Chapter Objectives

INTRODUCTION

1. Differentiate between embryological development and fetal development.

EMBRYONIC PERIOD

First Week of Development

2. Describe the process of fertilization, including capacitation and how the sperm penetrates the three layers surrounding the secondary oocyte.
3. Describe the two processes that stop penetration of the egg by more than one sperm.
4. Explain the process of cleavage and state how this process leads to the formation of a morula.
5. Specify the features of the blastocyst that distinguish it from the morula and describe which parts of the blastocyst will develop into what structures.
6. Describe the process of implantation.
7. List the three regions of the decidua.

Second Week of Development

8. Discuss the layers which develop from the trophoblast and state their function.
9. Discuss the formation and significance of the chorion.
10. Trace the development of the chorionic villi and placenta.
11. Explain the maternal and fetal parts of the placenta.
12. State the functions of the placenta.
13. Discuss the fate of the placenta after the birth of the baby.
14. Examine the development of the amnion and the formation of the amniotic fluid and state their function.
15. Discuss the formation and functions of the yolk sac.
16. Discuss the two layers that develop from the inner cell mass.

Third Week of Development

17. Describe gastrulation and the growth of the three primary germ layers.
18. Establish which organs arise from the different germ layers by the end of the embryonic development.
19. Describe the process of neurulation and the formation of the neural tube.
20. Examine the formation of the mesoderm, the three regions of mesoderm and which structures are formed from each region.
21. Describe the formation of the cardiovascular system.
Fourth Week of Development
22. Examine how embryonic folding converts the embryo to a three dimensional cylinder.
23. Trace the organ development that occurs during the fourth week of development.

Fifth Through the Eighth Weeks of Development
24. Match the events in the rapid development of the embryo with the week it occurs during this period.

FETAL PERIOD
25. Discuss the development of the fetus, which occurs during this period. Reference the pages indicated in the text that discuss the development of the various body systems.

HORMONES OF PREGNANCY
26. Compare the sources and functions of the hormones secreted during pregnancy.

LABOR
27. Outline the hormonal and neural regulation of the duration of pregnancy.
28. Describe the characteristics of the three stages of labor.

ADJUSTMENTS OF THE INFANT AT BIRTH
29. Discuss the respiratory system adjustments of the infant at birth.
30. Discuss the cardiovascular system adjustments of the infant at birth.

Chapter Lecture Notes

Introduction
Prenatal development - the time from fertilization until birth
divided into three trimesters
Embryonic period - the first two months (8 weeks) following fertilization
the developing human is referred to as an embryo
Fetal period - from week nine until birth
the developing human is referred to as a fetus

Fertilization
Fertilization – the merger of oocyte and sperm (Fig 29.1)
Oocyte - ovulated from ovary and then transported through the uterine tube
Sperm - swim up the uterus and into the uterine tube by the whip like movements of their tails (flagella) and muscular contractions of the uterus

Capacitation - final maturation of the sperm in preparation of fertilization
acrosomal membrane becomes fragile
allows sperm to fertilize a secondary oocyte
occurs 6 to 8 hours after deposited in female

Fertilization normally occurs in the uterine tube within 12 to 24 hours after ovulation

A sperm must penetrate the corona radiata and zona pellucida around the oocyte
A glycoprotein in the zona pellucida (ZP3) acts as a sperm receptor
triggers the acrosomal reaction - release of the contents of the acrosome onto the zona pellucida
Acrosomal enzymes digest a path through the zona pellucida allowing only one sperm to reach the oocyte’s plasma membrane
Sperm enters a secondary oocyte
The oocyte completes meiosis
The male DNA and female DNA combine forming the fertilized ovum or zygote
Syngamy - fusion of a sperm with a secondary oocyte
First sperm to fuse with oocyte membrane triggers the slow & the fast block to polyspermy
    Fast block to polyspermy - 1-3 seconds after contact, oocyte membrane depolarizes & other cells can not fuse with it
    Slow block to polyspermy - depolarization triggers the intracellular release of Ca^{+2} causing the exocytosis of molecules hardening the entire zona pellucida

First Week of Development
Cleavage – early cell division of a zygote (Fig 29.2 & 29.5)
cells become progressively smaller
blastomeres - cells produced by cleavage

1st cleavage (30 hours) produces 2 blastomeres (2 cell embryo)

2nd cleavage (Day 2) produces 4 cell embryo

16 cell embryo (Day 3)

morula (Day 4) - solid mass of more than 16 cells

blastocyst (Day 5) – a hollow ball of cells developed from a morula that has the following structures

- trophoblast cells - will form the future embryonic membranes & fetal portion of placenta
- trophoblast secretes human chorionic gonadotropin (hCG) that helps the corpus luteum maintain the uterine lining
- inner cell mass or embryoblast cells - the future embryo
- blastocele - an internal fluid-filled cavity

enters the uterine cavity by day 5

Implantation

Implantation – attachment of a blastocyst to the endometrium (Fig 29.3, 29.5 & 29.6)

the blastocyst remains free with the cavity of the uterus for two to four days

hatching – breakdown and shedding of the zona pellucida by the blastocyst

implantation occurs seven to eight days after fertilization

Following implantation the endometrium is known as the decidua and consists of three regions:

Decidua basalis - between the chorion and the stratum basalis of the uterus (Fig 29.4)

becomes the maternal part of the placenta

Decidua capsularis - covers the embryo and is located between the embryo and the uterine cavity

Decidua parietalis - lines the noninvolved areas of the entire pregnant uterus

Decidua capsularis fuses with decidua parietalis as fetus grows

Following pregnancy, all of decidua is lost with the placenta
Second Week of Development

Trophoblast forms (Fig 29.6, 29.10 & 29.11)

Chorion

Amnion

Amnionic cavity

these structure start formation at week 2 but continue development and persist throughout entire pregnancy

Chorion

becomes the embryonic contribution to the placenta

secretes human chorionic gonadotropin (hCG)

chorionic villi - projections of the trophoblast that eventually contain blood filled capillaries

Umbilical cord – connection of blood vessels in the chorionic villi to the embryonic heart

starts as a connecting stalk with primitive connective tissue

1 umbilical vein carries oxygenated blood to the fetus from the chorionic villi

2 umbilical arteries carry blood to the chorionic villi in the placenta

Placenta - chorionic villi from fetus + decidua basalis from the mother

Chorionic villi extend into maternal blood filled intervillous spaces in the decidua basalis

maternal & fetal blood vessels do not join & blood does not mix

diffusion of O2, nutrients, wastes

stores nutrients & produces hormones

barrier to microorganisms, except some viruses

AIDS, measles, chickenpox, poliomyelitis, encephalitis

not a barrier to drugs such as alcohol

Placenta fully forms during 3rd month

After the birth of the baby, placenta detaches from the uterus (afterbirth)

Amnion
thin, protective membrane

Initially the amnion overlies only the bilaminar embryonic disc

Eventually the amnion surrounds the entire embryo creating the amniotic cavity
contains amnionic fluid

filtrate of mother’s blood + fetal urine

shock absorber

regulates body temperature

prevents adhesions

Yolk sac - an exocoelmic structure formed in the former blastocyst cavity (with the hypoblast)

transfers nutrients to the embryo

site of early blood formation

gives rise to gonadal stem cells (spermatogonia & oogonia)

allantois - outpocketing off yolk sac that becomes part of the umbilical cord

Bilaminar embryonic disc - two layers of cells of the inner cell mass

hypoblast

primitive endoderm

borders yolk sac

epiblast

primitive ectoderm

borders amnionic cavity

Third Week of Development

Gastrulation – formation of tri-laminar disc (Fig 29.7 & 29.8)

Primitive streak – first step of gastrulation

Cells of the epiblast move inward below the primitive streak and detach from the epiblast

Cells of the embryonic disc produce 3 distinct layers (Table 29.1)

endoderm ➔ epithelial lining of GI & respiratory
mesoderm ➔ muscle, bone & other connective tissues

ectoderm ➔ epidermis of skin & nervous system

Induction – development of a particular structure due to the stimulation received from a neighboring structure

the development of the nervous tissue is due to induction

Notochord - a solid cylinder of mesoderm cells that sends signals to the overlying ectoderm signaling it to become nervous tissue

Neurulation (Fig 29.9)

Neural plate – ectoderm cell located over the notochord

Neural folds and neural groove – formed from the neural plate

the neural folds will fuse to form the neural tube

Neural crest cells - ectoderm cells that migrate and give rise to

spinal and cranial nerves and their ganglia

autonomic nervous system ganglia

the meninges of the brain and spinal cord

the adrenal medullae

several skeletal and muscular components of the head

Mesoderm (Fig 29.9 & 29.14)

Paraxial mesoderm - Somites - a series of paired, cube-shaped structures

42-44 pairs of somites will develop

Each somite has three regions

Myotome – skeletal muscle of neck, trunk and limbs

Dermatome – connective tissue including dermis of skin

Sclerotome – vertebrae and ribs

Intermediate mesoderm

Gonads and kidneys
Lateral plate mesoderm

Splanchnic mesoderm

Heart

Visceral layers of the pericardium, pleurae, and peritoneum

Blood vessels

Smooth muscle and connective tissue of the respiratory and digestive system

Somatic mesoderm

Bones

Ligaments

Dermis of the limbs

Parietal layers of the pericardium, pleurae, and peritoneum

Development of the cardiovascular system

Angiogenesis - the formation of blood vessels

begins in the yolk sac and chorion

Blood islands - isolated masses of aggregated blood forming cells

Angioblasts – cells that form the walls of the blood vessels

Spaces in the blood islands form the lumen of blood vessels

The heart forms in the cardiogenic area of the splanchnic mesoderm

Mesodermal cells form a pair of endocardial tubes

The tubes fuse to form a single primitive heart

Fourth week of Development

Embryonic folding converts the embryo from a flat, two-dimensional trilaminar embryonic disc to a three-dimensional cylinder. (Fig 29.12, 29.13 & 29.14)

Development of the somites and the neural tube occurs during the fourth week.

Several pharyngeal (branchial) arches develop on each side of the future head and neck regions.

With the pharyngeal clefts and pouches they will form structures of the head and neck.
Otic placode - the first sign of a developing ear

Lens placode - the first sign of a developing eye

The upper limb buds appear in the middle of the fourth week and the lower limb buds appear at the end of the fourth week.

Fifth Through Eight Weeks of Development

During the fifth week there is rapid brain development and considerable head growth.

During the sixth week the head grows even larger in relation to the trunk, there is substantial limb growth, the neck and truck begin to straighten, and the heart is now four-chambered.

During the seventh week the various regions of the limbs become distinct and the beginnings of the digits appear.

By the end of the eighth week all regions of the limbs are apparent, the digits are distinct, the eyelids come together, the tail disappears, and the external genitals begin to differentiate.

Fetal Period

During the fetal period, tissue and organs that developed during the embryonic period grow and differentiate. The rate of body growth is remarkable.

A summary of the major developmental events of the fetal period is presented in Table 29.2 and Figure 29.02.

Hormones of Pregnancy

Chorion

Human chorionic gonadotropin (hCG) (Fig 29.16)

secreted by chorion from day 8 until 4 months

mimics LH

keeps corpus luteum active

Corpus luteum

progesterone & estrogen

maintain lining of uterus
necessary for the continued attachment of the embryo and fetus to the lining of the uterus

Placenta

progesterone & estrogen

by 4th month produces enough that corpus luteum is no longer important

relaxin

Increases flexibility of pubic symphysis

Dilates the uterine cervix during labor

inhibits secretion of FSH and might regulate secretion of hGH

human chorionic somatomammotropoin (hCS) or human placental lactogen (hPL)

maximum amount by 32 weeks

role in breast development for lactation, protein anabolism, and catabolism of glucose and fatty acids

corticotropin-releasing hormone (CRH)

increases secretion of fetal cortisol (lung maturation)

thought to be the “clock” that establishes the timing of birth

Labor and Parturition

Parturition means giving birth

Labor is the process of expelling the fetus

progesterone inhibits uterine contraction and labor

placenta stimulates fetal anterior pituitary which causes fetal adrenal gland to secrete dehydroepiandrosterone (DHEA)

placenta converts DHEA to estrogen

the elevated levels of estrogens, plus elevated prostaglandins, oxytocin, and relaxin; and a decrease in progesterone levels are all probably involved in the initiation and progression of labor
True labor begins when uterine contractions occur at regular intervals, usually producing pain.

Other signs of true labor may be:

- Localization of pain in the back, which are intensified by walking,
- Dilatation of the cervix
- “Show” - discharge of blood-containing mucus from the cervical canal

Uterine contraction forces fetal head into cervix (stretch).

Nerve impulses reach hypothalamus causing release of oxytocin.

Oxytocin causes more contractions producing more stretch of cervix & more nerve impulses.

**Stages of Labor (Fig 29.18)**

**Dilation**

- 6 to 12 hours
- Regular contractions of the uterus
- Rupture of amniotic sac & dilation of cervix (10cm)

**Expulsion**

- 10 minutes to several hours
- Baby moves through birth canal

**Placental**

- 30 minutes
- Afterbirth is expelled by uterine contractions
- Constrict blood vessels that were torn
- Reduce the possibility of hemorrhage

Puerperium – a period of time after delivery of the baby and placenta

- About six weeks after delivery
- Reproductive organs and maternal physiology return to the prepregnancy state
uterus undergoes involution
lochia - uterine discharge of blood and serous fluid for two to four weeks after delivery

Adjustments of the Infant at Birth

Fetal adrenal medullae of secretes high levels of epinephrine and norepinephrine
afford the fetus protection against the stresses of the birth process
prepare the infant to survive extrauterine life

Respiratory System

after cord is cut, increased CO2 levels in blood
respiratory center in the medulla is stimulated
causes muscular contractions and first breath
breathing rate begins at 45/minute for the first 2 weeks & declines to reach normal rate

Cardiovascular System

foramen ovale closes at moment of birth
diverts deoxygenated blood to the lungs for the first time
remnant of the foramen ovale is the fossa ovalis
ductus arteriosus & umbilical vein close down by muscle contractions & become ligaments
ligamentum arteriosum is the remnant of the ductus arteriosus
ligamentum venosum is the remnant of the ductus venosus
pulse rate slows down (120 to 160 at birth)
increase in the rate of erythrocyte and hemoglobin production for several days after birth due
to a greater need for oxygen
This increase usually lasts for only a few days
white blood cell count at birth is very high
45,000 cells per cubic millimeter
decreases rapidly by the seventh day