Formation III
Morphogenesis: building 3D structures

Dorsal determination
See Purves 20.3

Egg
β-catenin
- phosphorylated
- unstable, cytoplasmic

2-4 cells and older:
- determinants inhibit β-catenin phosph.
- dorsally stable, nuclear

Mesoderm determination

animal pole
2 - 500+ cells
Nodal (ligand) gradient

vegetal pole
Low Nodal
induces mesoderm

500+ cells

animal pole

Low Nodal
induces mesoderm

(High Nodal induces endoderm)

Nodal binds receptor that activates Smad2 txn factor

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Dorsal mesoderm = future muscle

Somites: Segments that will form muscle, skeleton, and skin

Biological 3D structures

Specialized cell shape: neuron

- Dorsal
- vegetal pole
- 500+ cells
- 4,000+ cell stage
- dorsal mesoderm
- β-catenin
- low Nodal
- (Smad2)
- activates MyoD transcription

Somatic cell shape: neuron
Lab Grows Bladders From Cells of Patients
Washington Post
Tuesday, April 4, 2006

What processes would turn the pile of cells into a 3D structure? (about 6)
Cell sorting due to differential and homotypic cell adhesion (N-Cadherin vs E-cadherin)

Epithelium: cell sheet
extracellular matrix (ECM)
apical
basal

Mesenchyme: single cells
Epithelium/mesenchyme and transition
junctions
extracellular matrix

Platelets changing shape during clotting
resting clotting

Shape and movement: role of cytoskeleton

G-actin unpolymerized
F-actin polymerized

From Molecular Biology of the Cell/ Lodish
**Actin polymerization during cell movement**

From Molecular Cell Biology/Lodish

- Zone of actin polymerization
- Front/leading edge
- Rear/trailing edge
- Lamellipodia/filopodia
- Direction of movement

Rearrangement of microfilaments (F-actin) with cell movement

**Receptors connect ECM and cytoskeleton**

See Purves 4.26

Adhesion receptors: integrins
ECM proteins: collagen, laminin, fibronectin

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**Cell adhesion and signaling**

Front (leading edge)
*increased adhesion*

Rear (trailing edge)
*adhesion loss*

**ligand** (laminin) binds **receptor** (integrin) which activates Focal Adhesion Kinase and activates **GTPase** (rac/cdc42/rho) which activates profilin which increases **F-actin**

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Epithelial sheets and building tubes

Cell shape changes via cytoskeleton

Flat epithelial sheet

Bent epithelial sheet

Epithelial sheets can roll or bend to form a tube

*Examples: brain, spinal cord*

Amphibian neural tube forms by rolling up an epithelial sheet
Mesenchymal cells can condense to form a tube
*Examples: blood vessels, some kidney tubules*

Purves 48.12: Lung tubules

Lung tubule branching: initial steps

An epithelial sheet can extend to form a tube
*Example: primary tracheal tubules*
Single cells can roll or hollow into tubes.

Examples: secondary and terminal tracheal tubules

Tubule morphogenesis in culture

Primary tracheal outgrowth and branching (Drosophila)
See Purves 48.5

FGF (ligand) = branchless
FGF receptor = breathless
epithelium
Primary tubule
Secondary
Terminal

O₂ stress

FGF inhibitor = sprouty

FGF = ligand
Receptor (tyrosine kinase)

Purves: 15.9: Fibroblast Growth Factor signaling