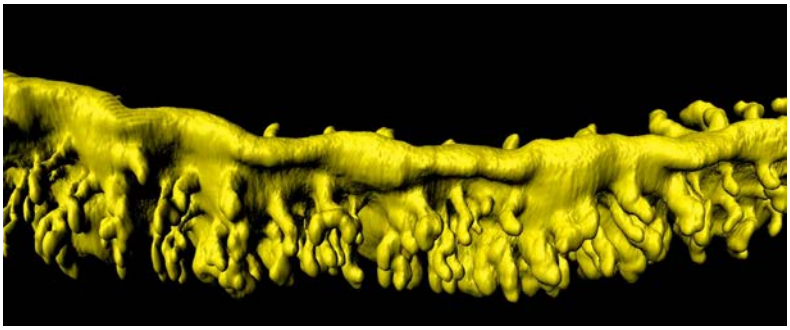
UNC SCHOOL OF MEDICINE

Tissue Organization; How do vertebrates make a spine?



Andrew B. Gladden, PhD; Associate Professor
Department of Pathology & Laboratory Medicine
University of North Carolina at Chapel Hill
Introduction to Pathology of Disease
August 31, 2021

1

Goals for today's class!

- Learn how to describe the orientation of cells and tissue in an organism.
- Understand what the three Germ Layers are and how they are organized.
- Define the proteins in cells that promote cell sorting.
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- Define the different types of epithelial tissues and how skin develops.

2

Try to Think in 3D!
How Can the Cans be Organized?

Poll Question for this slide:
Pick one answer:
What would you do with these cans?

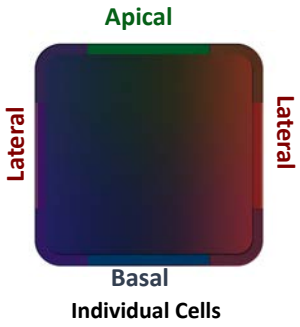
a) Throw them in the recycle bin.
b) Stand them all up.
c) Put them in small groups by color.
d) Place in a group with the tabs in one direction.

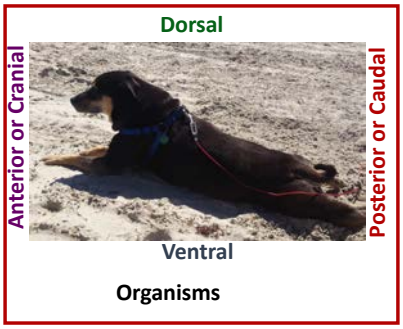
3

Try to Think in 3D! Like This?

4

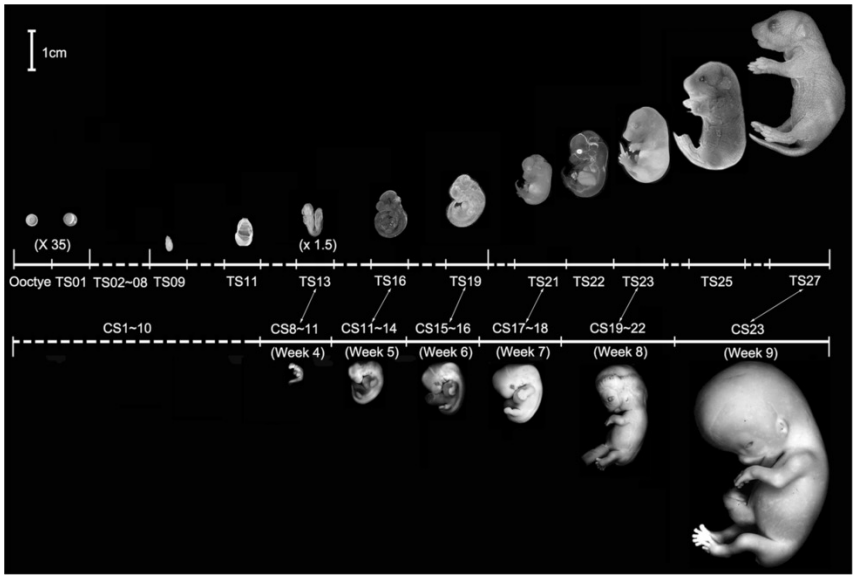
How do you describe orientation in tissue?





5

Mouse versus Human Embryo Development



Xue et al., BMC Genomics 2013

6

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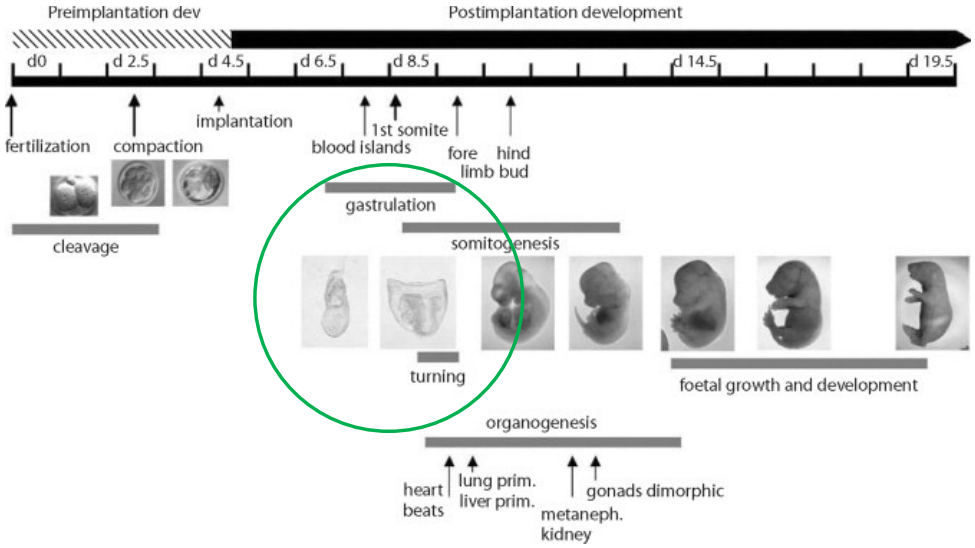
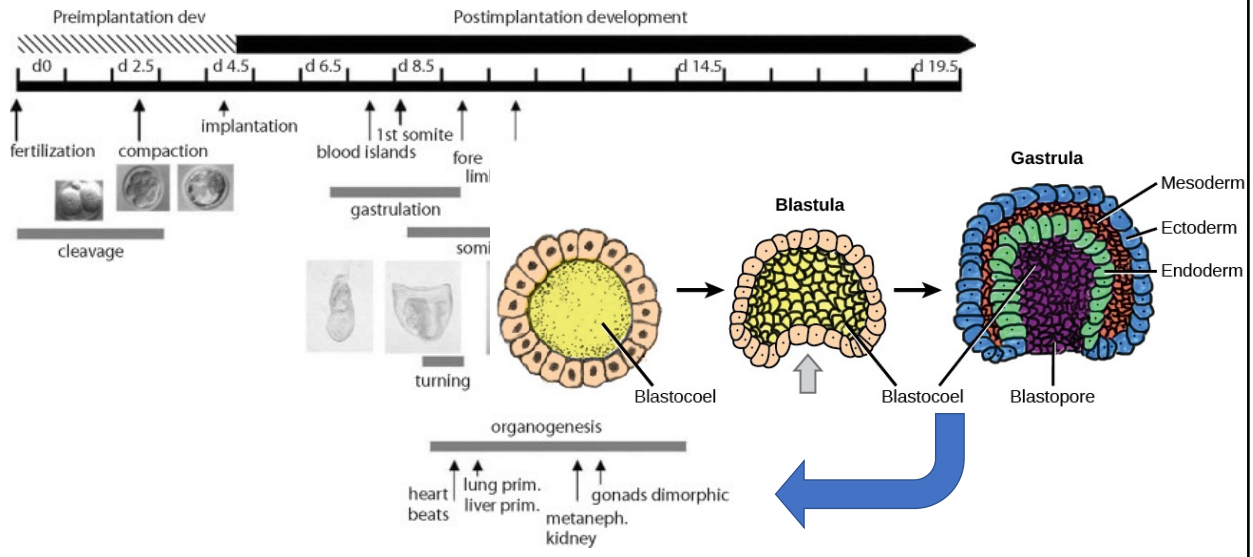
7

The Lab Mouse Developmental Timeline



8

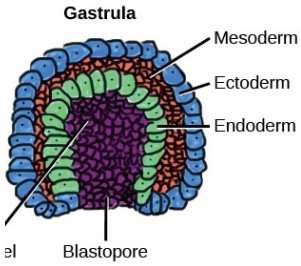
The Three Germ Layers

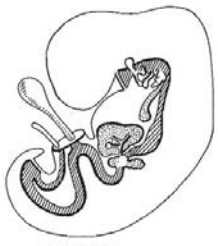


MacCord, Kate, "Germ Layers". *Embryo Project Encyclopedia, 2013.*

9

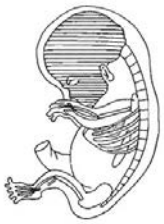
Germ Layer Derivatives





ENTODERM
Epithelium of GI tract
Liver
Pancreas
Urachus
Urinary bladder
Epithelial portions
Pharynx
Thyroid
Trachea, bronchi, lungs
Tympanic cavity
Pharyngotympanic tube
Tonsils
Parathyroids

Endoderm = Entoderm



MESODERM
Skeleton (head and body)
Muscle
Connective tissue
Circulatory system
Cardiovascular
Lymphatic
Urinary system
Spleen
Adrenal cortex
Genital system:
gonads, ducts, accessory glands
Dermis
Dentine of teeth

ECTODERM

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CNS
Retina
Post. pituitary
Pineal gland
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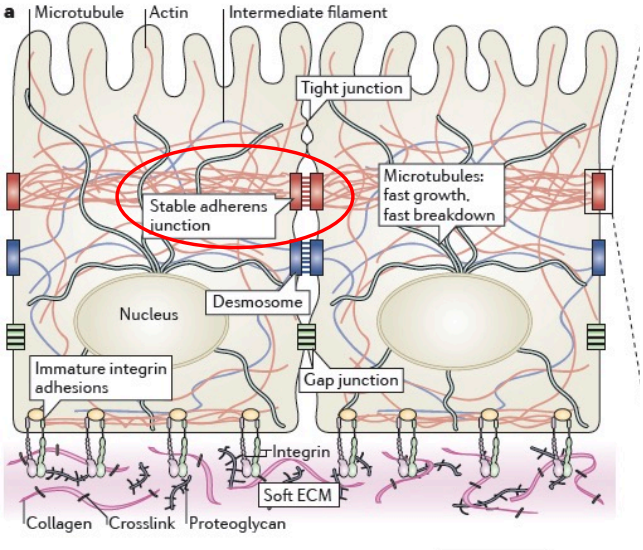
11

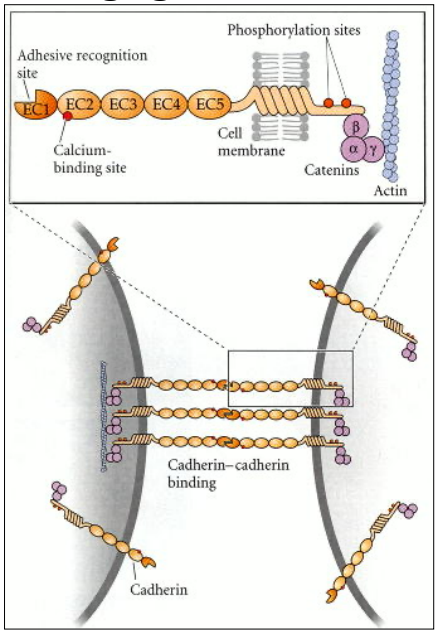
How do cells talk to each other?



Dufort … Weaver. Nature Revs 2011

12

Cadherins Engage in Cell-cell adhesion

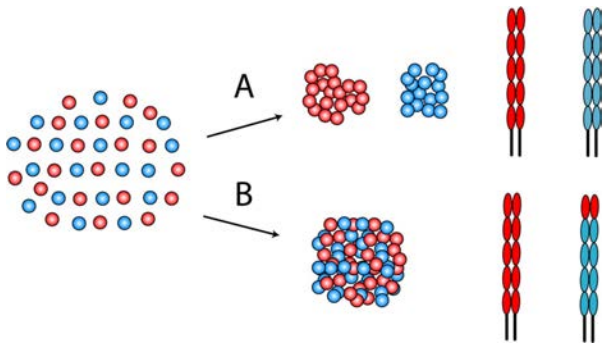


13

Cadherins Sort Cells During Embryo Development

Molecules	Ligands	Distribution
Cadherin E (1)	H	Epithelial
Cadherin N (2)	O	Neural
Cadherin BR (12)	M	Brain
Cadherin P (3)	O	Placental
Cadherin R (4)	P	Retinal
Cadherin M (15)	H	Muscle
Cadherin VE(5) (CD144)	I	Epithelial
Cadherin T and H (13)	L	Heart
Cadherin OB (11)	I	Osteoblast
Cadherin K (6)	C	Brain; kidney

Blue
Red



Niessen Physiol Rev. 2011

14

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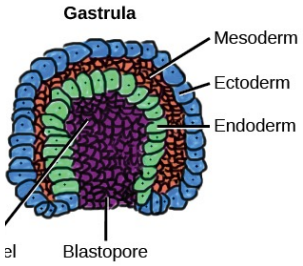
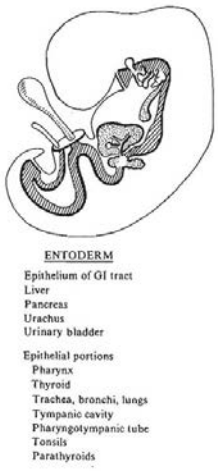
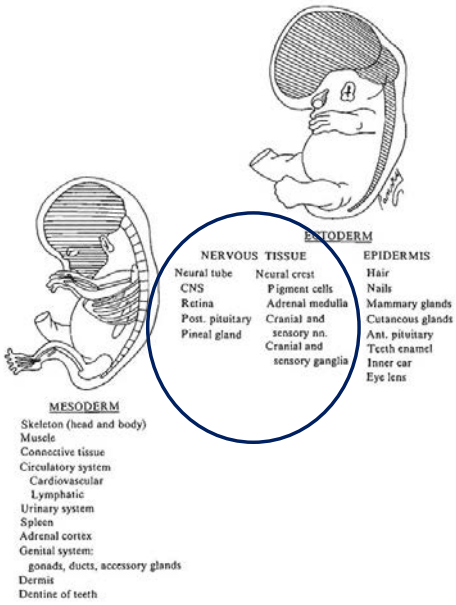
Germ Layer Derivatives





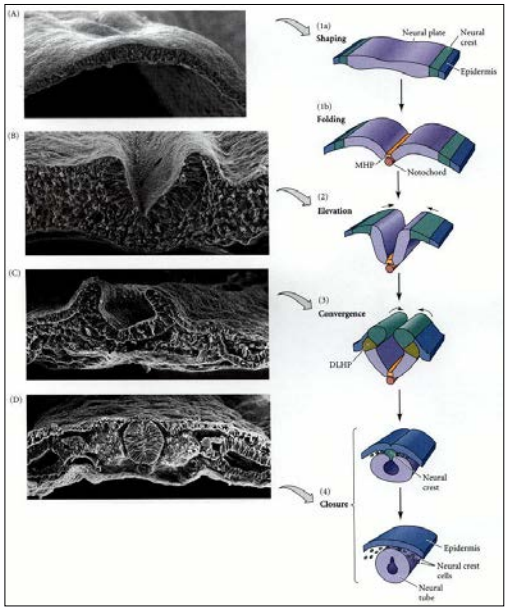
Endoderm = Entoderm



Pansky, B. Review of Medical Embryology, 1982.

16

The Beginning of a Spine!



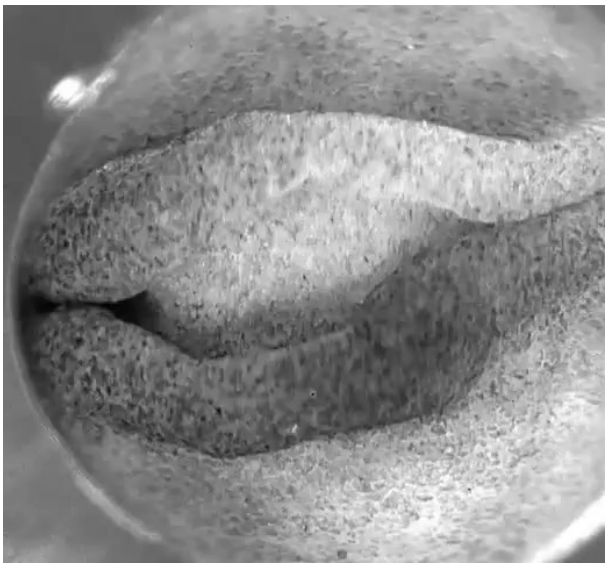
Starts at e8.5 in mouse, completed at e10.5.

Completed the fourth week of pregnancy in humans.

Gilbert SF. Developmental Biology. 6th edition. Sunderland (MA): Sinauer Associates; 2000. Formation of the Neural Tube.

17

The Beginning of a Spine! In Real Time!

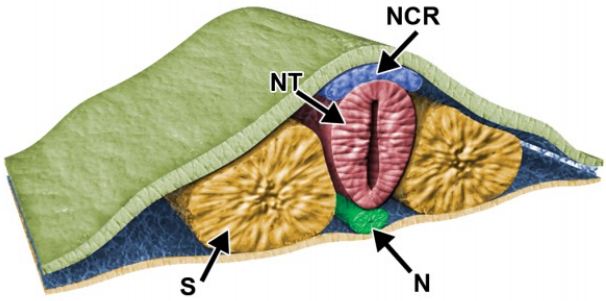


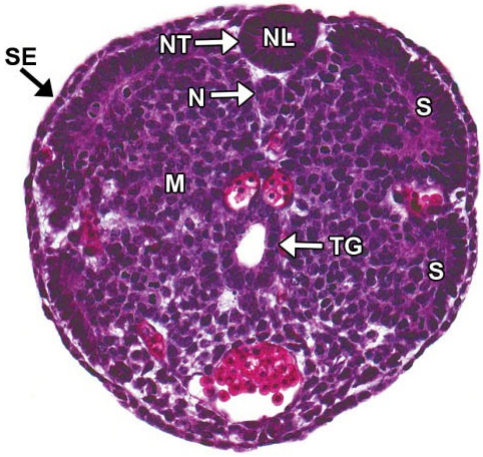
Axoloti embryo:
Tiger Salamander or
Mexican Salamander

Wallingford, J.B., Harland, R.M. Development, 2002, 12:5815-5825.

18

The Beginning of a Spine! In Still Time!





NT = Neural Tube
N. = Notocord
TG = Tail gut
S. = Somite
NCR = Neural Crest Cells
M. = Mesenchyme

Chen, VS, et al. Toxicologic Pathology, 2017.

19

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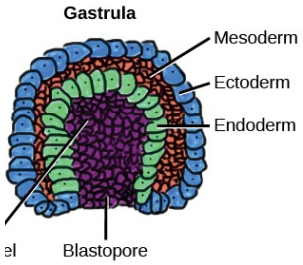

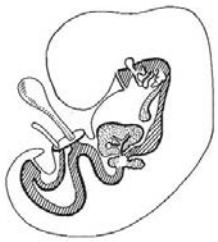

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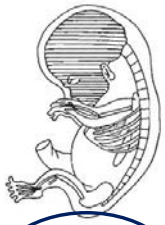

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Cutaneous glands
Ant. pituitary
Teeth enamel
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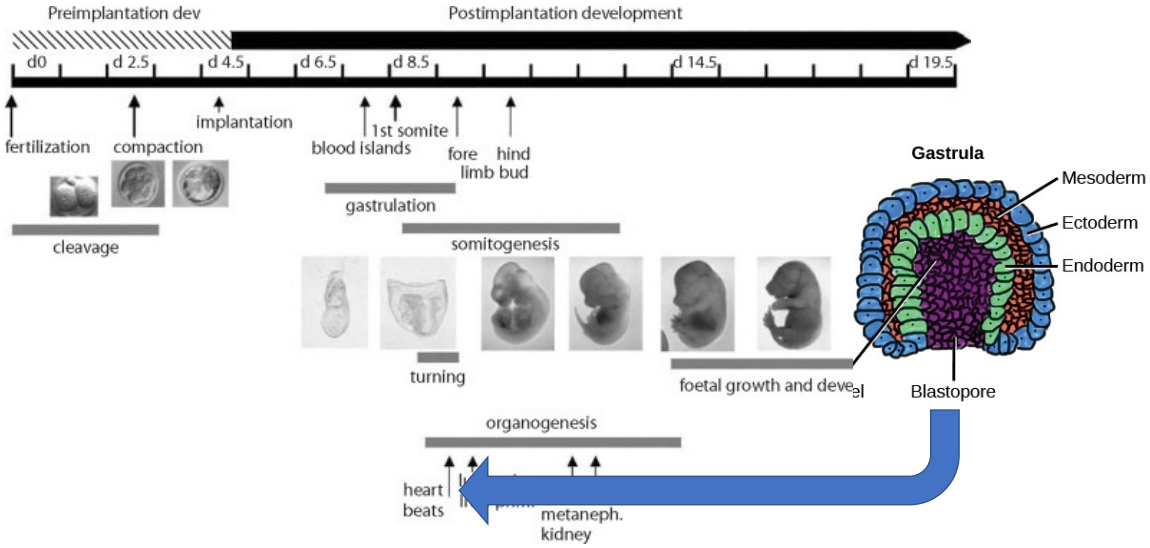
Eye lens

Pansky, B. Review of Medical Embryology, 1982.

21

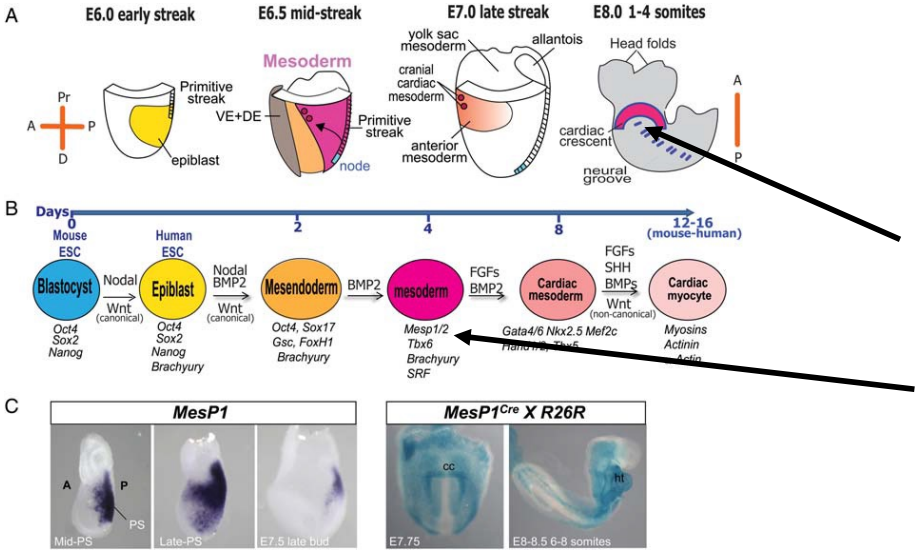
When does the heart form?



MacCord, Kate, "Germ Layers". *Embryo Project Encyclopedia, 2013.*

22

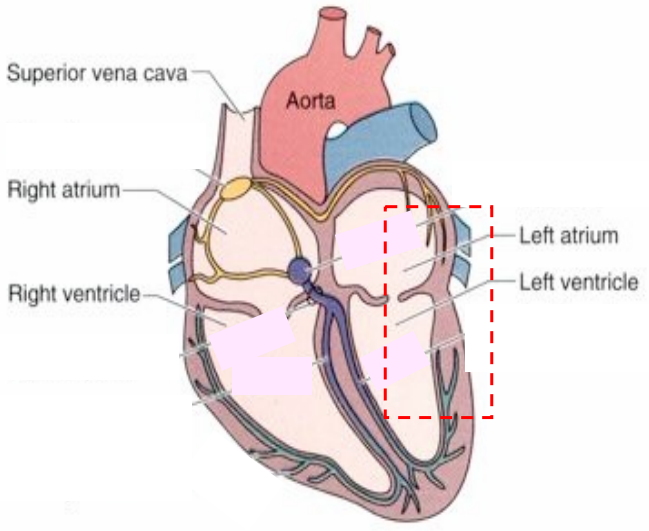
What cells form the early heart?

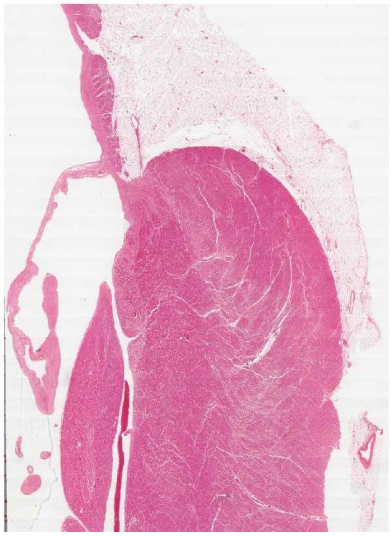


Van Vliet P., et al. Cardiovascular Research 2012

23

Looking at the Heart by H&E





24

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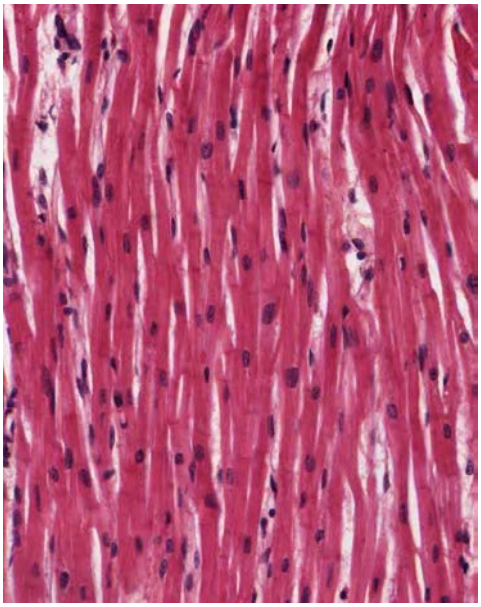
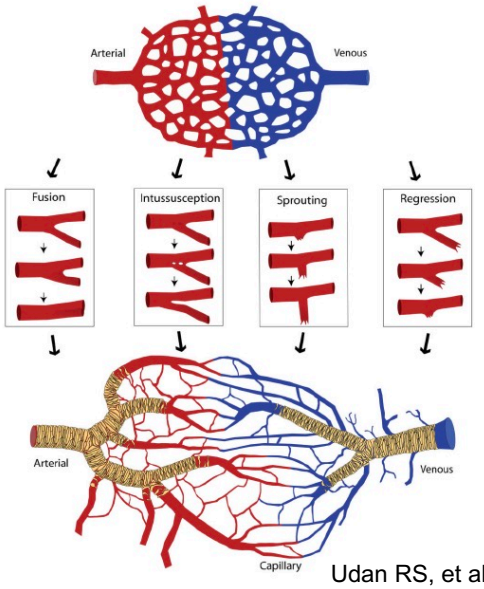


25

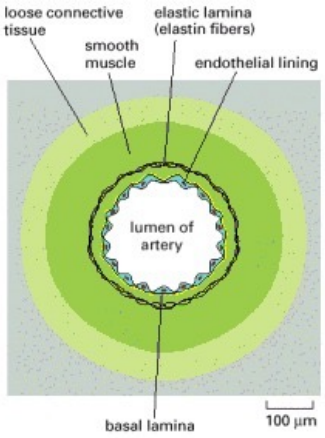
Forming the Vascular System

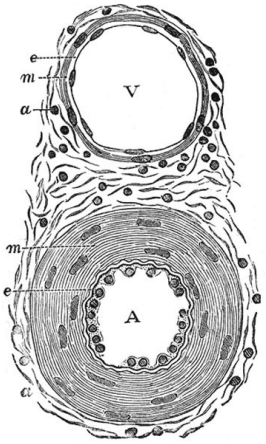


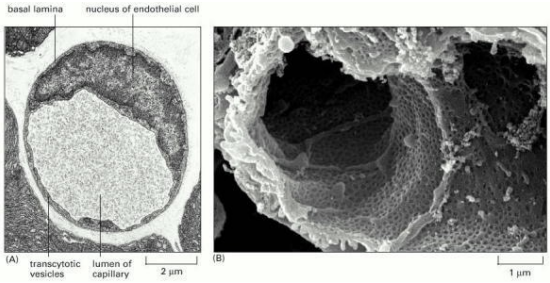
Udan RS, et al. WIRE Developmental Biology, 2012

26

What are the cellular components of the peripheral vasculature?







27

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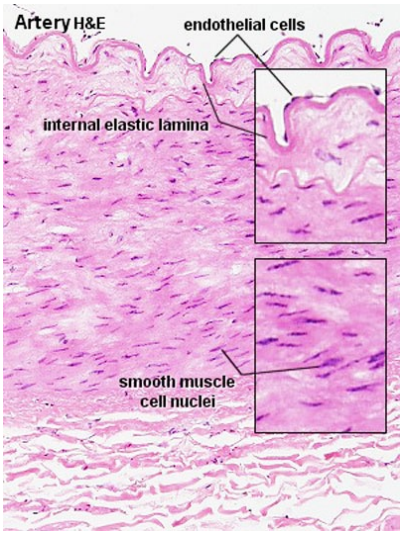

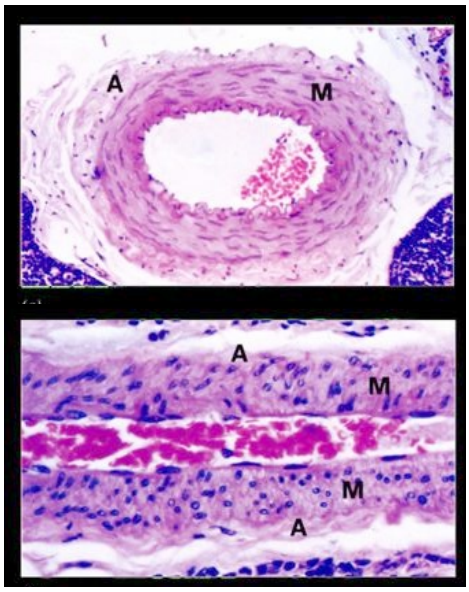

28

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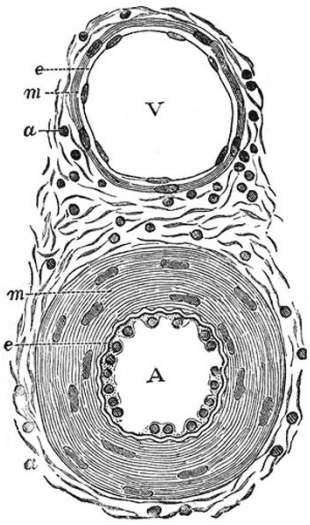

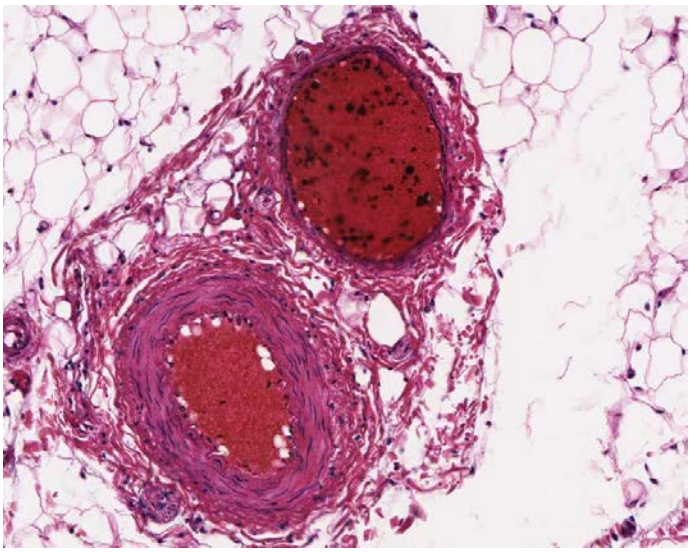

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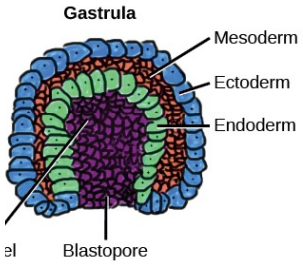

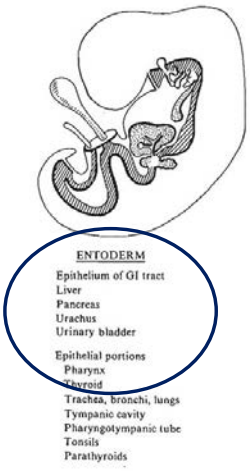

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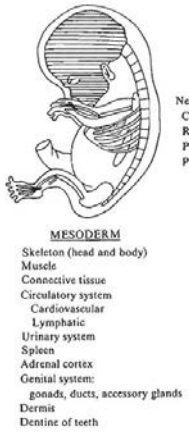
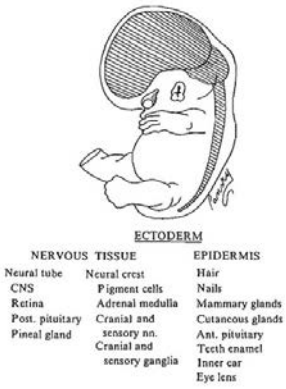
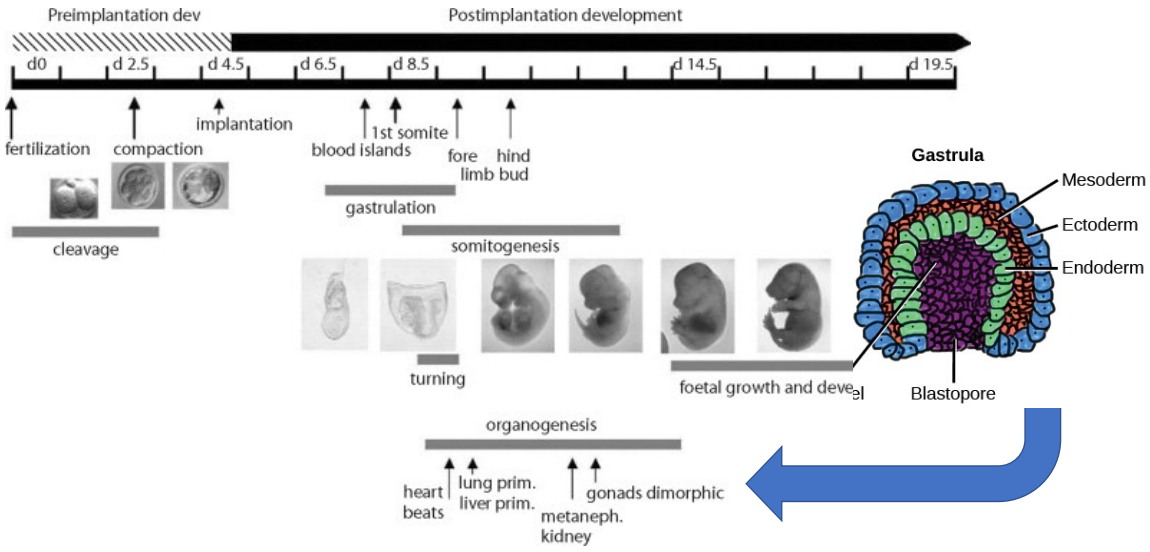




Pansky, B. Review of Medical Embryology, 1982.

31

When does the gut form?



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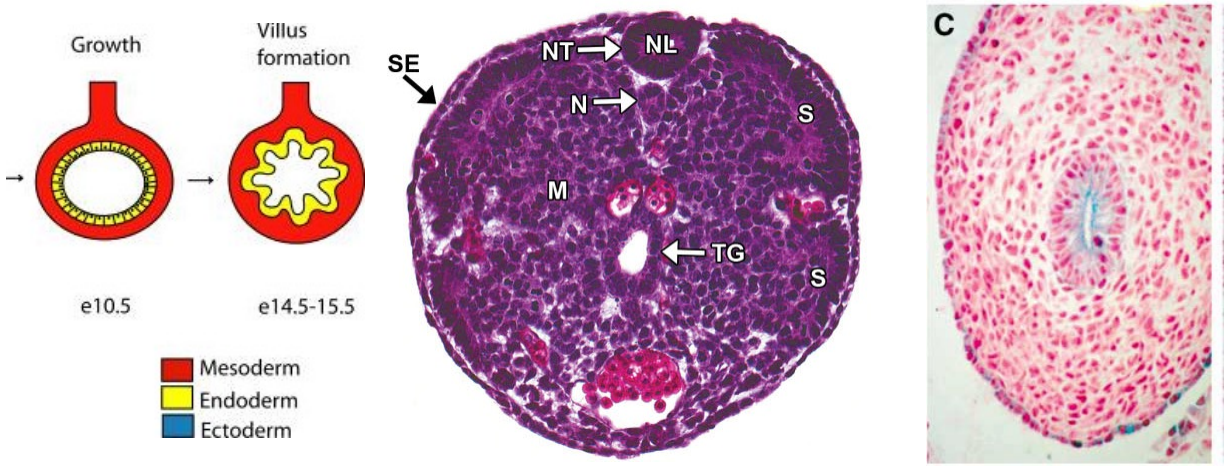
32

How does the gut form?



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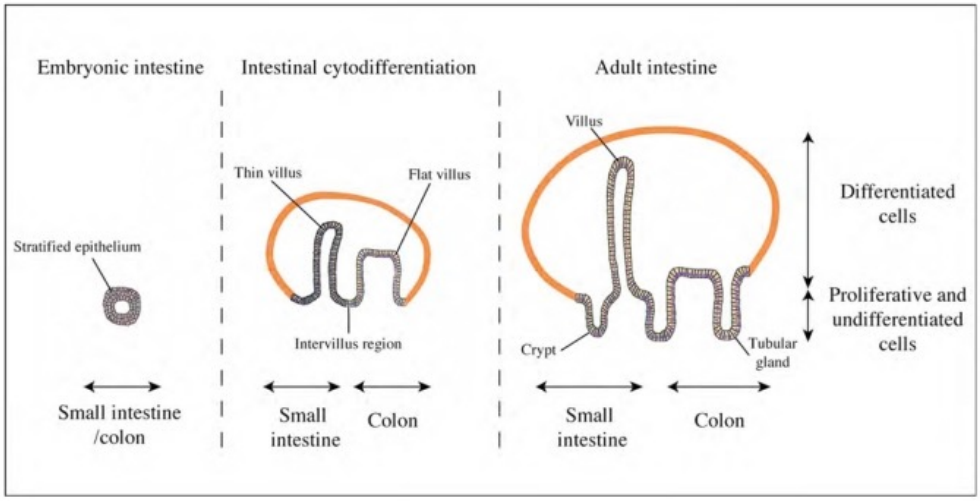
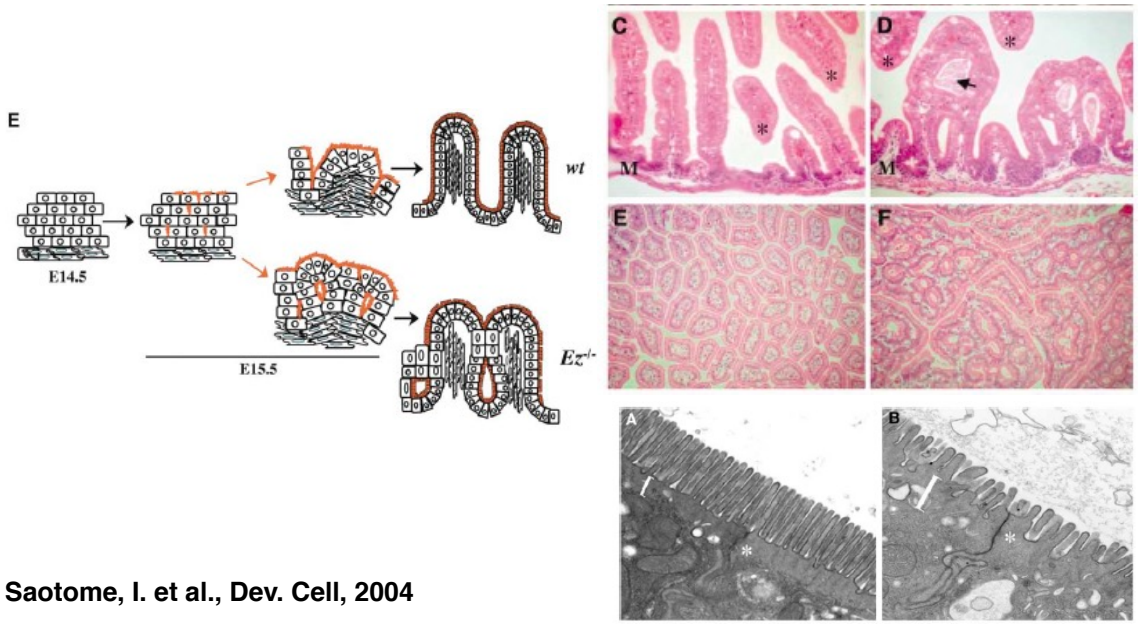


34

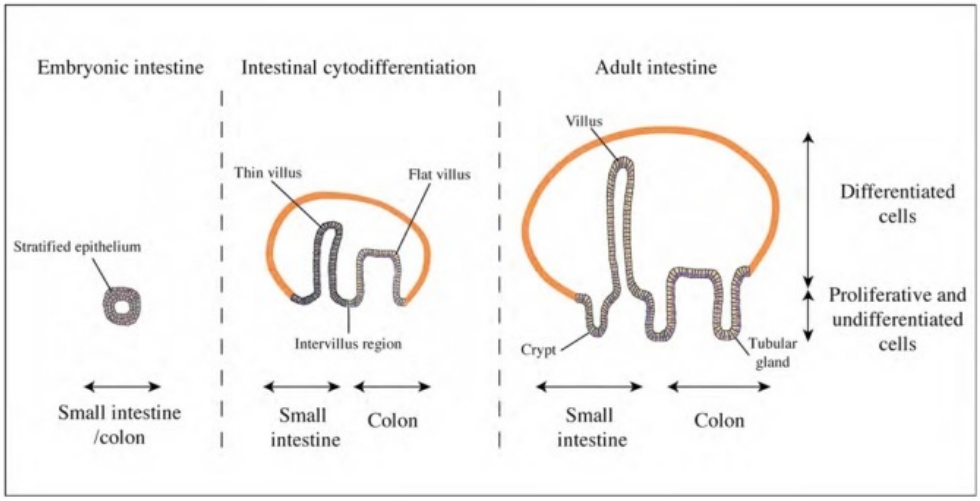
What happens when villus formation is disrupted?



Saotome, I. et al., Dev. Cell, 2004

35

Forming different sections of the gut?



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Histology of different sections of the gut

Small Intestine

Large Intestine (colon)

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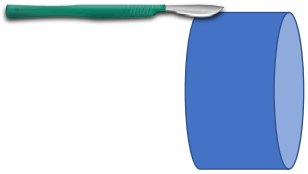
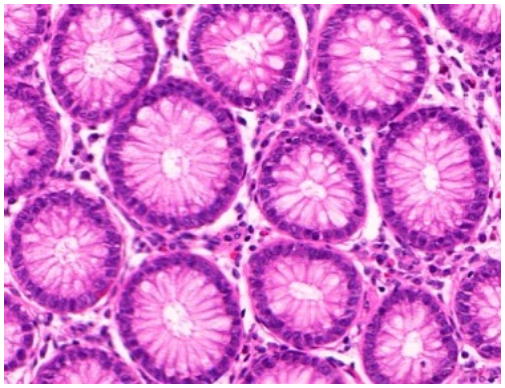
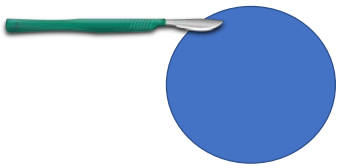
Histology of different orientations of the gut

Small Intestine (lateral)





Small Intestine (transverse)



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Goals for today's class!

- Learn how to describe the orientation of cells and tissue in an organism.
- Understand what the three Germ Layers are and how they are organized.
- Define the proteins in cells that promote cell sorting.
- Learn how the neural tube is formed.
- Understand what and how different cellular components contribute to heart and vascular development.
- Learn how the gut forms and what the different sections look like histological.
- Define the different types of epithelial tissues and how skin develops.

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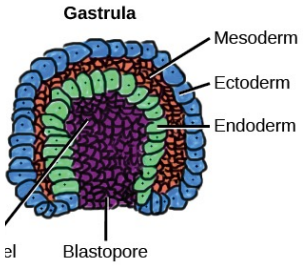
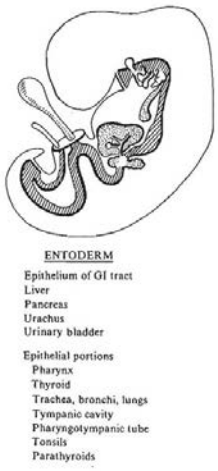
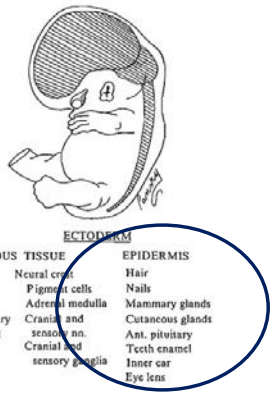
Germ Layer Derivatives





Endoderm = Entoderm



Pansky, B. Review of Medical Embryology, 1982.

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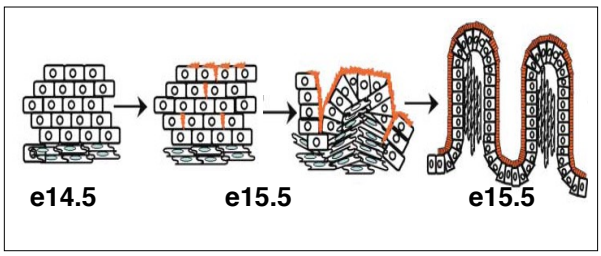
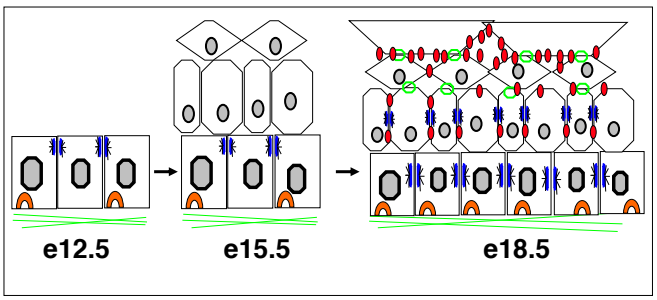
Tail of Two Epithelial Developmental Processes

Intestinal Development



Epidermal Development



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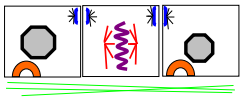
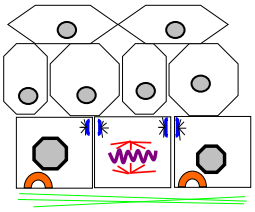
Initiation of Stratification in the Embryonic Epidermis



e12.5

Ratio of symmetric to asymmetric spindle orientation in wild type basal cells: 70% to 30%



e15.5

Ratio of symmetric to asymmetric spindle orientation in wild type basal cells: 30% to 70%

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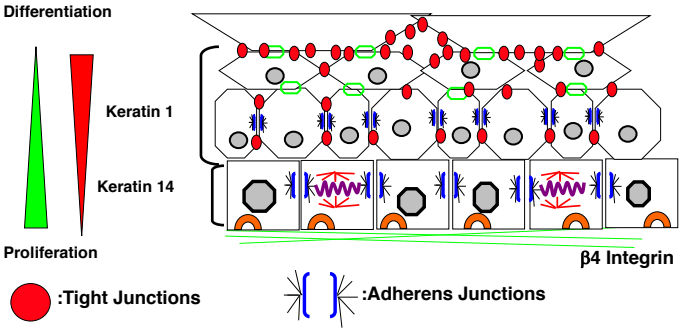
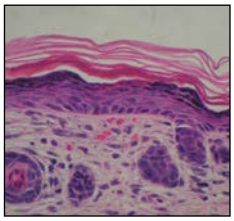
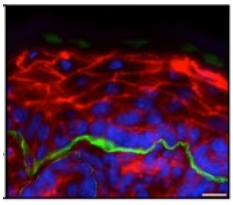
Developmental Process of the Developing Epidermis







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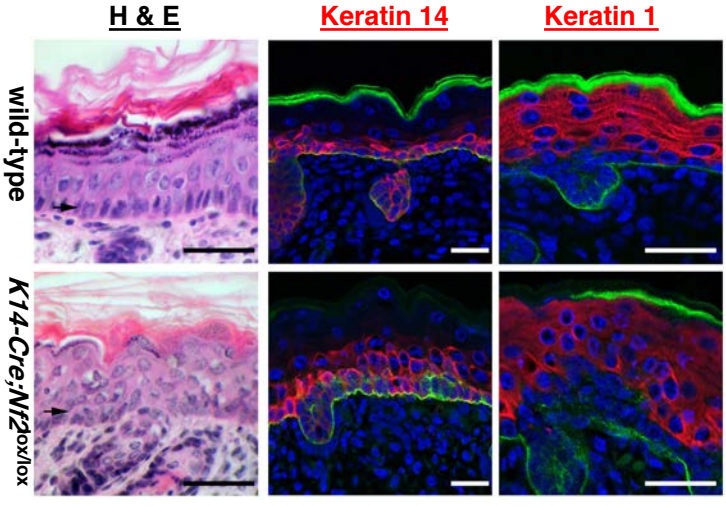
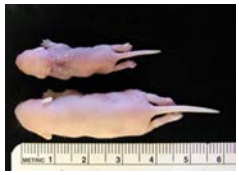
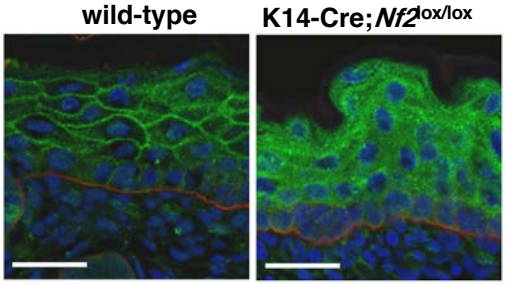
Example of Differentiation Defect in the Epidermis







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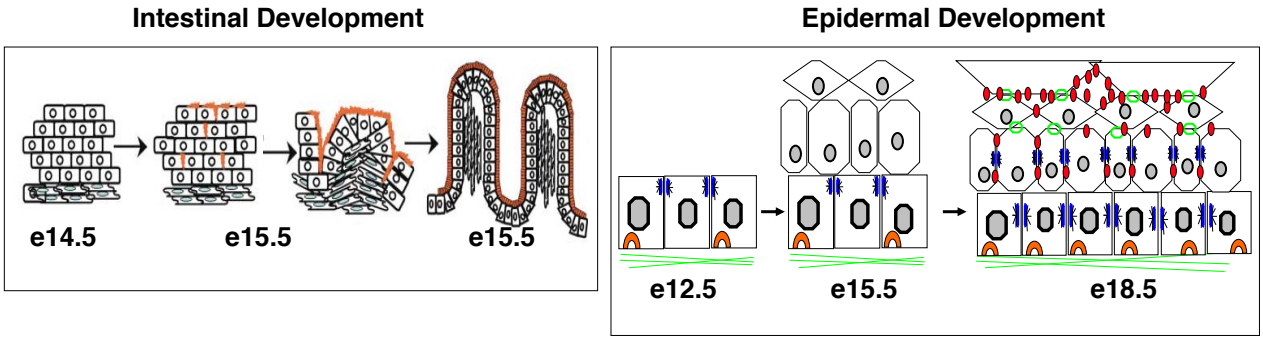
Tail of Two Epithelial Developmental Processes



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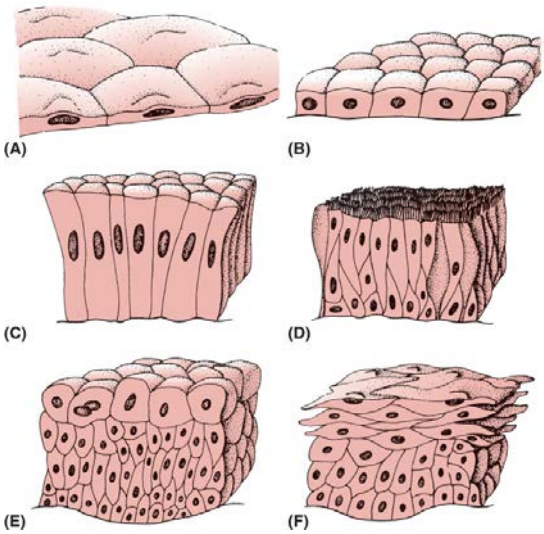
Different Types of Epithelial Tissues



02.F04: Common types of epithelium: (A) simple squamous, (B) cuboidal, (C) columnar, (D) pseudostratified columnar (ciliated), (E) transitional, and (F) stratified squamous.

From Reisner and Reisner, An Introduction to Human Disease. 2022, Jones and Bartlett Learning

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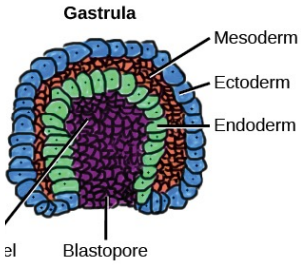
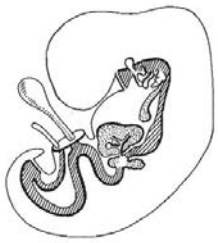
Conclusions





ENTODERM

Epithelium of GI tract
Liver
Pancreas
Urachus
Urinary bladder

Epithelial portions
Pharynx
Thyroid
Trachea, bronchi, lungs
Tympanic cavity
Pharyngotympanic tube
Tonsils
Parathyroids

Endoderm = Entoderm

MESODERM

Skeleton (head and body)
Muscle
Connective tissue
Circulatory system
Cardiovascular
Lymphatic
Urinary system
Spleen
Adrenal cortex
Genital system:
gonads, ducts, accessory glands
Dermis
Dentine of teeth

ECTODERM

NERVOUS TISSUE

Neural tube
CNS
Retina
Post. pituitary
Pineal gland

Neural crest
Pigment cells
Adrenal medulla
Cranial and sensory nn.
Cranial and sensory ganglia

EPIDERMIS

Hair
Nails
Mammary glands
Cutaneous glands
Ant. pituitary
Teeth enamel
Inner ear
Eye lens

Questions:
Email: agladden@email.unc.edu

Pansky, B. Review of Medical Embryology, 1982.

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