Development
Development & Embryology

• Development:
  – The continual modification of structures from conception to maturity due to the growth, differentiation and reorganization of cells
  – Developmental Stages:
    • Prenatal – development from conception to birth
    • Postnatal – development from birth through maturity

• What is embryology?
  – The study of developmental events that occur during the prenatal stage

• Why study embryology?
  – To gain an understanding of where and how the anatomical structures came to be
Embryology

• Embryonic period vs. Fetal period
  – Embryonic – first 8 weeks
    • Development of the three primary germ layers give rise to all structures
    • Basic body plan takes shape
  – Fetal period – remaining 30 weeks
    • Structures and organs continue to grow and develop, increasing in complexity

6 weeks
9 weeks
28 weeks
The Embryonic Period

• Major Events of First Week
  – Conception – in lateral third of uterine tube
    • Fusion of female and male pronuclei = amphimixis
  – Zygote (46 chromosomes) moves toward the uterus
  – Blastomeres – daughter cells formed from zygote
  – Morula (means mulberry) – cluster of 12–16 blastomeres
  – Blastocyst – blastomeres form hollow sphere– about 60 cells
    • Inner cavity is called the blastocoele
    • Trophoblast – layer separating blastocoele from external environment
Fertilization and the Events of the First 6 Days of Development

(a) Sperm cell penetrating a secondary oocyte

PATH OF SPERM CELL:
- Corona radiata
- Zona pellucida
- Plasma membrane of secondary oocyte
- Cytoplasm of secondary oocyte

(b) Sperm cell in contact with a secondary oocyte

(c) Male and female pronuclei

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Fertilization and the Events of the First 6 Days of Development

1. Fertilization
   (occurs within uterine tube 12–24 hours after ovulation)

2. Cleavage
   (first cleavage completed about 30 hours after fertilization)

3. Morula
   (3–4 days after fertilization)

4. Blastocyst
   (4½–5 days after fertilization)

5. Implantation
   (occurs about 6 days after fertilization)

Frontal section through uterus, uterine tube, and ovary

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First week Pictures

Zygote

Two cell stage

Four cell stage

Morula

Early implantation
Implantation

• When:
  – Occurs during weeks 1 & 2

• Where:
  – Endometrium of uterine wall

• Why:
  – To further support, nourish (with developing vascularity) and protect embryo

• How:
  – When contact occurs, the trophoblast divides rapidly, creating a multinucleated mass called the syncytial trophoblast
  – This syncytial trophoblast secretes enzymes allowing the blastocyst to penetrate
Week 2 – The Two-Layered Embryo (Blastodisc)

• Bilaminar embryonic disc formed when the inner cell mass divide and forms into two sheets
  – Epiblast (5) and the hypoblast (2)
  • Together make up the bilaminar embryonic disc or blastodisc
Week 2 – Blastodisc

• Amniotic sac – formed by an extension of epiblast as the cells divide
  – Inner membrane – forms the **amniotic sac cavity** (in conjunction with the outer membrane)
    • Filled with amniotic fluid
  – Outer membrane (future mesoderm) – forms the **amnion**

• Yolk sac – formed by an extension of hypoblast
  – Digestive tube forms from yolk sac
  – Tissues (future mesoderm) around yolk sac gives rise to earliest blood cells and blood vessels
Week 3 – Three-Layered Embryo

- Primitive streak – raised groove on the dorsal surface of the epiblast
- Gastrulation – a process of invagination of epiblast cells. A very incredibly important step in development as this process forms the
  - Endoderm – formed from migrating cells that replace the hypoblast
  - Mesoderm – formed between epiblast and endoderm, these cells divide and spread and form parts of the amnion and yolk sac.
  - Ectoderm – formed from epiblast cells that stay on dorsal surface
• Developmental "time line" of the three primary germ layers
Following the Germ Layers and changes in the Embryo

(a) Dorsal and partial sectional views of embryonic disc, about 15 days after fertilization

(b) Transverse section of trilaminar embryonic disc, about 16 days after fertilization

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Following the Germ Layers and changes in the Embryo

(a) 17 days

(b) 19 days

(c) 20 days

(d) 22 days

Dorsal views

Transverse sections

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Week 4 – The Body Takes Shape

- Folding of embryo laterally and at the head and tail
  - Primitive gut – formed by lateral folding
  - "Tadpole shape" by day 24
Germ Layer Destinations

• Ectoderm – forms brain, spinal cord, and epidermis

• Endoderm
  – Forms inner epithelial lining of the gut tube
  – Forms respiratory tubes, digestive organs, and urinary bladder
Germ Layer Destinations cont...

- Mesoderm – forms muscle, bone, dermis, and connective tissues
  - Somites divide into sclerotome, dermatome, and myotome
  - Intermediate mesoderm – forms kidneys and gonads
  - Splanchnic mesoderm
    - Forms musculature, connective tissues, and serosa of the digestive and respiratory structures
    - Forms heart and most blood vessels
  - Somatic mesoderm – forms dermis of skin, bones, and ligaments
The Germ Layers in Week Four

- Ectoderm
- Somite
- Intermediate mesoderm
- Notochord
- Endoderm
- Neural tube
- Somatic portion of lateral mesoderm
- Developing coelom
- Splanchnic portion of lateral mesoderm
- Dermatome
- Myotome
- Sclerotome
- Kidney and gonads (intermediate mesoderm)
- Visceral serosa (splanchnic mesoderm)
- Smooth muscle and connective tissues of gut (splanchnic mesoderm)
- Peritoneal cavity (coelom)
- Neural tube (ectoderm)
- Epidermis (ectoderm)
- Gut lining (endoderm)
- Limb bud
- Parietal serosa (somatic mesoderm)
- Dermis (somatic mesoderm)

(a) Yolk sac

(b) Somatic mesoderm
- Coelom
- Future gut (digestive tube)
- Lateral fold

(c) Spinal cord
- Vertebral column
- Kidney
- Rib
- Outer body wall
- Trunk
- Trunk muscles
- Parietal serosa
Week 5-8 – The Second Month of Embryonic Development

- Limb buds form
- Embryo first looks recognizably human
- Head is disproportionately large
- All major organs are in place
Fetal Period Facts & Stats

• A time of maturation and rapid growth
• Cells are differentiating during the first half of the fetal period
• Normal births occur 38 weeks after conception
• Premature birth is one that occurs before 38 weeks
Developmental Events of the Fetal Period

- Eyes & ears take on human form
- Neck becomes evident & head is almost as large as rest of body
- Liver is large in relation to size of body
- Bone formation begins as do weak muscle contractions
- Limbs are formed and digits are separated
- Cardiovascular system is functioning and heart is pumping (since week 4)
- Size: 3 cm (crown to rump)
Developmental Events of the Fetal Period

- Head is still large (body is elongating) & brain development continues and retina is formed
- Differentiation of epidermis & dermis occurs
- Liver is large, hard palate fusion starts, smooth muscle appears in hollow visceral organs
- Blood cells formation gets underway in bone marrow & spleen
- Notochord is being replaced by bone
- Gender determination is possible in ultrasound viewing
- Size: 9 cm (crown to rump)
Developmental Events of the Fetal Period

13-16 weeks (month 4)

- Sucking actions occur & eye movement is seen (eyes still closed)
- Body starts to catch up to head size & limbs appear more proportionate
- Hard palate is fused
- Kidneys take on normal appearance
- Joint cavities present & most bones are distinct
- Size: 14 cm (crown to rump)
Developmental Events of the Fetal Period

- Eyelashes & eyebrows present, fatty skin secretion covers the body, lanugo covers the skin
- Quickening occurs
- Fetal position is attained (due to space restrictions)
- Limbs reach normal proportions
- Size: 19 cm
Developmental Events of the Fetal Period

- Body size & weight increase
- Eyes open
- Fingernail & toenails are developed
- Skin is wrinkled & red, subcutaneous fat is just starting to accumulate
- Bone marrow becomes sole site for blood cell development
- Testes descend into scrotum
- Size: 28 cm
Developmental Events of the Fetal Period

- Fat accumulation occurs in subcutaneous layer
- Size: 36 cm
- Weight: 2.7 – 4.1 kg.
Postnatal Development

• What are the events of postnatal development?
  – We will discuss some of this during system studies!