GASTRULATION is a complex series of cell movements that:
--rearranges cells, giving them new neighbors
--results in the formation of 3 GERM LAYERS that will form the subsequent embryo: ectoderm, endoderm and mesoderm
--forms the main body axes of the embryo (they were specified earlier but not formed)

Invagination - the infolding of a region of cells

Involution - the inturning of an expanding outer layer of cells

Ingression - the migration of individual cells from surface to interior
Delamination - the splitting of one sheet of cells into two parallel sheets of cells

Epiboly - the movement of epithelial sheets that spread as a unit to cover the embryo

Convergent extension - the lengthening of a group of cells in the long axis while shortening in the perpendicular axis

Fate map of the fly embryo at cellular blastoderm stage

Early Gastrulation in Drosophila
Figure 9.40

Gastrulation in Drosophila

Schematic Representation of Mid-Gastrulation in Drosophila

Germ Band Extension in Drosophila

GERM BAND EXTENDED PROCESSES:
--organogenesis – e.g. nervous system forms by neuroblast ingestion from ectoderm
--segmentation – A-P segment unique identity set up
--imaginal disc specification – cells set aside that will survive pupation

Germ Band Retraction in Drosophila

Gastrulation in Drosophila - lateral view
**Gastrulation in Drosophila – Vade Mecum Movie**

**FGF Signaling is Critical to Gastrulation in Drosophila**

Stage 7  Stage 8  Stage 9

WildType  Mutant

early gastrulation  mid-gastrulation  extended germ band

Neurotactin, membrane marker
Twist, mesoderm marker

(Grzegorczyk and Muller, 2004)

**Model for FGF signaling in Drosophila gastrulation**

(Fate Map of the Blastula of the Frog Xenopus laevis)

**Cell Movements During Frog Gastrulation - Early**

**Cell Movements During Frog Gastrulation - Mid**
**Cell Movements During Frog Gastrulation - Late**

- Epiboly of the Ectoderm Is Accomplished by Cell Division and Intercalation

**Convergent Extension**

Convergent extension - the lengthening of a group of cells in the long axis while shortening in the perpendicular axis

**Xenopus Gastrulation – Vade Mecum**

**Movie of Xenopus Gastrulation**

**Fibronectin and Amphibian Gastrulation**

- Normal
- FN block peptides
Blastocoel Roof Explants deposit matrix that directs the migration of mesoderm

FGF Expression during avian gastrulation and the putative role of Sprouty/spred

Wnt Signaling Mediates Two Distinct Aspects of Gastrulation

Amphibian Convergence Extension Requires Non-canonical Wnt Signaling

CE in Zebrafish Requires Oriented Cell Division

papc Expression is Defective in spt Mutant Embryos

from Nagel et al, 2004

from Keller, 2005

(Huelsken and Birchmeier, 2001)

(Habas et al, 2003)

(Gong et al, 2004)

(WT)
At the end of gastrulation--
--the basic body plan is set up
--the three germ layers have formed
and will produce all embryonic structures except the germline

ECTODERM--
--skin, nervous system, neural crest

MESODERM--
--muscle, bones, blood and vessels, kidney, gonads, connective tissue

ENDODERM--
--gut, liver, lungs, pancreas

C. elegans embryogenesis

Drosophila embryogenesis

Frog embryogenesis
**Zebrafish embryogenesis**

- 2.8h: First cleavage
- 5h: Gastrulation
- 10h: Segmentation
- 24h: Organogenesis
- 48-72h: Organogenesis

**Chick embryogenesis**

- 24h: Egg laid
- 4d: Gastrulation
- 7d: Segmentation
- 21d: Organogenesis

**Mouse embryogenesis**

- 24h: First cleavage
- 4.5d: Implantation
- 6.5d: Gastrulation
- 14d: Segmentation
- 20d: Organogenesis

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