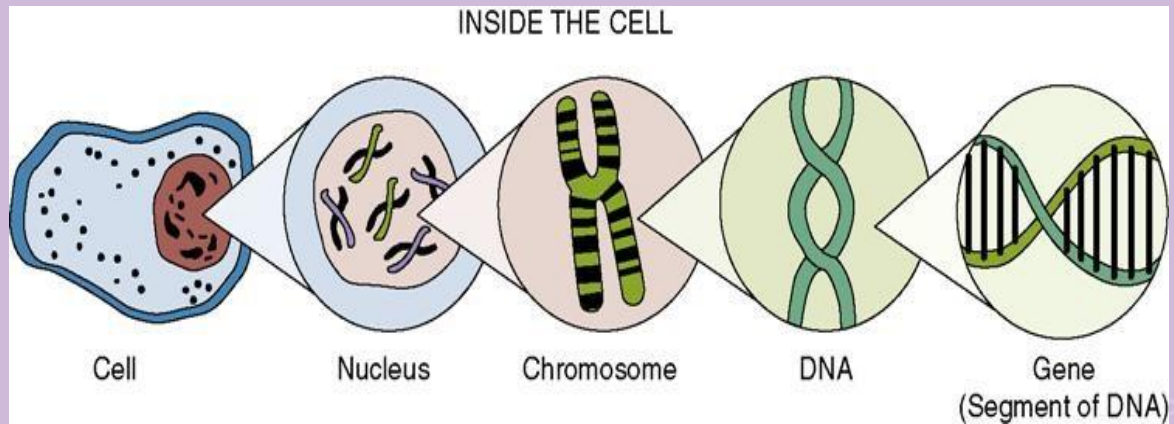
CHAPTER 3
Fetal Development

Body Cell

- DNA and nucleus control cell function
  - The genes and chromosomes in the DNA determine individual traits
- Each contains 46 chromosomes
  - 22 pairs of autosomes
  - 1 pair of sex chromosomes
- Biological development influenced by
  - External environment (teratogens)
  - Drug use
  - Undernutrition
- Smoking

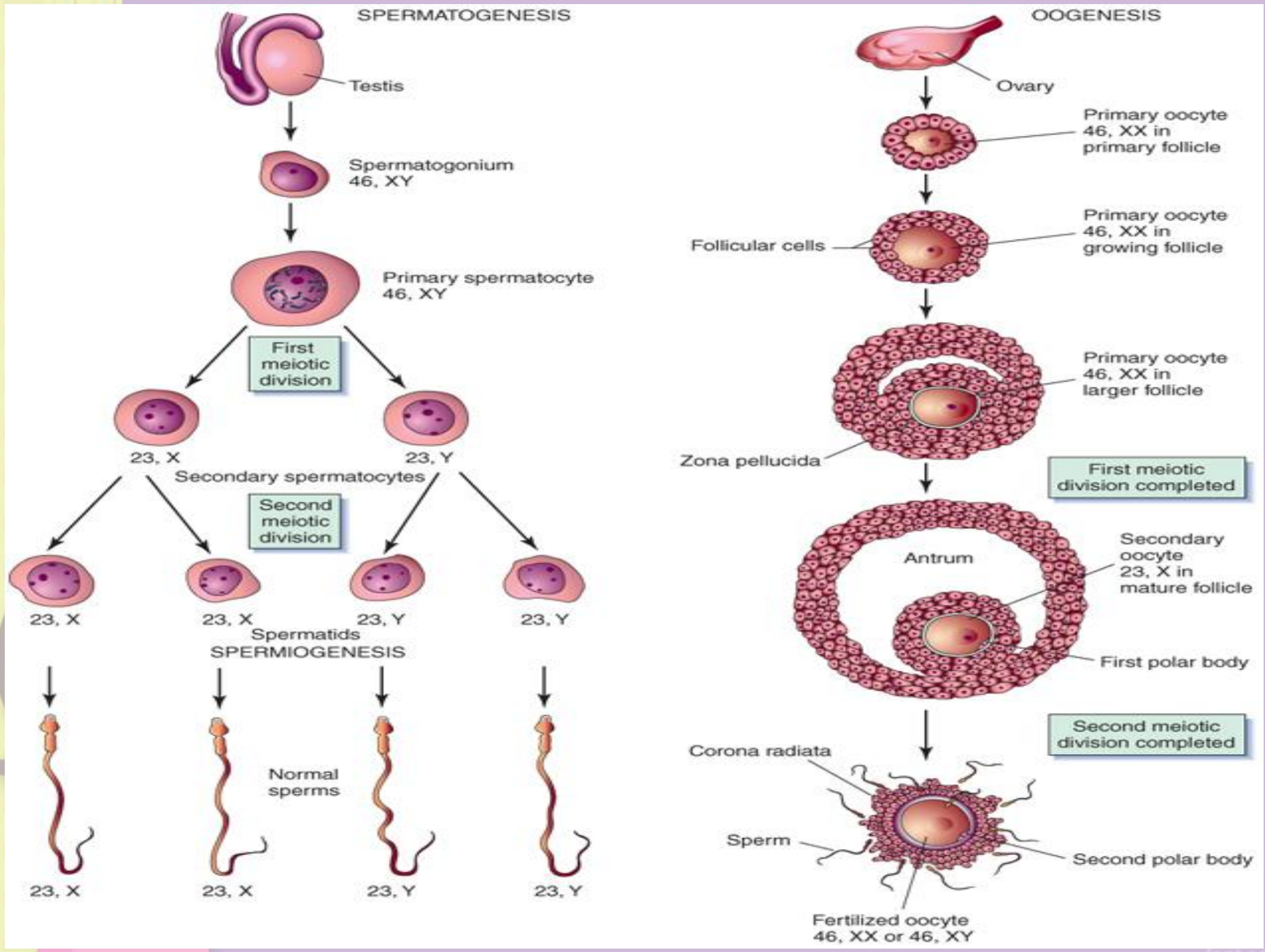


Cell Division and Gametogenesis

- Mitosis
  - Continuous process
  - Body grows, develops, and dead cells are replaced
  - Each daughter cell contains same number of chromosomes as parent cell—called *diploid*
  - Process of mitosis for sperm is spermatogenesis
  - Process of mitosis for ovum is oogenesis

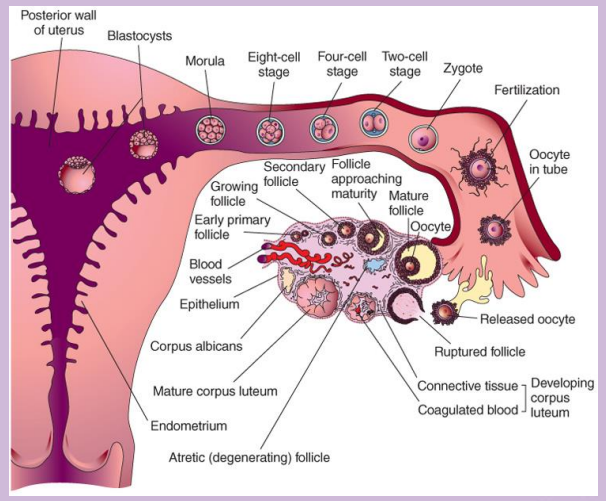
Cell Division and Gametogenesis

- Meiosis
  - Reproductive cells undergo two sequential divisions
  - Number of chromosomes is 23 per cell with only one sex chromosome—called *haploid*
  - At fertilization, the new cell contains 23 chromosomes from the sperm and 23 chromosomes from the ova
  - Formation of gametes by this type of cell division is gametogenesis


SPERMATOGENESIS
Testis
Spermatogonium
46, XY
Primary spermatocyte
46, XY
First
meiotic
division
23, X
23, Y
Secondary spermatocytes
Second
meiotic
division
23, X
23, X
23, Y
23, Y
Spermatids
SPERMIOGENESIS
Normal
sperms
23, X
23, X
23, Y
23, Y
OOGENESIS
Ovary
Primary oocyte
46, XX in
primary follicle
Follicular cells
Primary oocyte
46, XX in
growing follicle
Primary oocyte
46, XX in
larger follicle
Zona pellucida
First meiotic
division completed
Antrum
Secondary
oocyte
23, X in
mature follicle
First polar body
Second meiotic
division completed
Corona radiata
Sperm
Second polar body
Fertilized oocyte
46, XX or 46, XY

Fertilization

- Occurs when a sperm penetrates an ovum and they unite
- Takes place in the outer third of the fallopian tube, near the ovary
- As soon as it occurs, a chemical change in the membrane around the fertilized ovum prevents further sperm from penetrating the ovum



Nursing Tip

- During sexual counseling, the nurse should emphasize that the survival time of sperm ejaculated into the area of the cervix may be up to 5 days and that pregnancy can occur with intercourse as long as 5 days before ovulation

Sex Determination

- Sperm can carry either an X or a Y chromosome
- Male determines the gender of the fetus
- pH of female reproductive tract influences survival rate of the X- and Y-bearing sperm, including speed of motility
- XX results in female
- XY results in male

Sex Determination

- The gender of a baby is determined by the father's sperm.
- The conception and birth of a child of a certain sex is a source of concern to some families

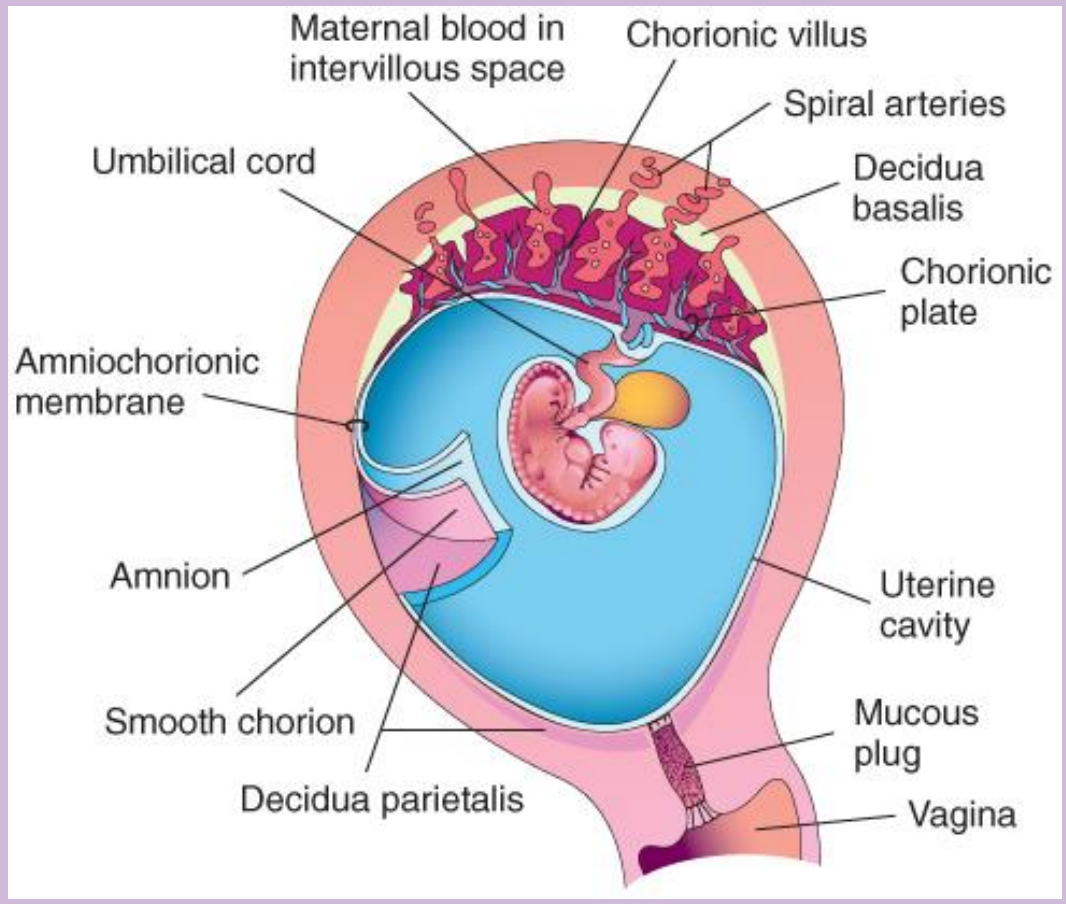
Inheritance

- Each gene is coded for inheritance
  - Genes carry instruction for dominant and recessive traits
  - Dominant usually overpower recessive
  - Passed on to offspring

Tubal Transport of the Zygote

- Zygote is formed by union of sperm and ovum
- Transported through fallopian tube into uterus
- During transport, zygote undergoes rapid mitotic division (known as *cleavage*)
- Size of zygote does not increase, individual cells become smaller as they divide, then form a solid ball (known as a *morula*)

Maternal-Fetal Circulation



Morula

- Enters uterus on third day
  - Floats for another 2 to 4 days
  - Cells form a cavity
  - Two distinct layers evolve
    - Inner layer is a solid mass of cells called *blastocyst*
    - Develops into embryo and embryonic membranes
  - Outer layer—trophoblast
  - Develops into embryonic membrane—chorion

Implantation of the Zygote

- Usually in upper section of posterior uterine wall
  - Cells burrow into prepared lining—endometrium
  - Endometrium now called *decidua*
  - Area under blastocyst is decidua basalis
    - Becomes maternal part of the placenta

Development

- Cell differentiation
  - Occurs after implantation
  - Special functions
    - Chorion
    - Amnion
    - Yolk sac
    - Primary germ layers

Chorion

- Develops from trophoblast
- Envelops amnion, embryo, and yolk sac
- Thick membrane has projections called *villi*
- Villi extend into decidua basalis on uterine wall
- Form the embryonic/fetal portion of placenta

Amnion

- Second membrane
- Thin structure that envelops and protects embryo
- Together, chorion and amnion form an amniotic sac filled with fluid (bag of waters)
- Amniotic fluid is clear, mild odor, may contain bits of vernix or lanugo
- Volume of fluid steadily increases from ~30 mL at 10 weeks to 350 mL at 20 weeks; at 37 weeks, fluid is ~1000 mL

Functions of Amniotic Fluid

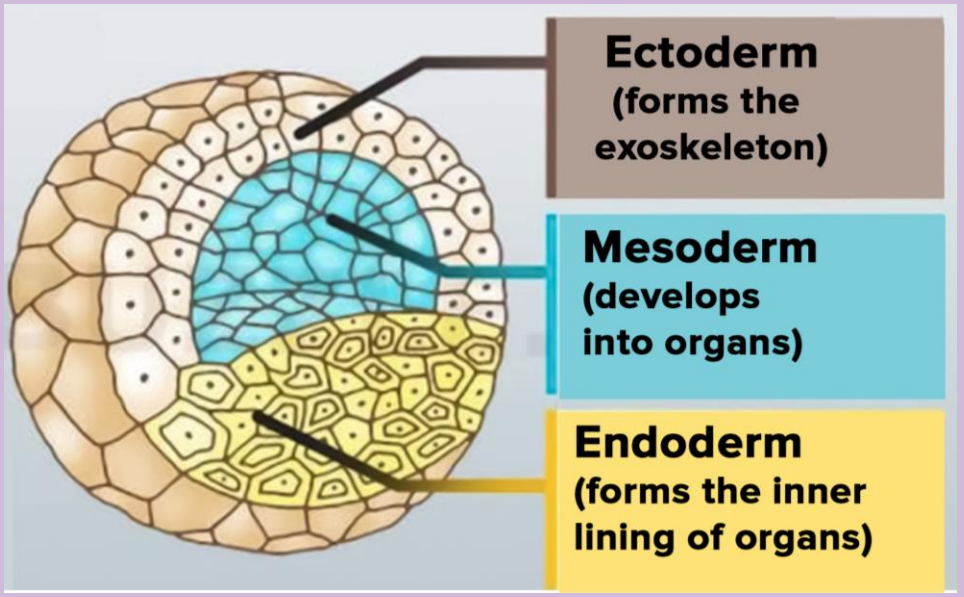
- Maintains an even temperature
- Prevents the amniotic sac from adhering to the fetal skin
- Allows symmetrical growth of fetus
- Allows buoyancy and fetal movement
- Acts as a cushion to protect the fetus and umbilical cord from injury

Yolk Sac

- A cavity develops on the ninth day after fertilization
- Functions only during embryonic life
- Initiates production of red blood cells
- Continues until fetal liver takes over around 6 weeks
- Umbilical cord encompasses yolk sac which then degenerates

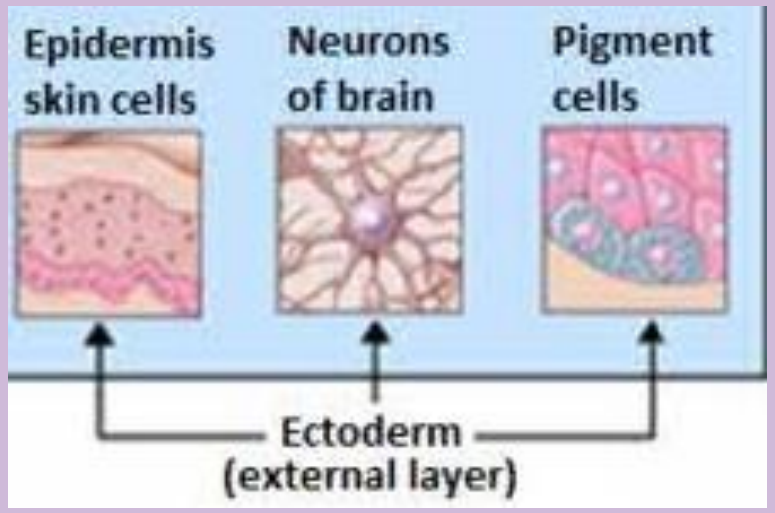
Germ Layers

- Zygote in blastocyst stage transforms into three primary germ layers
  - Ectoderm
  - Mesoderm
  - Endoderm



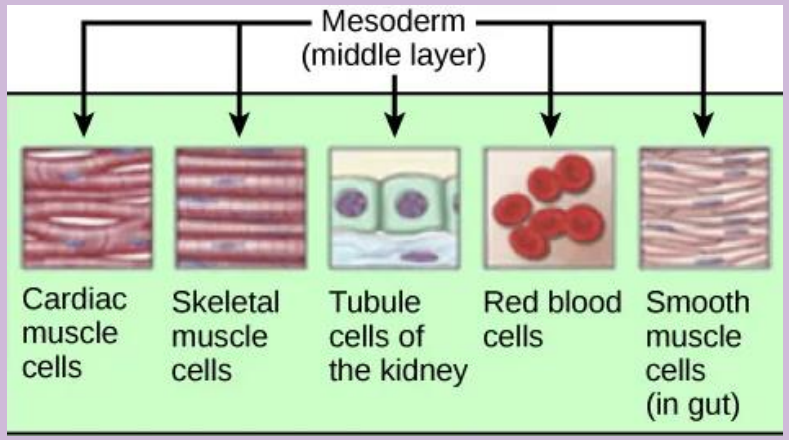
Ectoderm

- Outer layer of skin
- Oil glands and hair follicles of skin
- Nails and hair
- External sense organs
- Mucous membrane of mouth and anus



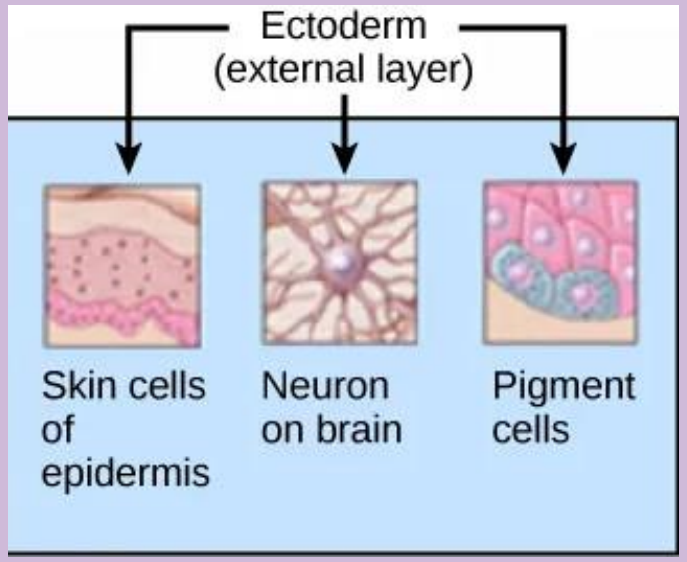
Mesoderm

- True skin
- Skeleton
- Bone and cartilage
- Connective tissue
- Muscles
- Blood and blood vessels
- Kidneys and gonads



Endoderm

- Lining of trachea, pharynx, and bronchi
- Lining of digestive tract
- Lining of bladder and urethra



Three Stages of Prenatal Development

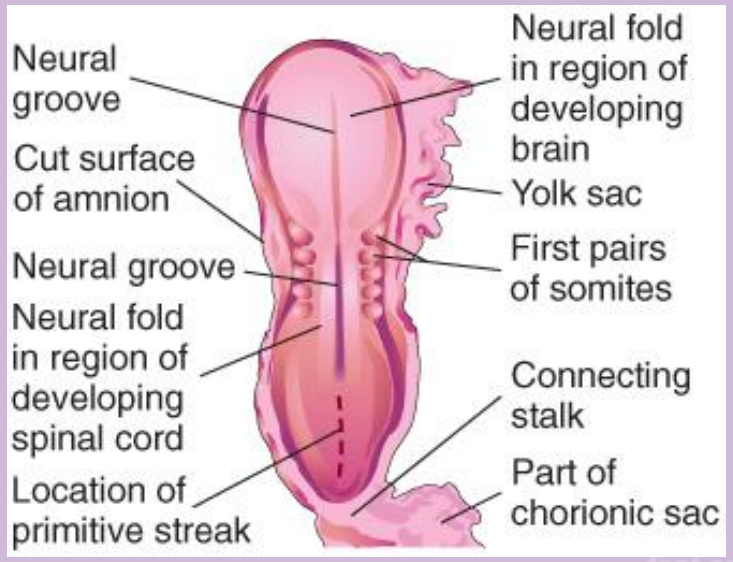
- Zygote: cell formed by union of sperm and ovum
- Embryo: second to eighth week of development
- By third week heart will pump blood
- Fetus: ninth week until birth
- Age of viability: 20 weeks of gestation but requires NICU care to survive

Nutritional Consideration

- Folic Acid Supplements can help prevent most neural tube defects..which can help with prevention of spina bifada
- It is important that mother start with supplements in the first days of the embryo.

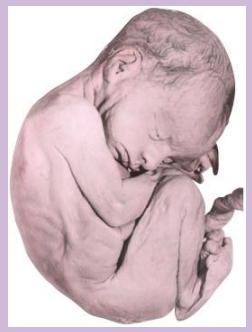
Prenatal Development

- Embryo at 3, 4, 6, and 8 weeks and by 9th week able to see sex organs on Ultra sound



Prenatal Development

- Embryo at 17- leg movement and 25 weeks, bones ossified; eye movement occurs
- Embryo at 25 - eyes are open, now viable, vernix caseosa and lanugo on skin, brown fat formed, lungs begin to secrete surfactant



Prenatal Development

- Embryo at 29 and 36 weeks

Accessory Structures of Pregnancy

- Placenta
- Umbilical cord
- Fetal circulation
  - Supports fetus

Placenta

- Organ for fetal respiration, nutrition, and excretion
- Produces four hormones
  - Progesterone
  - Estrogen
  - Human chorionic gonadotropin (hCG)
  - Human placental lactogen (hPL)

Placental Transfer

- Fetal deoxygenated blood and waste products leave the fetus through two umbilical arteries
- Fetal and maternal blood do not normally mix
- Oxygenated, nutrient-rich blood from mother spurts into intervillous space from spiral arteries in the decidua
- Fetal blood releases carbon dioxide and waste products

Placental Transfer

- Fetal blood takes oxygen and nutrients before returning to fetus through umbilical vein
- Many harmful substances can be transferred to fetus
  - Drugs, nicotine, viral infectious agents
  - May cause fetal drug addiction, congenital anomalies, and fetal infection

Placental Hormones

- Progesterone
- Functions during pregnancy
  - Maintains uterine lining for implantation of the zygote
  - Reduces uterine contractions to prevent spontaneous abortion
  - Prepares the glands of the breasts for lactation
  - Stimulates testes to produce testosterone, which aids the male fetus in developing the reproductive tract

Placental Hormones

- Estrogen
- Stimulates uterine growth
  - Increases the blood flow to uterine vessels
  - Stimulates development of the breast ducts to prepare for lactation
- Effects of estrogen, not related to pregnancy
  - Increased skin pigmentation
  - Vascular changes in the skin and mucous membranes of nose and mouth
  - Increased salivation

Human Chorionic Gonadotropin (hCG)

- Causes the corpus luteum to persist and continue production of estrogen and progesterone to sustain pregnancy
- hCG is detectable in maternal blood as soon as implantation occurs (usually 7 to 9 days after fertilization)

Human Placental Lactogen (hPL)

- Also known as *human chorionic somatomammotropin* (hCS)
- hPL causes decreased insulin sensitivity and utilization of glucose by mother
  - Helps to make more glucose available to fetus to meet growth needs

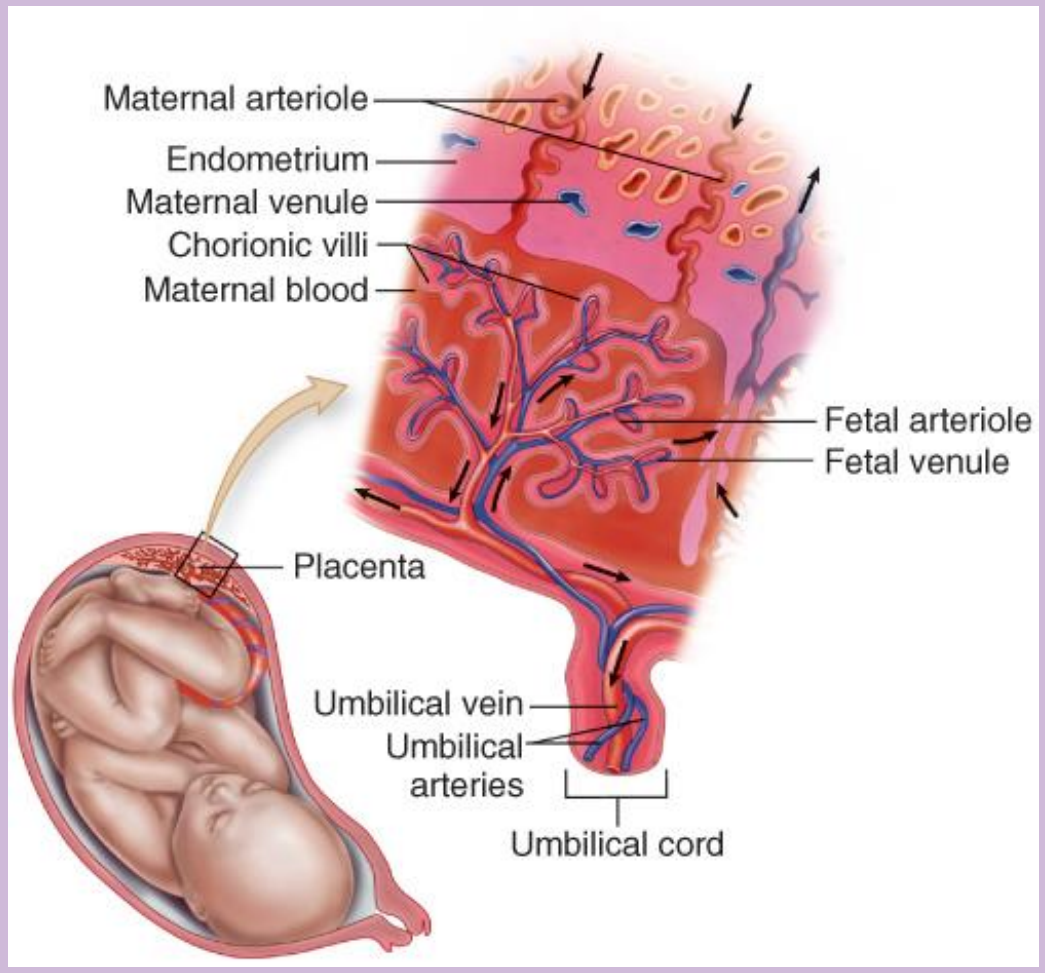
Umbilical Cord

- Lifeline between mother and fetus
- Two arteries carry blood away from fetus
- One vein returns blood to the fetus
- Wharton’s jelly covers and cushions cord vessels
- Normal length is 55 cm (22 inches)
- The umbilical cord usually protrudes near the center of the placenta

Memory Jogger

- An easy way to remember the number and type of umbilical cord vessels is the woman's name "AVA," which stands for "Artery-Vein-Artery"

Maternal-Fetal Circulation



Fetal Circulatory Shunts

- Foramen ovale-diverts most blood from right atrium to left atrium
- Ductus arteriosus-diverts most blood from the pulmonary artery into the aorta
- Ductus venosus-diverts some blood away from the liver as it returns from the placenta

Circulation Before Birth

- Blood enters fetal body through umbilical vein
- About half goes to the liver, remainder enters inferior vena cava through the ductus venosus, then goes through foramen ovale, then ductus arteriosus
- Blood containing waste products is returned to placenta through umbilical arteries

Circulation After Birth

- Foramen ovale closes within 2 hours after birth (permanently by age 3 months)
- Ductus arteriosus closes within 15 hours (permanently in about 3 weeks)
- Ductus venosus closes functionally when cord is cut (permanently in about 1 week)
- If newborn has untreated respiratory distress it can cause the foramen ovale to reopen the increased resistance to blood flow
- After permanent closure, the ductus arteriosus and ductus venosus become ligaments

Impaired Prenatal Development

- Undernutrition
  - Can result in permanent changes in fetal structure, physiology, and metabolism
  - Can influence development of conditions such as heart disease and stroke in adulthood
  - Exposure to toxins in utero
  - Can also influence health in later life

Impaired Prenatal Development

- Intrauterine growth restriction may reduce number of cells in organs
  - Can predispose to the development of specific diseases later in life
- Fetal growth best assessed when weight, length of gestation, placental size, and newborn head and abdominal circumference are considered
- Fetal growth limited by nutrients and oxygen received from mother-for instance monozygotic twins
- A healthy mother can produce a healthy child who is less prone to illness

Impaired Prenatal Development and Subsequent Illness

- Undernutrition in utero can result in:
  - Permanent changes in fetal structure, physiology, metabolism
  - Development of chronic conditions later in life
- To prevent illness of the next generation, this generation must focus on their own health practices

Multifetal Pregnancy

- Twins occur once in every 90 pregnancies
- When hormones are used to assist with ovulation, twinning and other multifetal pregnancies occur
- Monozygotic twins are from a single fertilized ovum (identical)
- Dizygotic twins are from two separate fertilized ovum (fraternal) so will have separate chorions
  - Usually a familial tendancy

Multifetal Pregnancy