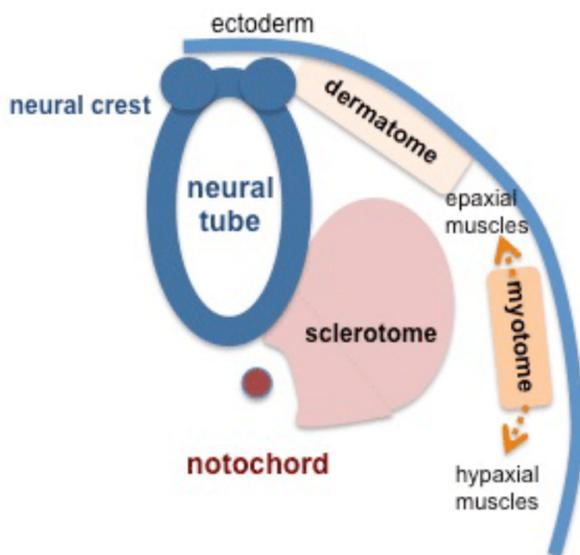
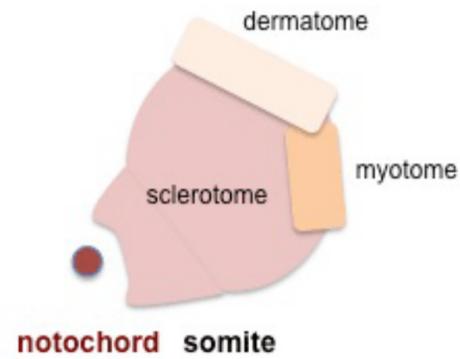
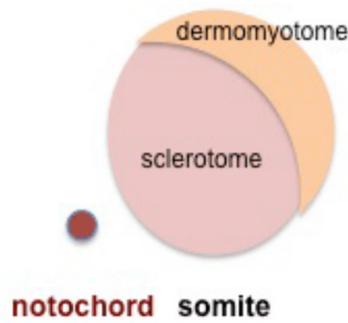
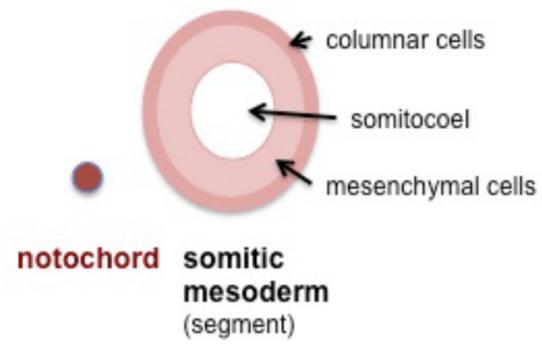
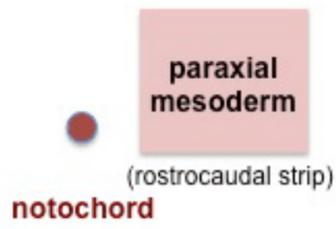
Carnegie stage 9 scanning electron microscope image showing somite formation



Carnegie stage 13 somitocoel



Carnegie stage 13 sclerotome



- ball forms through epithelialization and interactions (cell-cell, cell-extracellular matrix, ECM) fibronectin, laminin
- has 2 populations of cells - peripheral columnar and central mesenchymal
- early somite has cavity- somitocoel, cavity is lost during growth
- somite enclosed by ECM connected to nearby tissues

Somite Specification

- Different segmental level somites have to generate different segmental body structures?
- somite has to form different tissues?
- Somite Differentiation
- Compartmentalization accompanied by altered patterns of expression of Pax genes within the somite

- rostro-caudal axis appears regulated by Pax/Hox expression, family of DNA binding transcription factors

Somite initially forms 2 main components

- ventromedial- **sclerotome** forms vertebral body and intervertebral disc
- dorsolateral - **dermomyotome** forms dermis and skeletal muscle

Sclerotome

- sclerotome later becomes subdivided
- rostral and caudal halves separated laterally by von Ebner's fissure
 - half somites contribute to a single vertebral level body
 - other half intervertebral disc
- therefore final vertebral segmentation, "shifts"

Dermomyotome

- later divides into dorsal **dermatome** and ventral **myotome**
 - This topic of muscle and skeleton development will be covered in 2 later lectures (Musculoskeletal Development and Limb Development)
- lateral myotome edge migrates at level of limbs
- upper limb first then lower
- mixes with somatic mesoderm
- dermatome continues to contribute cells to myotome

Myotome

- Myotome component of Somite
 - epaxial myotome (dorsomedial quarter) forms the dorsal epimere (erector spinae)
 - hypaxial myotome (dorsolateral quarter) forms the ventral hypomere, 3 primary muscle layers which are different at neck, thorax and abdomen

Muscle

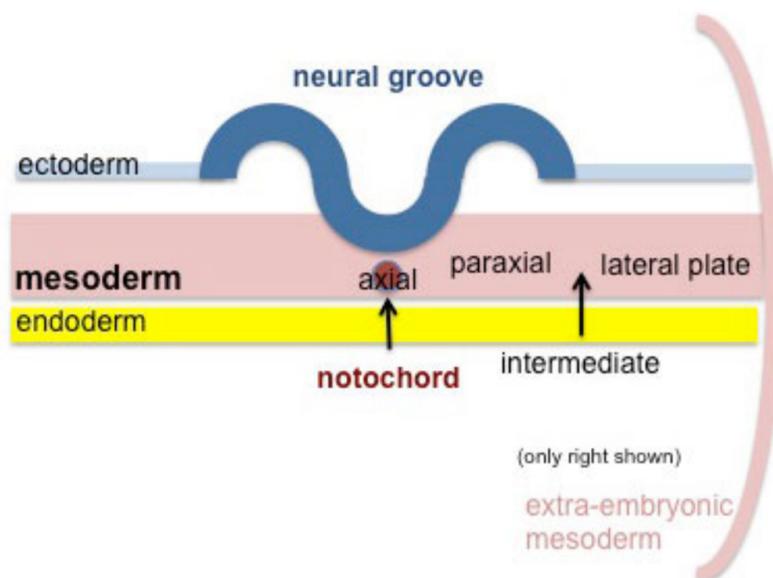
- Myoblast determining transcription factor MyoD is first expressed in the dorsomedial quadrant of the still epithelial somite whose cells are not yet definitely committed
 - basic Helix Loop Helix
 - from myotome

Muscle Development Abnormalities

- Duchenne Muscular Dystrophy
 - Embryonic muscle development normal and changes occur postnatally
 - X-linked dystrophy, large gene encoding cytoskeletal protein - Dystrophin
 - progressive wasting of muscle, die late teens
- Becker Muscular Dystrophy, milder form, adult onset

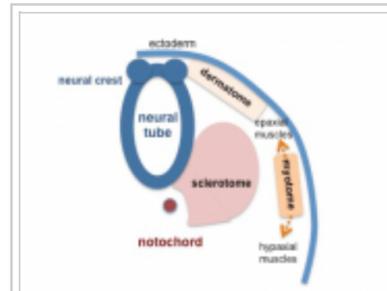
Intermediate Mesoderm

- lies between paraxial and lateral mesoderm
- generates urogenital system
 - Wolffian duct, kidney
 - **MH** - covered in Kidney Development Lecture/Laboratory

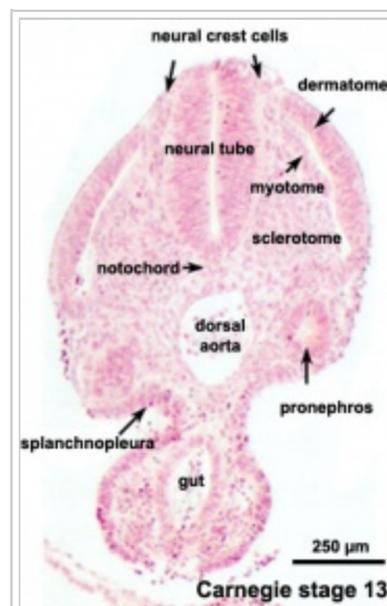


Lateral Plate Development

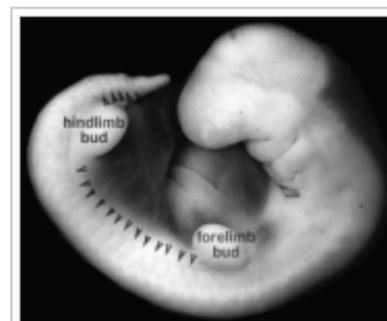
- lying at the surrounding edge of the embryonic disc
- a cavity begins in this week to form within the mesoderm itself



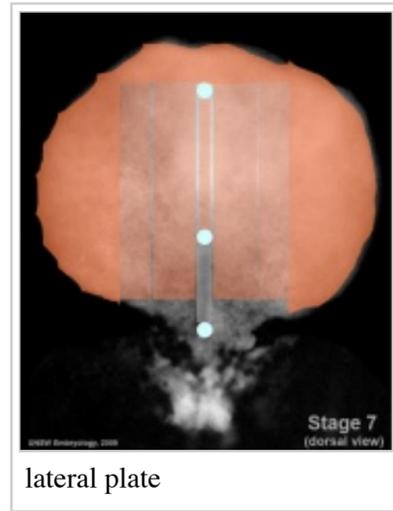
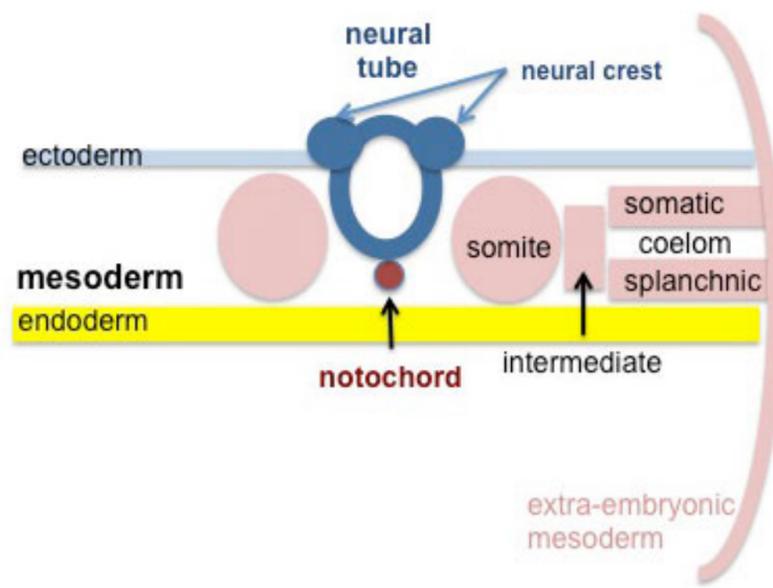
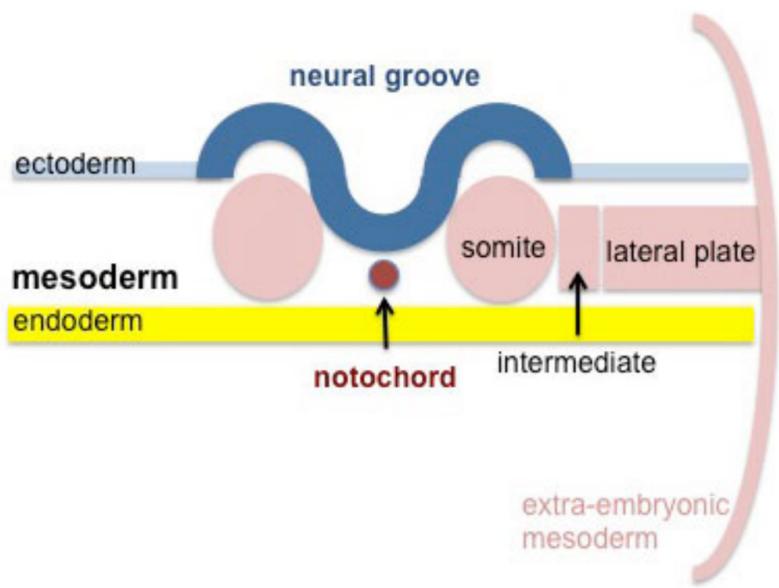
Somite Specification



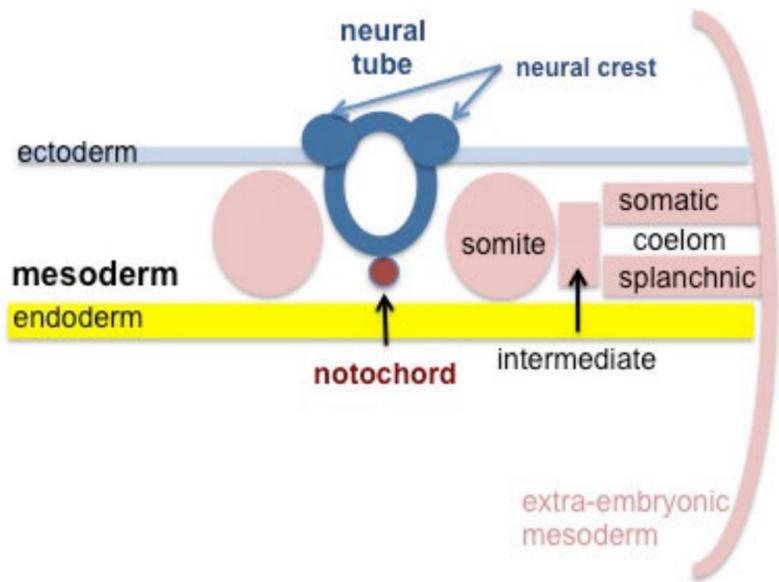
Human embryo (Carnegie stage 13) caudal trunk



Stage 14 Embryo showing somites and limb buds (Week 5)



Intraembryonic Coelom



- small spaces (vacuoles) begin appearing within the lateral plate mesoderm
- enlarge forming a single cavity within the lateral plate mesoderm
 - divides lateral plate mesoderm into 2 parts at about day 18-19
- this cavity is called the **Intraembryonic Coelom**
- when the embryonic disc folds the intraembryonic coelom will form all 3 major body cavities:

1. **Pericardial**
2. **Pleural**
3. **Peritoneal**

Coelom is a general term for a "cavity" and can lie within the embryo (intraembryonic) and outside the embryo (extra embryonic). Later anatomical spaces within the embryo and fetus can also be described as coeloms.

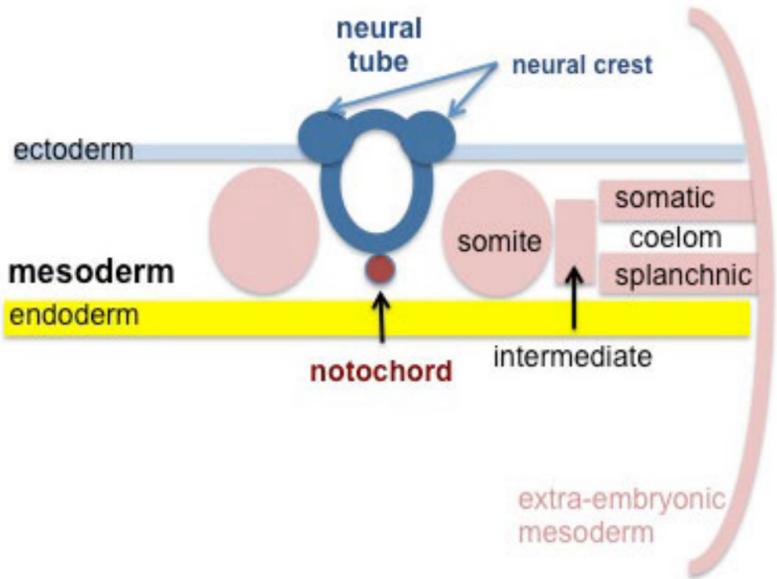
Somatic Mesoderm

The intraembryonic coelom divides the lateral plate into 2 portions

- closest to ectoderm
- body wall osteogenic, chondrogenic and fibrogenic
- except ribs and scapula

Splanchnic Mesoderm

- lies closest to endoderm
- prechordal splanchnic mesoderm - cardiac mesoderm
- splanchnic mesoderm - smooth muscle of gastrointestinal tract (GIT) and blood vessels

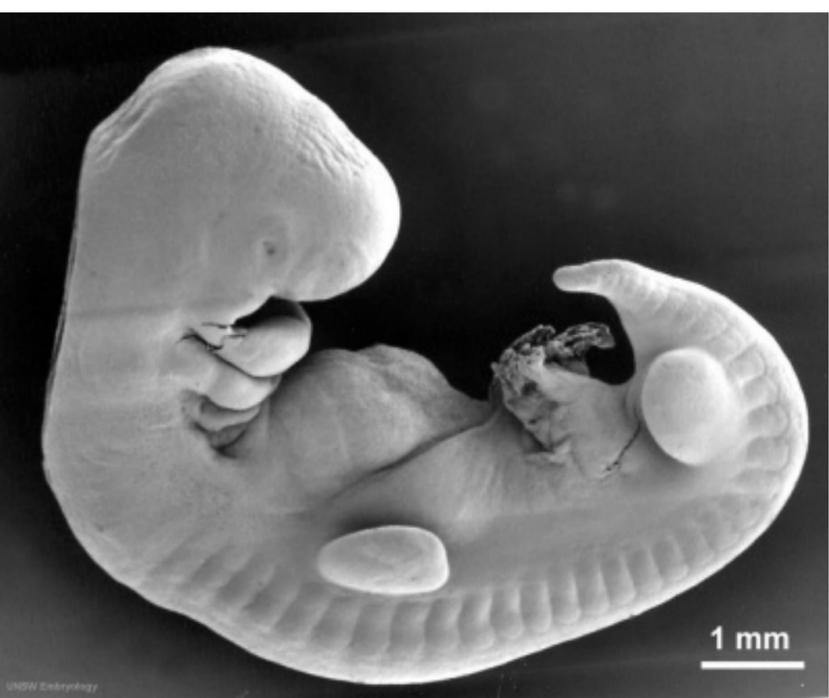


Carnegie Stages: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | About Stages | Timeline

Somitogenesis

Stage	Days (approx)	Size (mm)	Images (not to scale)	Events
7	15 - 17 (week 3)	0.4		gastrulation, notochordal process
8	17 - 19	1.0 - 1.5		primitive pit, notochordal canal
9	19 - 21	1.5 - 2.5		Somite Number 1 - 3 neural folds, cardiac primordium, head fold
10	22 - 23 (week 4)	2 - 3.5		Somite Number 4 - 12 neural fold fuses
11	23 - 26	2.5 - 4.5		Somite Number 13 - 20 rostral neuropore closes
12	26 - 30	3 - 5		Somite Number 21 - 29 caudal neuropore closes
13	28 - 32 (week 5)	4 - 6		Somite Number 30 leg buds, lens placode, pharyngeal arches

Stage 13/14 shown in serial embryo sections series of Embryology Program



Stage 14

Links: Somitogenesis

2014 Course: **Week 2** Lecture 1 Lecture 2 Lab 1 | **Week 3** Lecture 3 Lecture 4 Lab 2 | **Week 4 Lecture 5** Lecture 6 Lab 3 | **Week 5** Lecture 7 Lecture 8 Lab 4 | **Week 6** Lecture 9 Lecture 10 Lab 5 | **Week 7** Lecture 11 Lecture 12 Lab 6 | **Week 8** Lecture 13 Lecture 14 | Lab 7 | **Week 9** Lecture 15 Lecture 16 Lab 8 | **Week 10** Lecture 17 Lecture 18 Lab 9 | **Week 11** Lecture 19 Lecture 20 Lab 10 | **Week 12** Lecture 21 Lecture 22 Lab 11 | **Week 13** Lecture 23 Lecture 24 Lab 12 | **Student Projects** - Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Group 8 | Moodle (<http://moodle.telt.unsw.edu.au/course/view.php?id=9262>)

Glossary Links

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | Numbers | Symbols

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What Links Here? (http://php.med.unsw.edu.au/embryology/index.php?title=Special:WhatLinksHere/Lecture_-_Mesoderm_Development)

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