Gastrulation –
Chick, Fish, Mammal

November 15, 2005
Zebrafish gastrulation

Haffter et al., 1996
Zebrafish gastrulation

hypoblast formation – ingression and/or involution of deep cells

embryonic shield

ENL → periderm (extraembryonic protective membrane)
epiblast → ectoderm
hypoblast → mesendoderm (mesoderm and endoderm precursors)
YSL → endoderm
Zebrafish embryonic shield

Embryonic shield functionally equivalent to amphibian dorsal lip of the blastopore
- can organize 2° axis when transplanted
Zebrafish gastrulation

blastodisc
yolk syncytial layer
epiblast
hypoblast
somite
notochord

4-cells 1 h sphere 4 h shield 6 h
80% epiboly 8 1/3 h 1 somite 10 1/3 h 19 somites 18 1/2 h

neural tube notochord somites floor plate
hindbrain midbrain forebrain eye
pharyngula period 29 h

Haffter et al., 1996
Figure 5.16

Chick cleavage

- epiblast forms all three germ layers (plus extraembryonic membrane)
- hypoblast forms extraembryonic endoderm
  - does not form any embryonic endoderm or mesoderm
  - forms primordial germ cells
  - different from fish hypoblast
Gastrulation - chick

- *area pellucida* = inner transparent portion of the blastoderm above subgerminal space

- *area opaca* = ‘opaque’ peripheral area; cells in contact with yolk

- gastrulation starts with extensive cell rearrangements in posterior epiblast

- cells move to midline and the forward *primitive streak*
Gastrulation - chick

- elongation of primitive streak and formation of *primitive groove & primitive pit*

- anterior end of primitive ridges are thickened = *Hensen’s node*

- major gastrulation events occur at the primitive pit & primitive groove

- functional equivalent of amphibian blastopore
Chick gastrulation

- future endoderm ingress first; displace hypoblast
Chick gastrulation

- future mesoderm (axial, paraxial, lateral) cells ingress from anterior end of primitive pit
- epithelial to mesenchymal transformation

extraembryonic membranes surround yolk
- ectoderm – spread by epiboly
- hypoblast cells spread along yolk surface
- mesoderm cells in between
Gastrulation fate map - chick

Figure 10.26
Figure 10.27

Chick – 24 h
head region starts to lift off the yolk
ventral closure of the body proceeds from anterior to posterior
Chicken development 3

ventral closure of the body is completed
Chicken development

extraembryonic membranes and extraembryonic blood vessels completely surround the yolk

after completed ventral closure, embryo rests on top of the yolk sac

yolk sac is connected to the gut by a narrow bridge
Early mammalian development not very well studied:
- small eggs
- difficult to maintain in culture beyond blastocyst stage
- ethical issues

- holoblastic cleavage results in a blastocyst:

(c) Blastocyst (32–64 cells)

- inner cell mass & trophoblast are equivalent to epiblast & hypoblast of the chicken embryo
- embryo enters the uterus in the ‘morula’ stage
- blastocyst stage makes contact with uterus
- before implantation into uterus, the embryo sheds zona pellucida
Early development in mammals

hatching of a mouse blastocyst from the zona pellucida

mouse blastocyst entering the uterus

initial implantation of the blastocyst (rhesus monkey)

Gilbert SF, Developmental Biology, 6th ed, Sinauer, 2000
Early development in mammals

Human: 7 – 11 days

- inner cell mass delaminates hypoblast cells that line the blastocoel, forming extraembryonic endoderm
  - results in epiblast & hypoblast

- trophoblast divides into:
  - cytotrophoblast - anchors embryo to uterus tissue
  - syncytiotrophoblast - furthers progression of the embryo into uterus wall by digesting uterus tissue

- amniotic cavity begins to form
Early development in mammals

Human 9 – 11 days

- epiblast delaminates the amniotic ectoderm that surrounds the amniotic cavity
- two-layered blastodisc similar to that in birds embryonic epiblast & hypoblast
- cytotrophoblast enzymatically remolds maternal blood vessels (trophoblastic lacunae)
- uterus sends additional blood vessels
- embryo is nourished by maternal blood
- extraembryonic mesoderm forms; it will develop into the extraembryonic coelom
Figure 10.31

Human blastocyst – 12 d

- Trophoblastic lacunae
- Maternal blood vessels
- Amniotic ectoderm
- Amniotic cavity
- Embryonic epiblast
- Hypoblast
- Extraembryonic coelom
- Extraembryonic mesoderm
- Primitive yolk sac
Gastrulation in mammals

cells ingress and involute along the primitive groove and at Hensen’s node
- form endoderm (replaces hypoblast) and mesoderm

Gilbert SF, Developmental Biology, 6th ed, Sinauer, 2000
Human gastrulation – 16 d

(a) Plane of section for part b
- Anterior
- Cut edge of amnion
- Plane of section for part c
- Axial mesoderm
- Paraxial and lateral mesoderm
- Plane of section for part d

(b) Amniotic cavity
- Ectoderm
- Axial mesoderm
- Primitive streak
- Allantois

(c) Ectoderm
- Paraxial and lateral mesoderm
- Endoderm
- Axial mesoderm

(d) Primitive streak
- Ingressing mesoderm and endoderm cells
- Epiblast
- Amnion
- Yolk sac
- Hypoblast

Figure 10.32
Primate germ layer derivatives

Figure 10.30