Development

Human reproduction statistics:

~ 50% of concepti do not implant

a further ~30% die and abort after implantation.

- **3-4% of all live births possess an obviously visible congenital defect (120,000 babies/year in the USA).**
- **1% of all babies are born with a heart defect.(not counting septum defects)**
- **20% of newborn deaths are caused by congenital defects (the leading cause of neonatal death in the USA)**
- **congenital disorders are the cause of 50% of pediatric admissions in the USA**

PRINCIPLES OF EMBRYONIC DEVELOPMENT

- Fertilization results in a zygote and triggers embryonic development

- The shape of a human sperm cell is adapted to its function

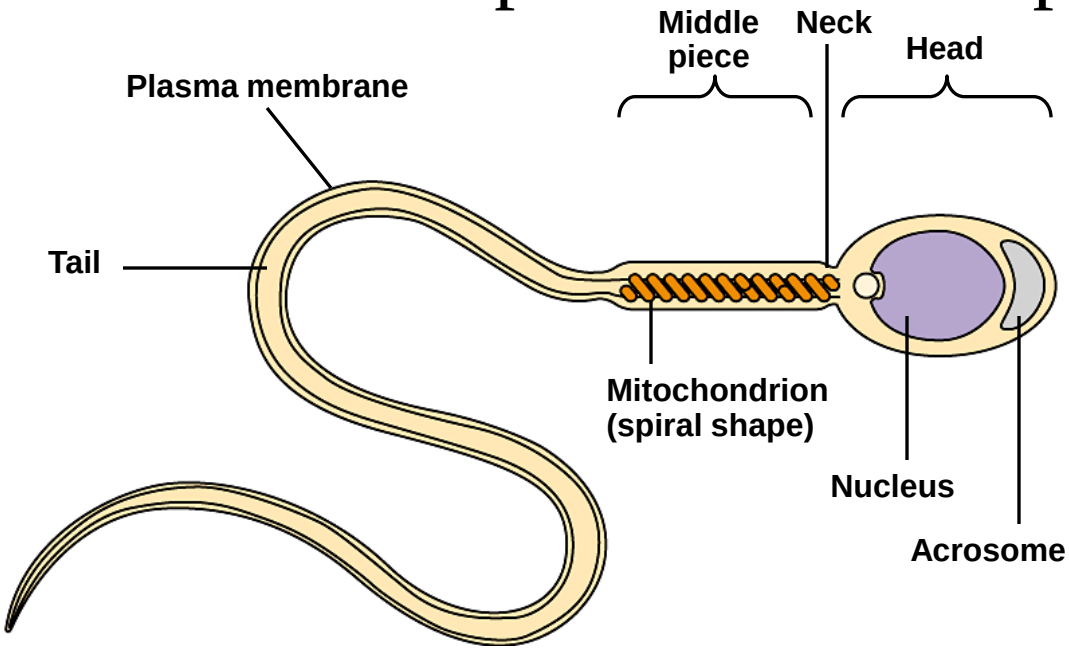
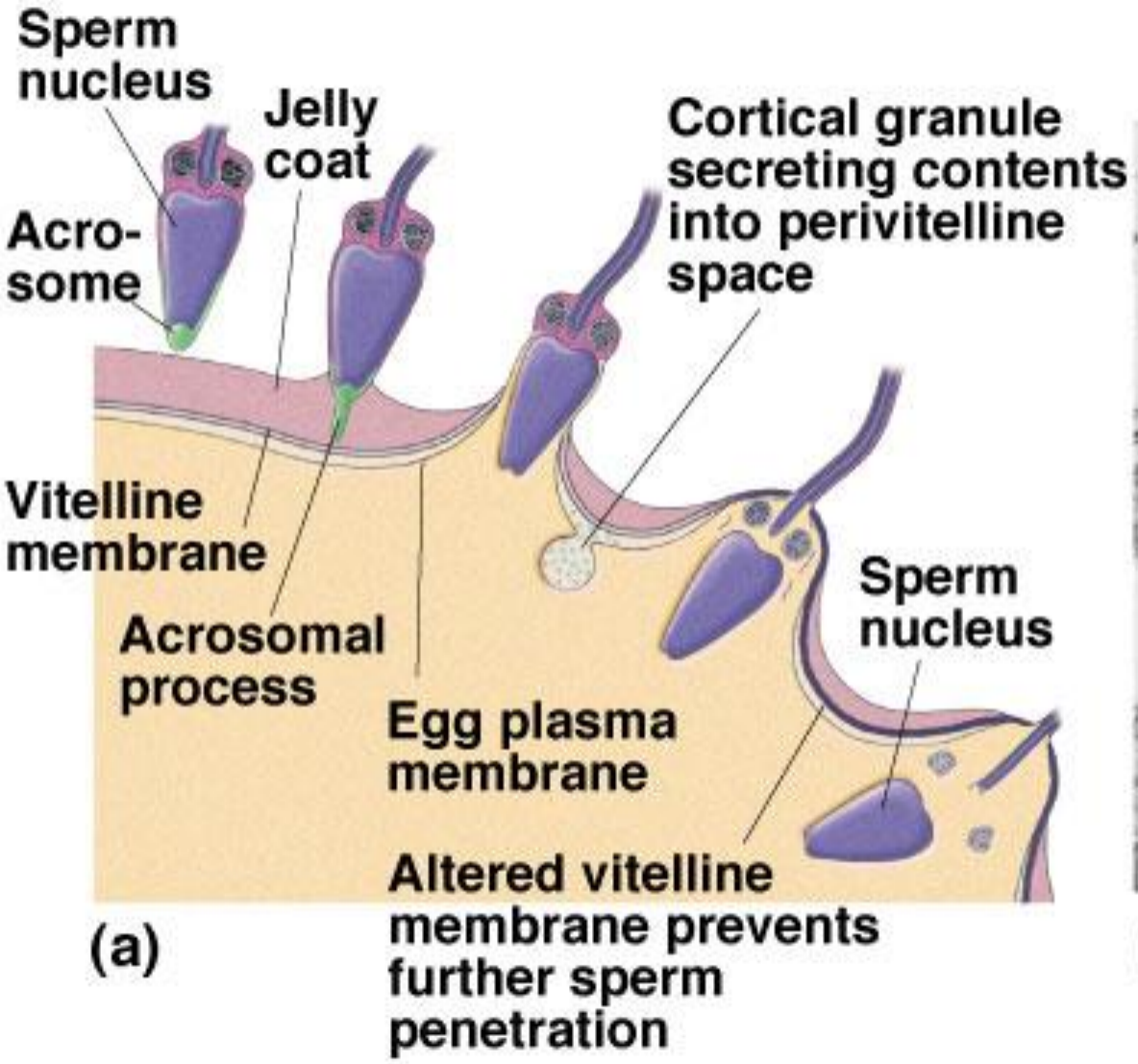
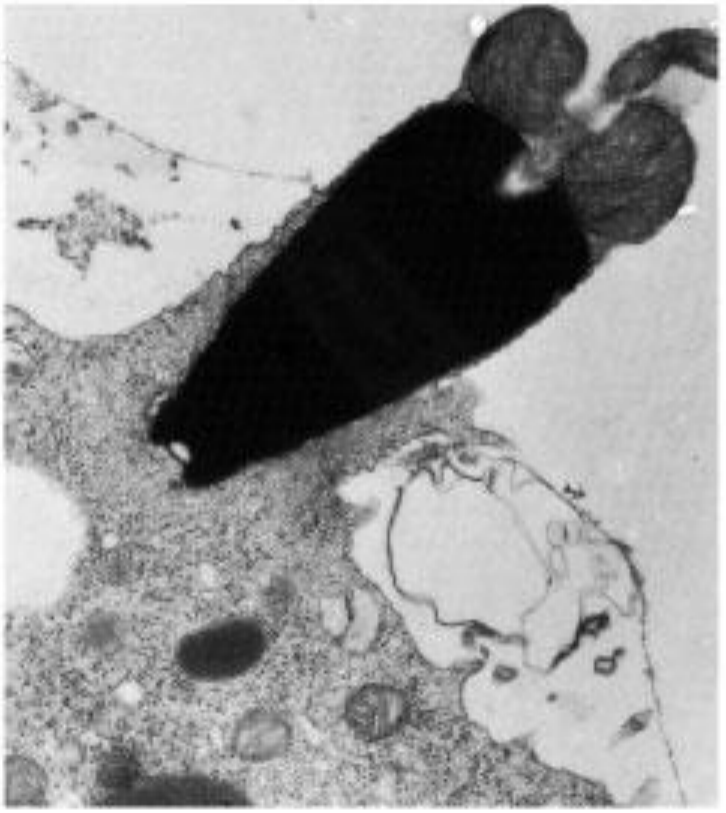


Figure 27.9B

Frogs, reptiles and birds: >1 sperm enters, but 1 succeeds
Mammals: 1 sperm prevents the 2nd entry





Sperm penetration of sea urchin egg (20-30 sec)

- Only one of these sperm will penetrate this human egg cell to initiate fertilization
  - Fertilization is the union of a sperm and an egg to form a diploid zygote

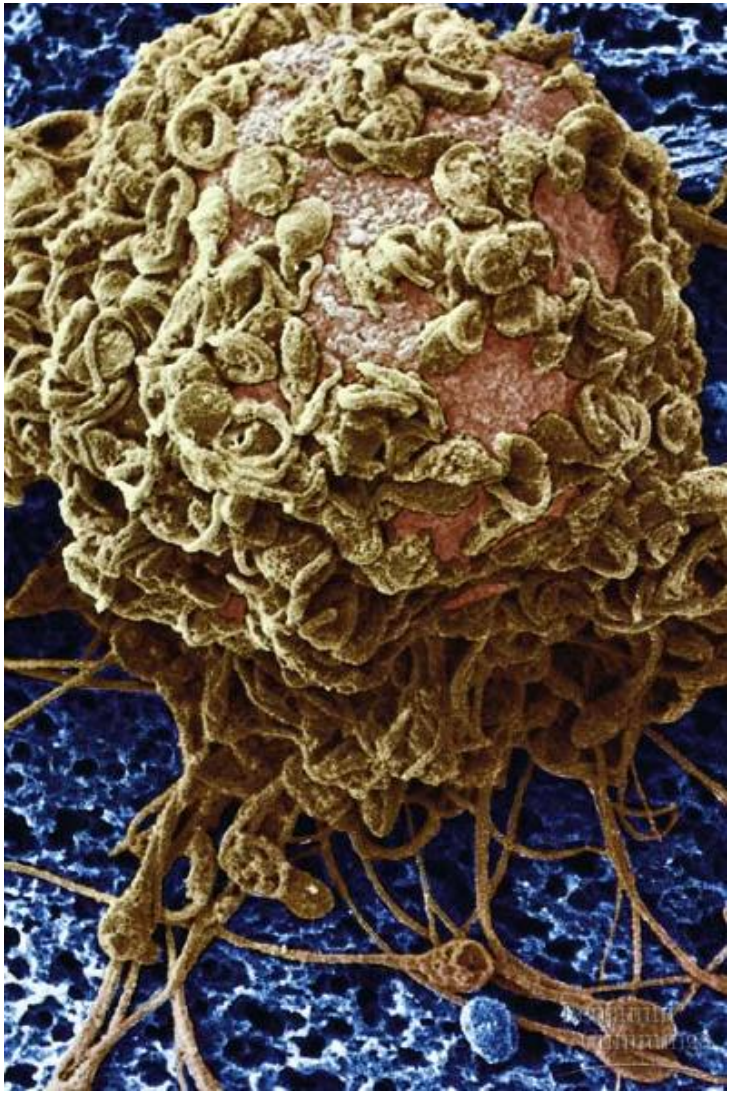


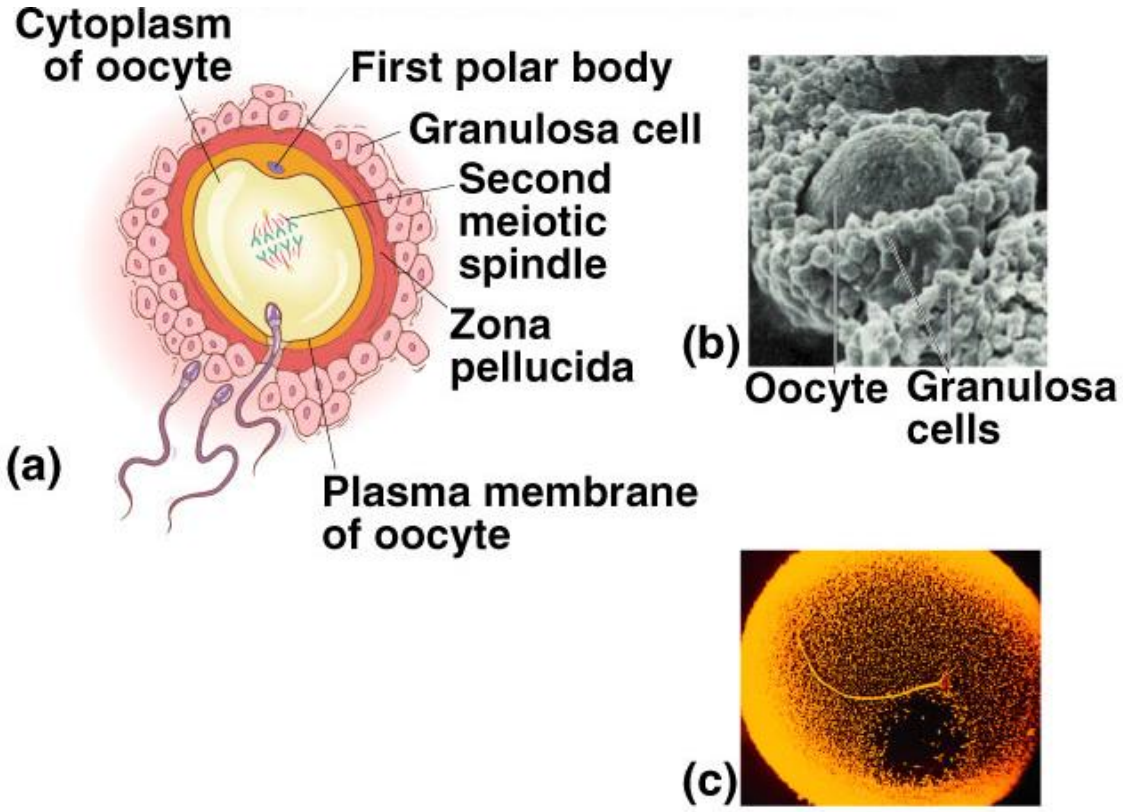
Figure 27.9A

Three Stages of Fertilization

- Penetration
- Activation
- Fusion

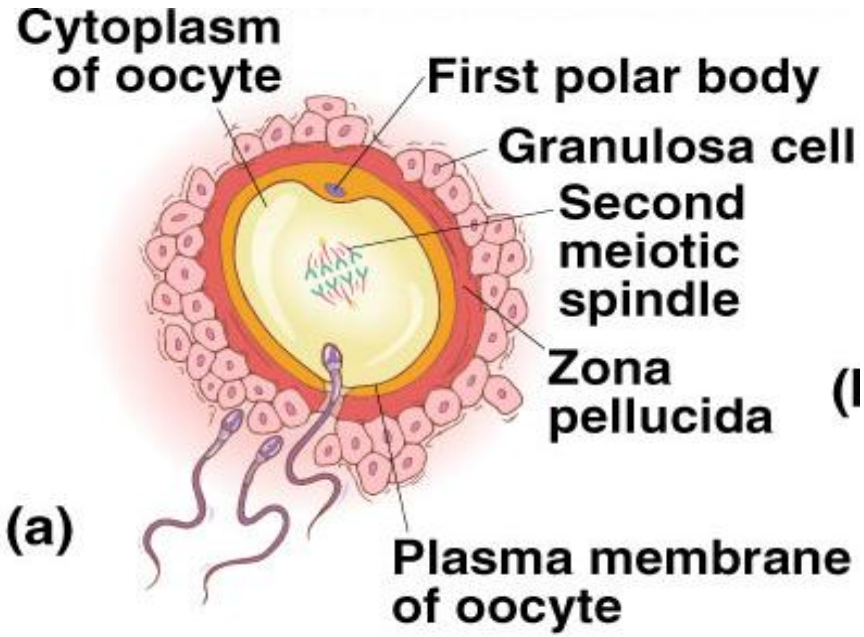
Fertilization

- Penetration
  - glycoprotein-digesting enzymes in acrosome of sperm head



Fertilization

- Activation
  - events initiated by sperm penetration
    - chromosomes in egg nucleus complete second meiotic division
    - triggers movement of egg cytoplasm
    - sharp increase in metabolic activity



Fertilization

- Nuclei fusion
  - The third stage of fertilization is fusion of the entering sperm nucleus with the haploid egg nucleus to form the diploid nucleus.

Stages of Early Development

- Cleavage is the first major phase of embryonic development
  - It is the rapid succession of cell divisions
  - It creates a multicellular embryo from the zygote
  - It partitions the multicellular embryo into developmental regions

- Blastula as the result of cleavage
  - Blastocoel- forms a hollow portion called blastula

Cleavage -

- **When the original zygote cleaves into many smaller cells by the process of mitosis**
- **Blastula - the group of cells that form as a result of cleavage**
  - **Blastocoel - when the blastula forms a hallow portion with in the ball of cells**
- **In all more complex animals a yolk forms in what is called the vegetal pole**

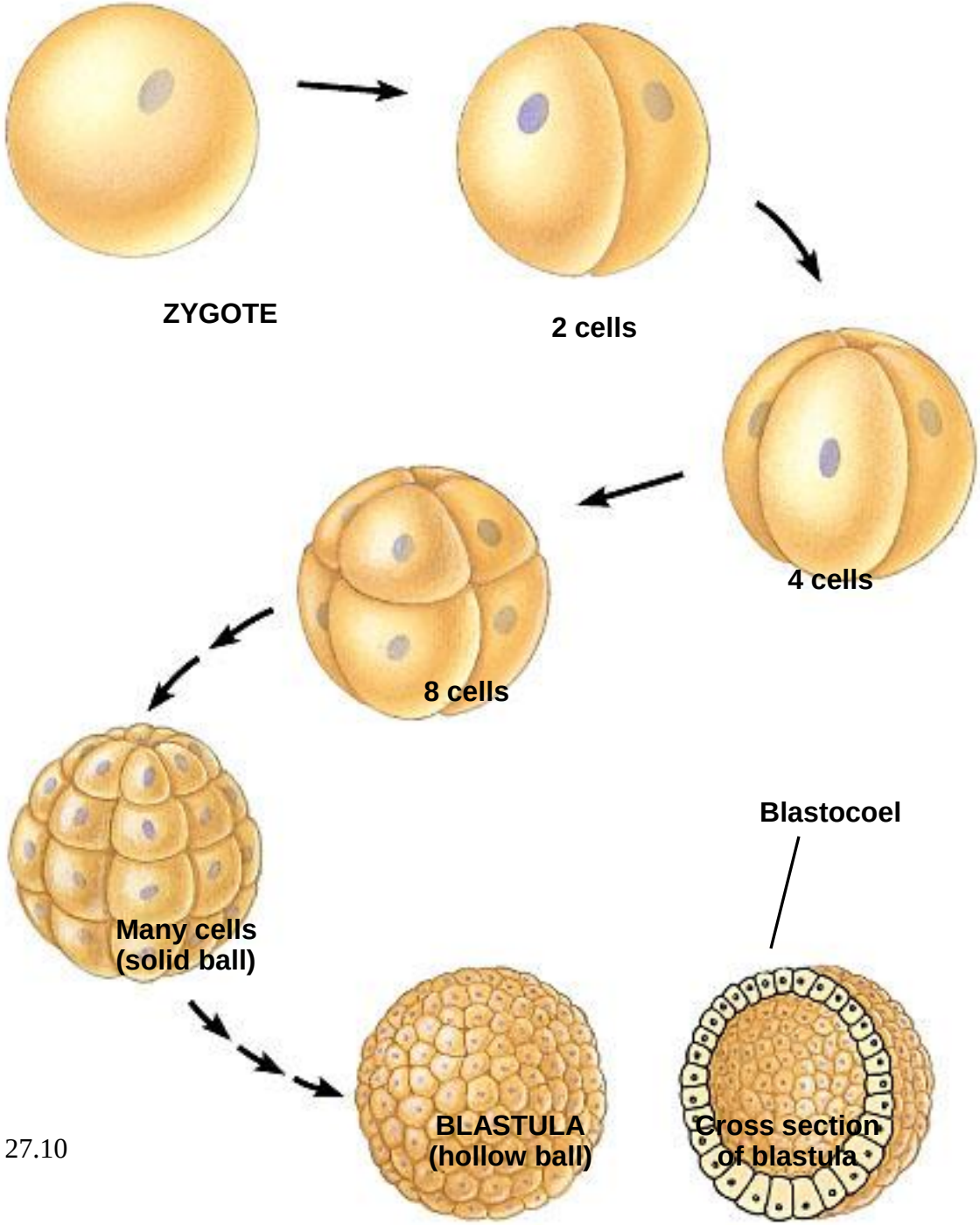
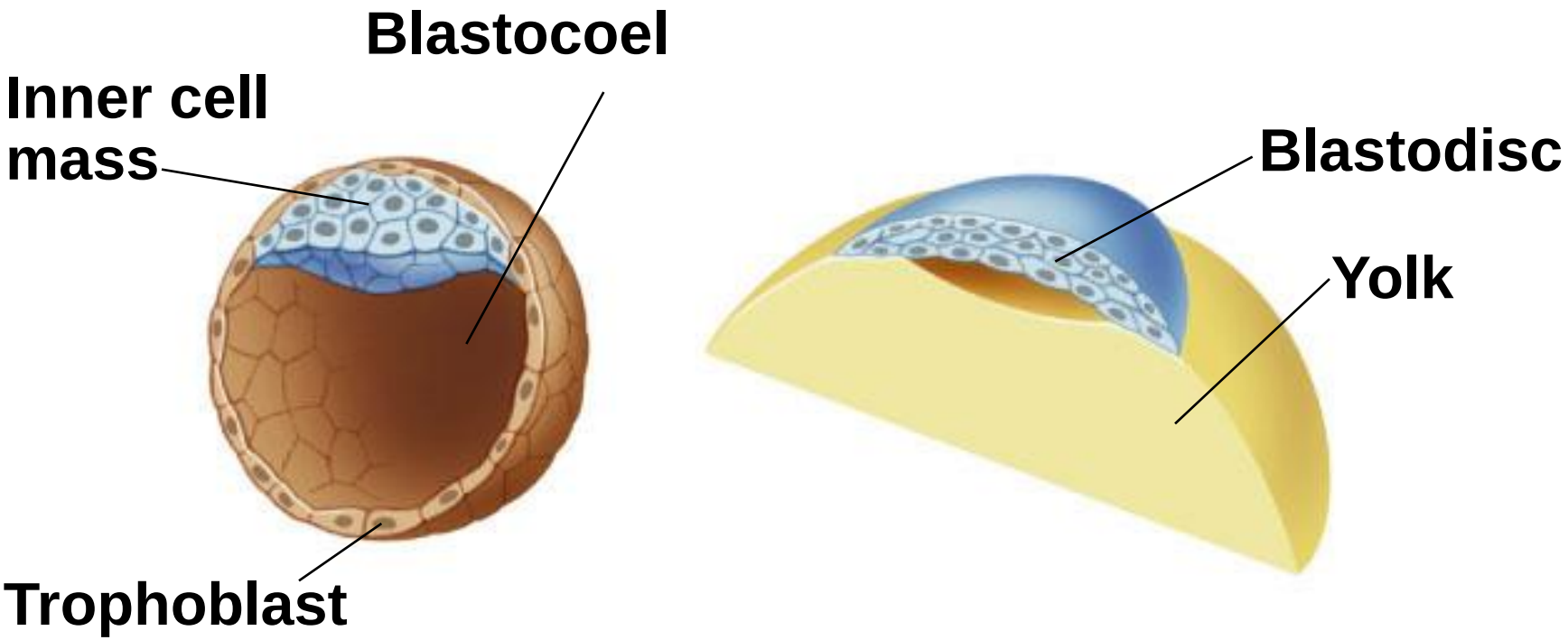

ZYGOTE
2 cells
4 cells
8 cells
Many cells
(solid ball)
BLASTULA
(hollow ball)
Blastocoel
Cross section
of blastula

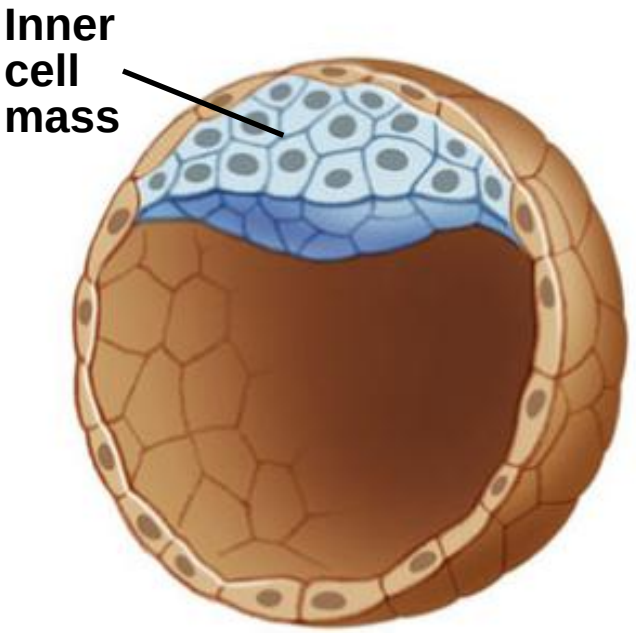
Figure 27.10



Mammalian blastula/blastocyst and Bird blastula

Cell Cleavage Patterns

- Blastula
  - Each cell is in contact with a different set of neighboring cells.
    - Interactions are a major factor influencing developmental fate.

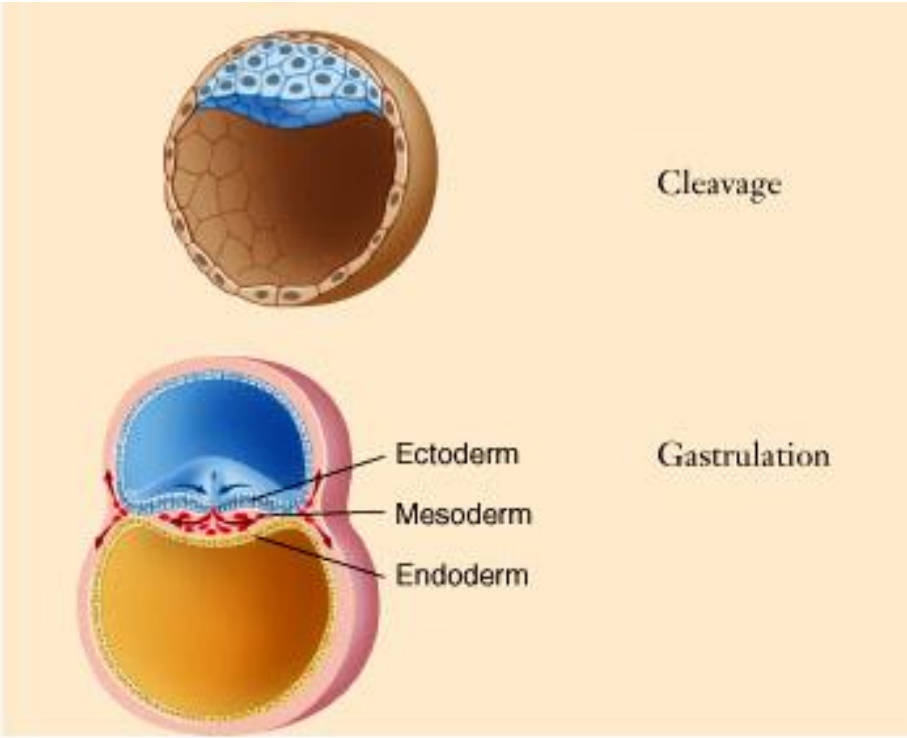


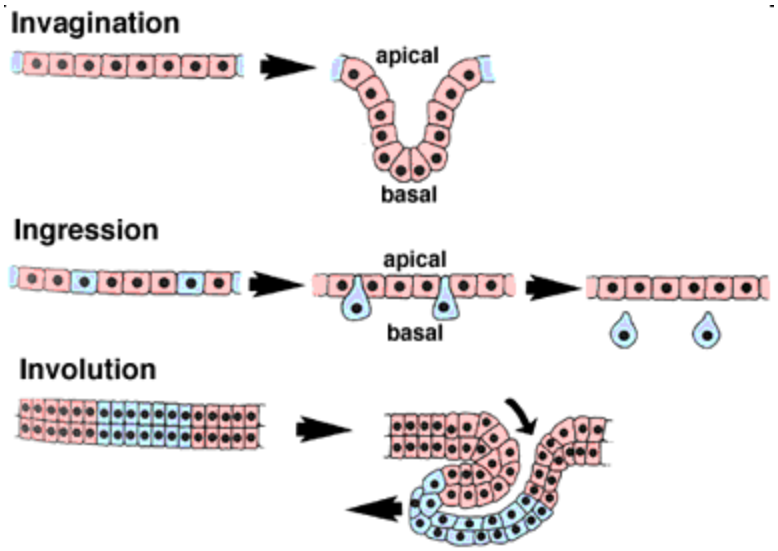
Morphogenesis –

- **Is the beginning of form and structure of the organism (Structure Beginning)**
- **Gastrulation *is the second major phase of embryonic development**
- **Gastrolation - is when the blastula further develops into three distinct development layers called germ layers, endoderm, mesoderm and ectoderm**
  - It adds more cells to the embryo
  - It sorts all cells into three distinct cell layers
  - The embryo is transformed from the blastula into the gastrula
- **Gastrula - is the result of gastrulation**
  - **The lower cavity called the archenterons forms from the endoderm and will form the digestive tract**

Gastrulation

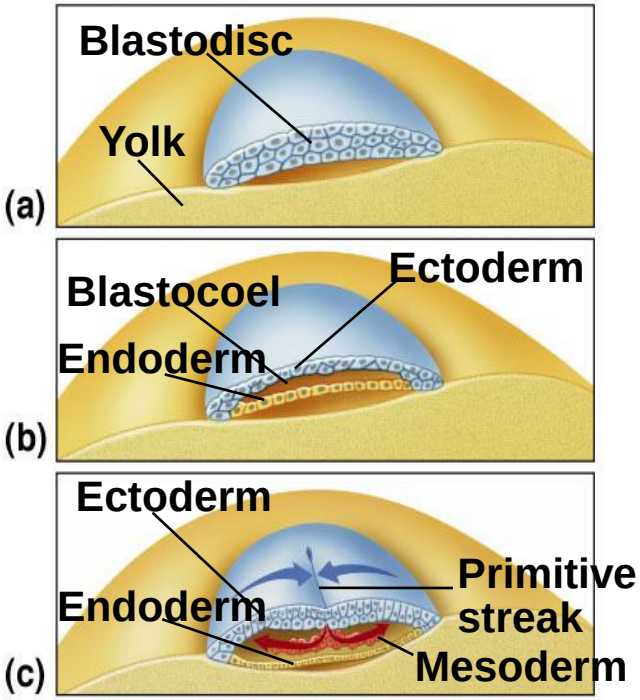
- Certain groups of cells invaginate (dent inwards) and involute (roll) from the surface of the blastula during gastrulation.
  - By the end of gastrulation, embryonic cells have rearranged into three primary germ layers:
    - ectoderm
    - mesoderm
    - endoderm

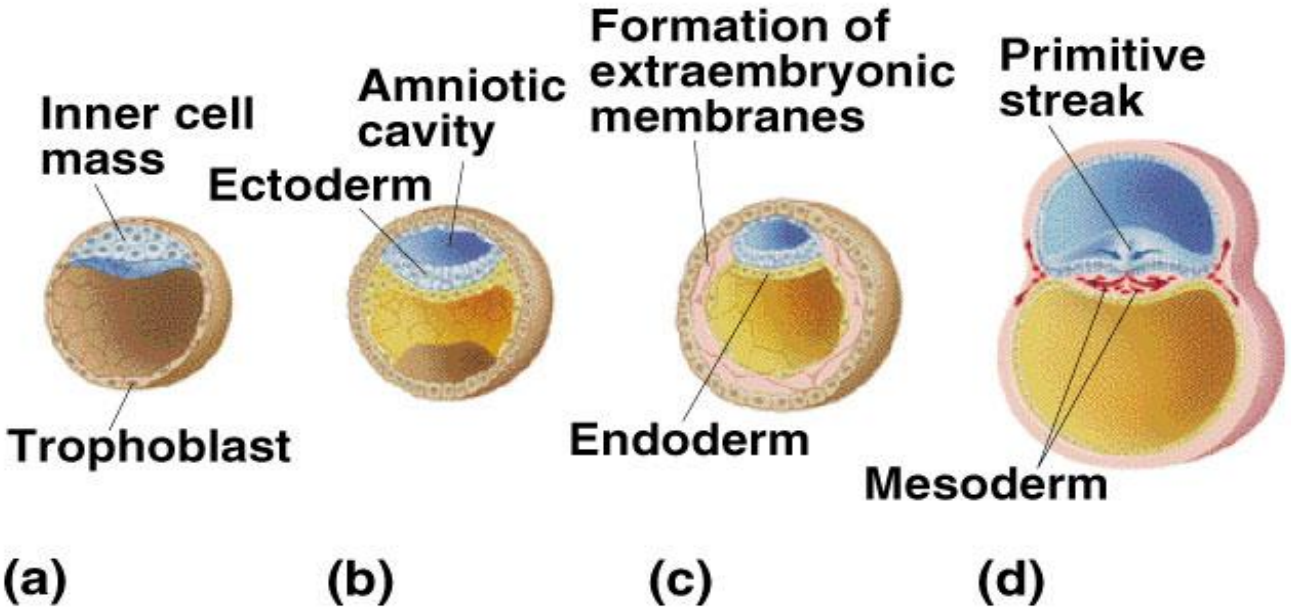




Gastrulation

- Gastrulation in reptiles, birds, mammals
  - **no yolk separates two sides of embryo**
    - **lower cell layer differentiates into endoderm and upper layer into ectoderm without cell movement**





Control and differentiation

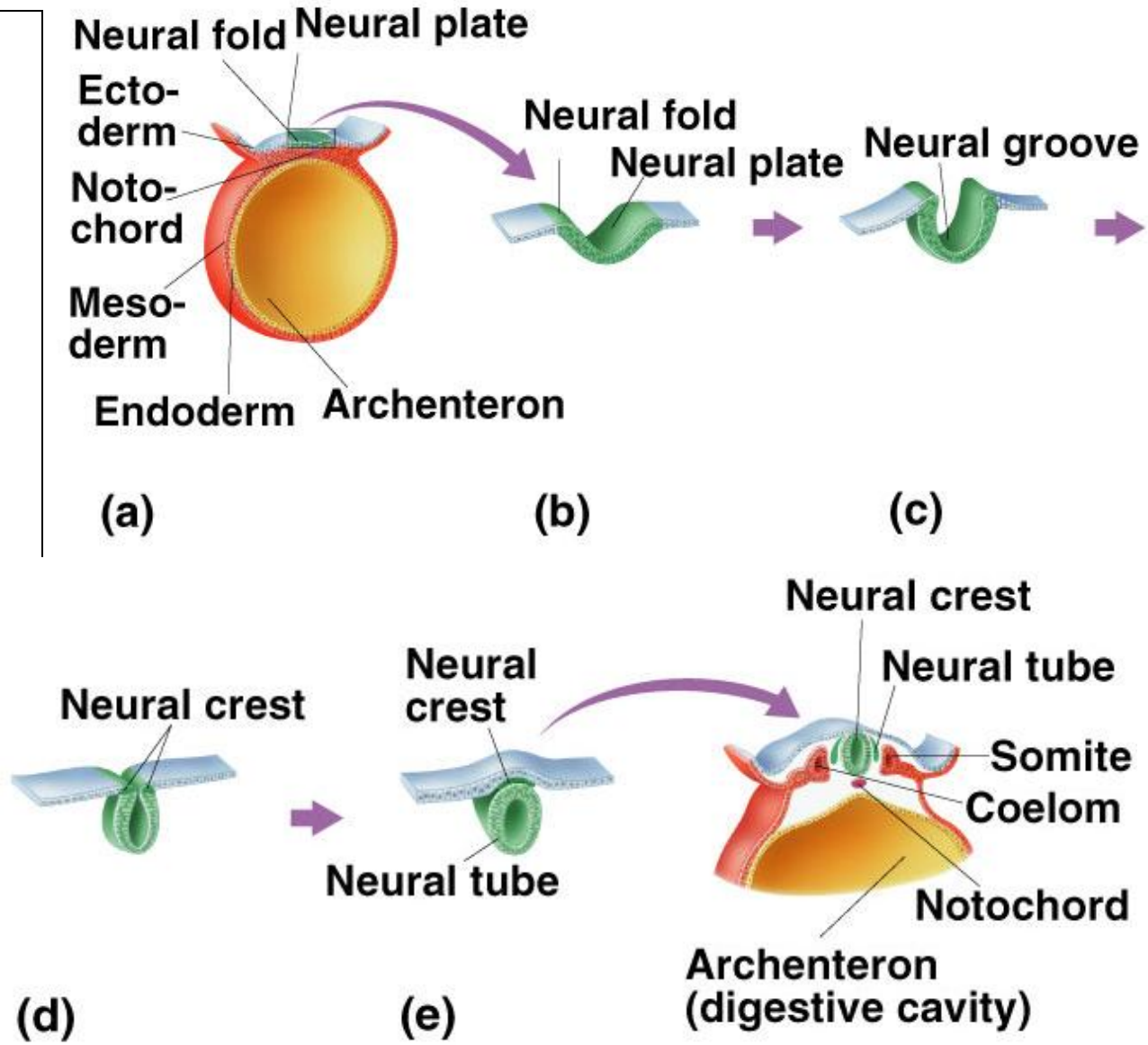
- **all animal and plant nuclei have all the information to develop a complete new organism**
- **Discuss Cloning**

Organs start to form after gastrulation

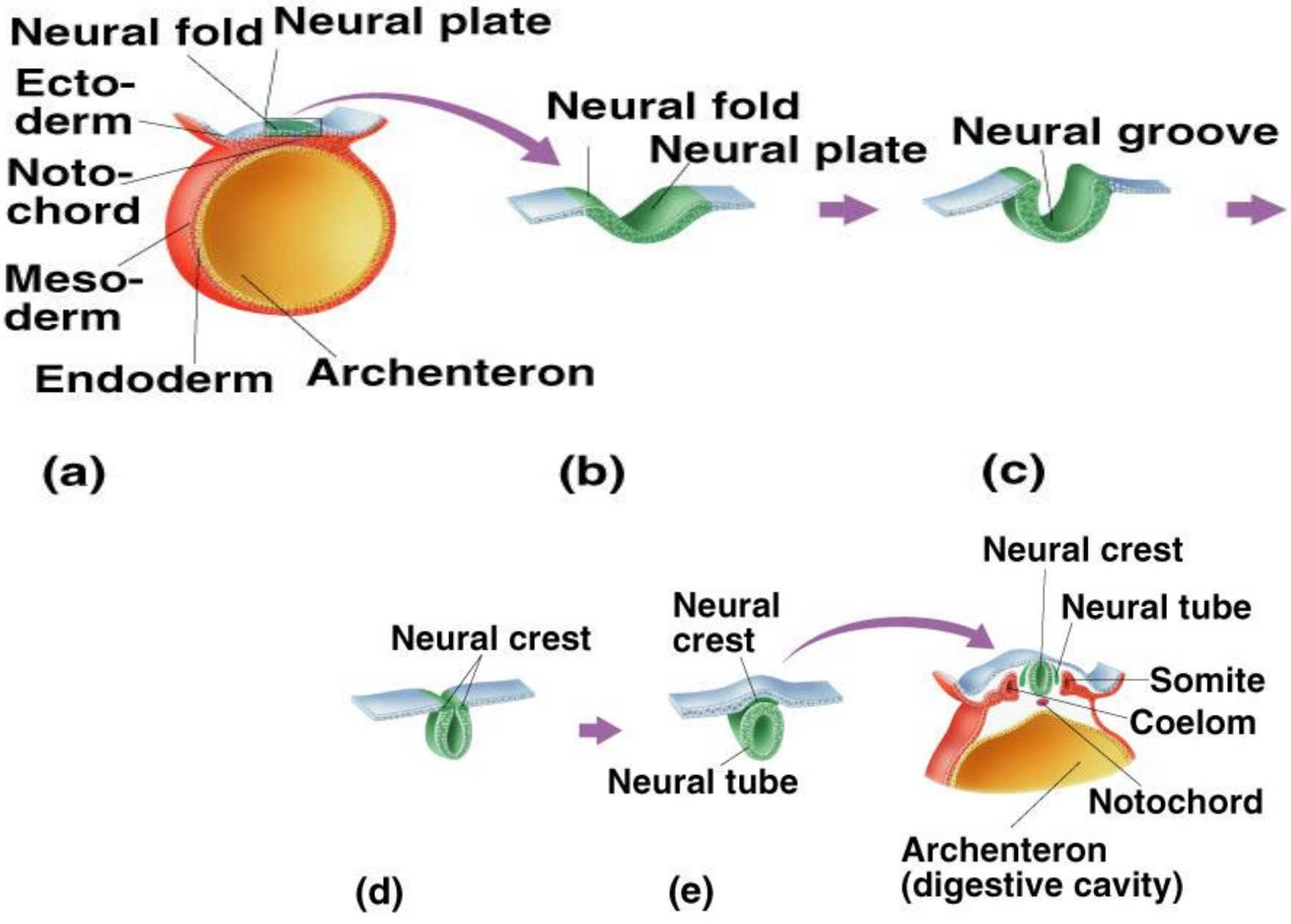
- Embryonic tissue layers begin to differentiate into specific tissues and organ systems
- In chordates
  - the notochord develops from the mesoderm
  - the neural tube develops from the ectoderm
- The neural tube becomes the brain and spinal cord

Developmental Processes During Neurulation

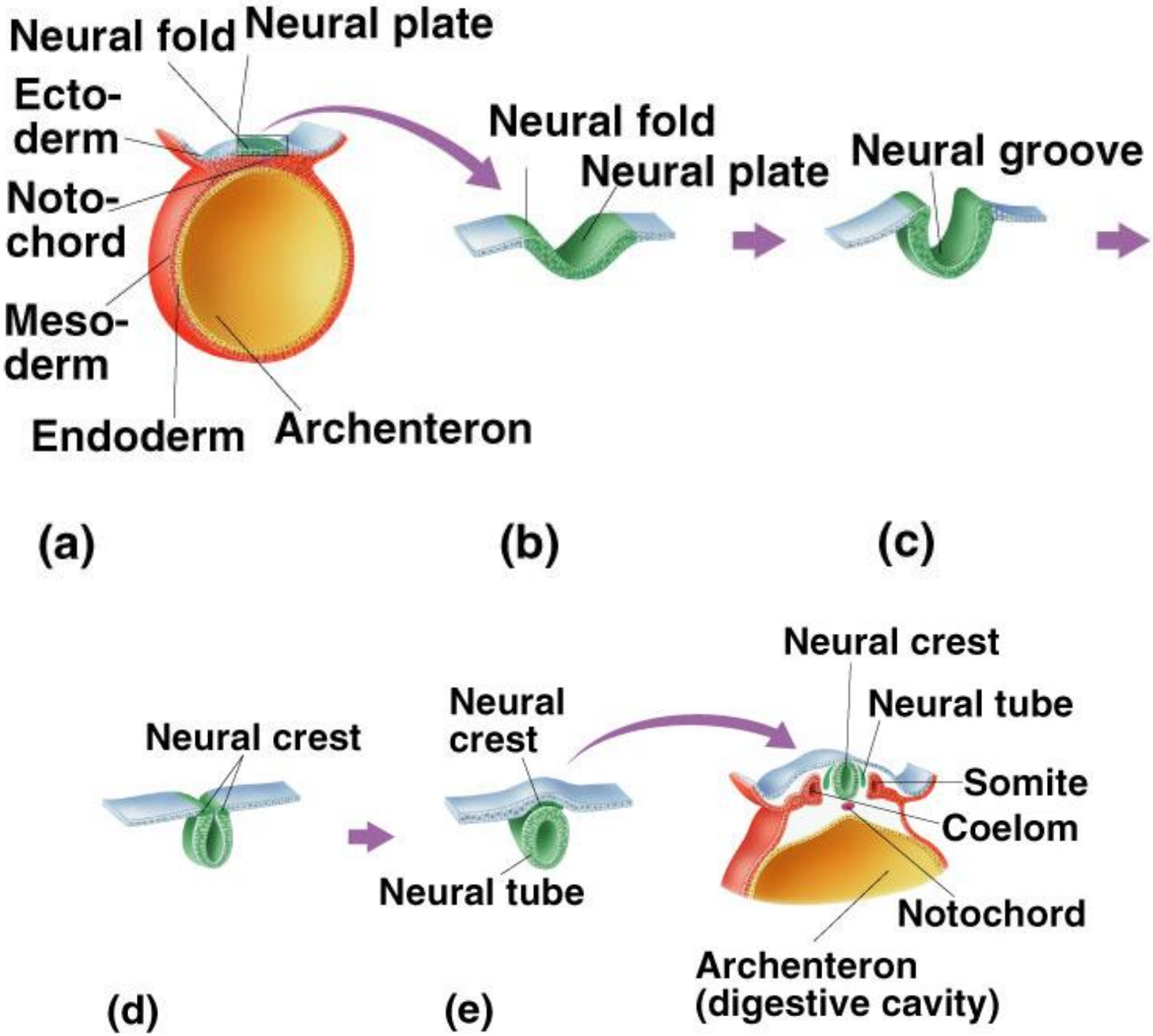
- **Tissue differentiation begins with the formation of the notochord and the hollow dorsal nerve cord.**
  - **neurulation**



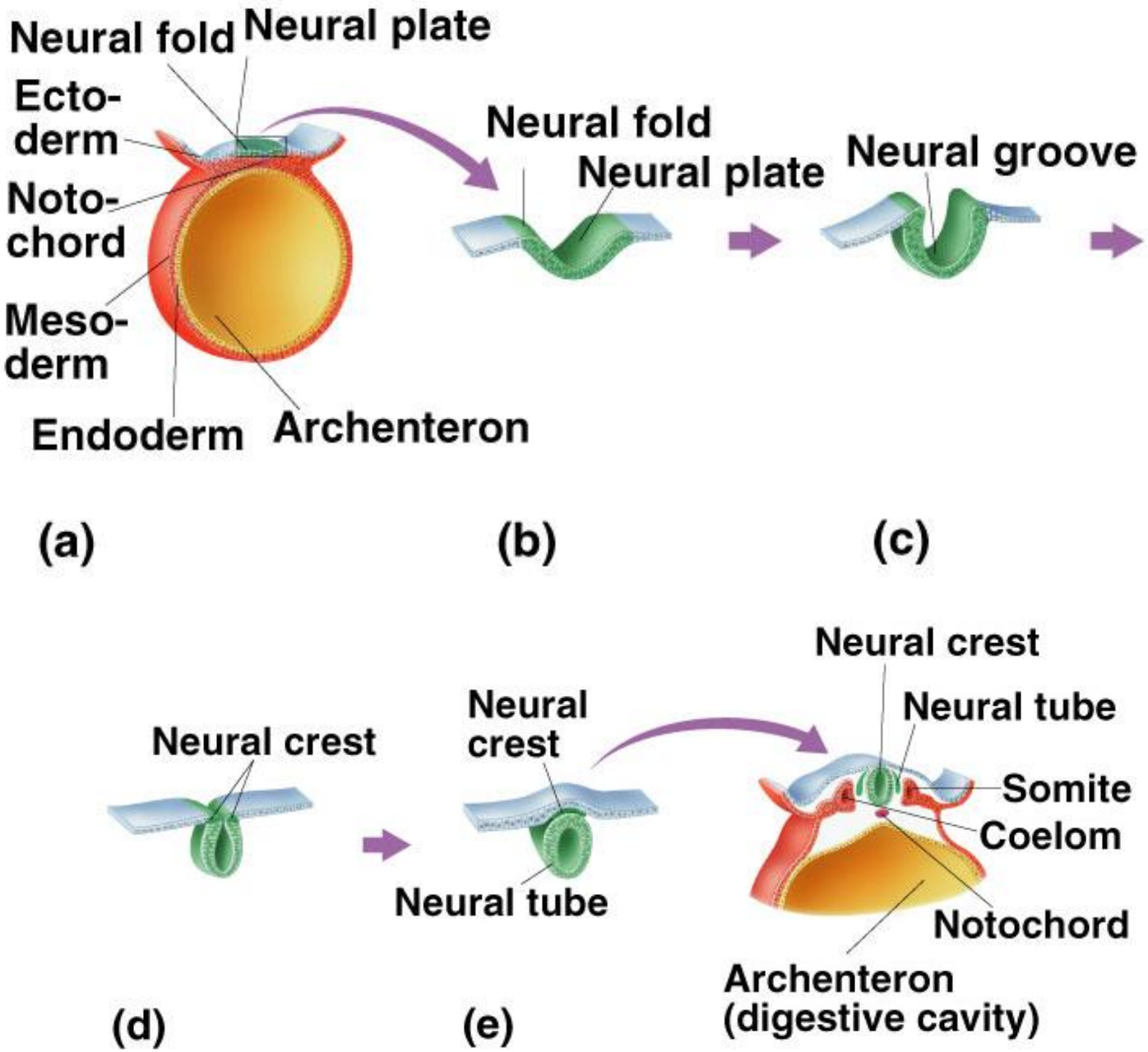
Developmental Processes During Neurulation



Developmental Processes During Neurulation



Developmental Processes During Neurulation



Differentiation

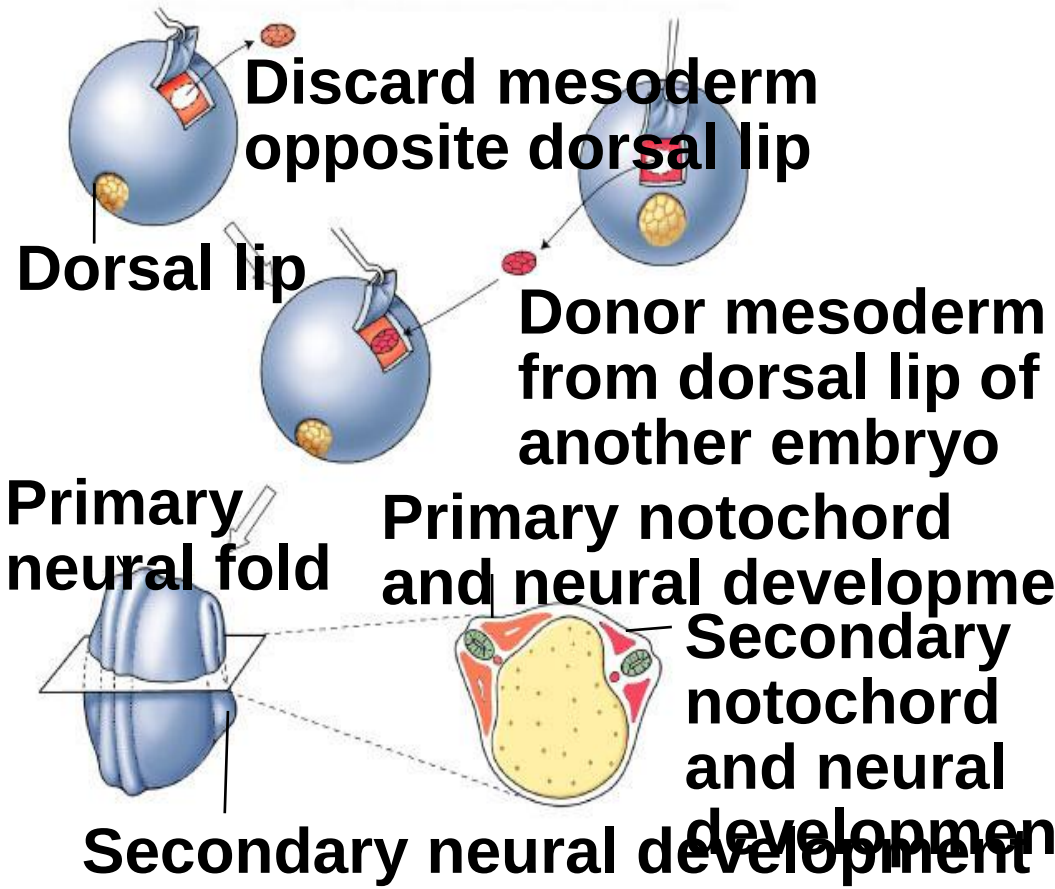
- **when the developmental layers begin to form into specialized parts**

Embryonic induction

- **When one part of an embryo influence**
  - **Stem Cells are cells from early development that can develop into any type of cell**
  - **Inducers - a chemical (hormone) that cause cells to develop into special parts**

How Cells Communicate During Development

- Inductions between the three primary tissue types are referred to as primary inductions.



How Cells Communicate During Development

Inductions between tissues that have already been differentiated are called secondary inductions.

How Cells Communicate During Development

- Nature of development decisions
  - Some cells become determined early in development.
  - At some stage, every cell's fate becomes fixed (commitment).
    - not irreversible, but rarely reverses under normal conditions

Twinning

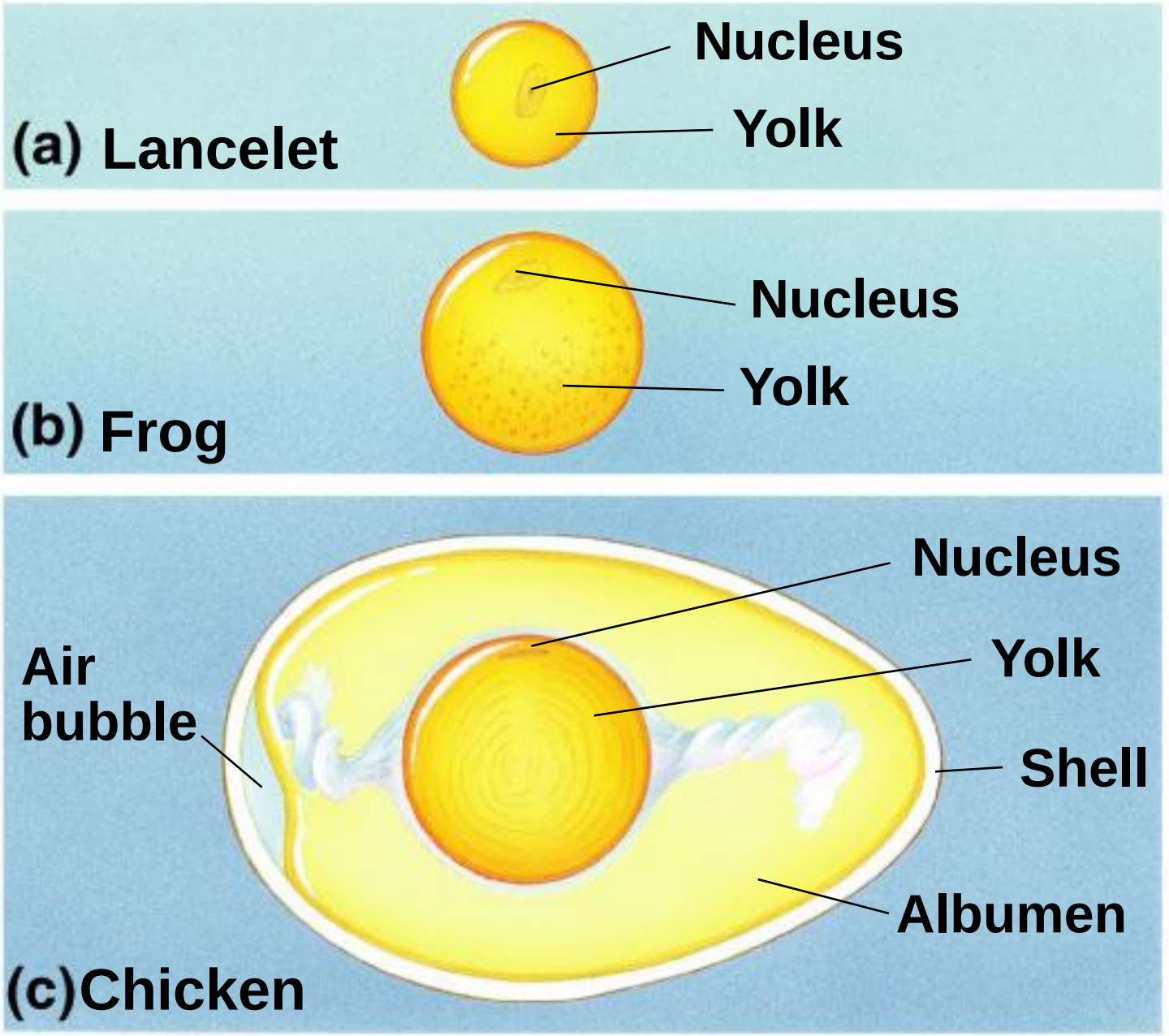
- **Fraternal twins - are from separate sperm an different egg**
- **Identical twins - When the cells of the blastula or gastrula separate into two cell masses**

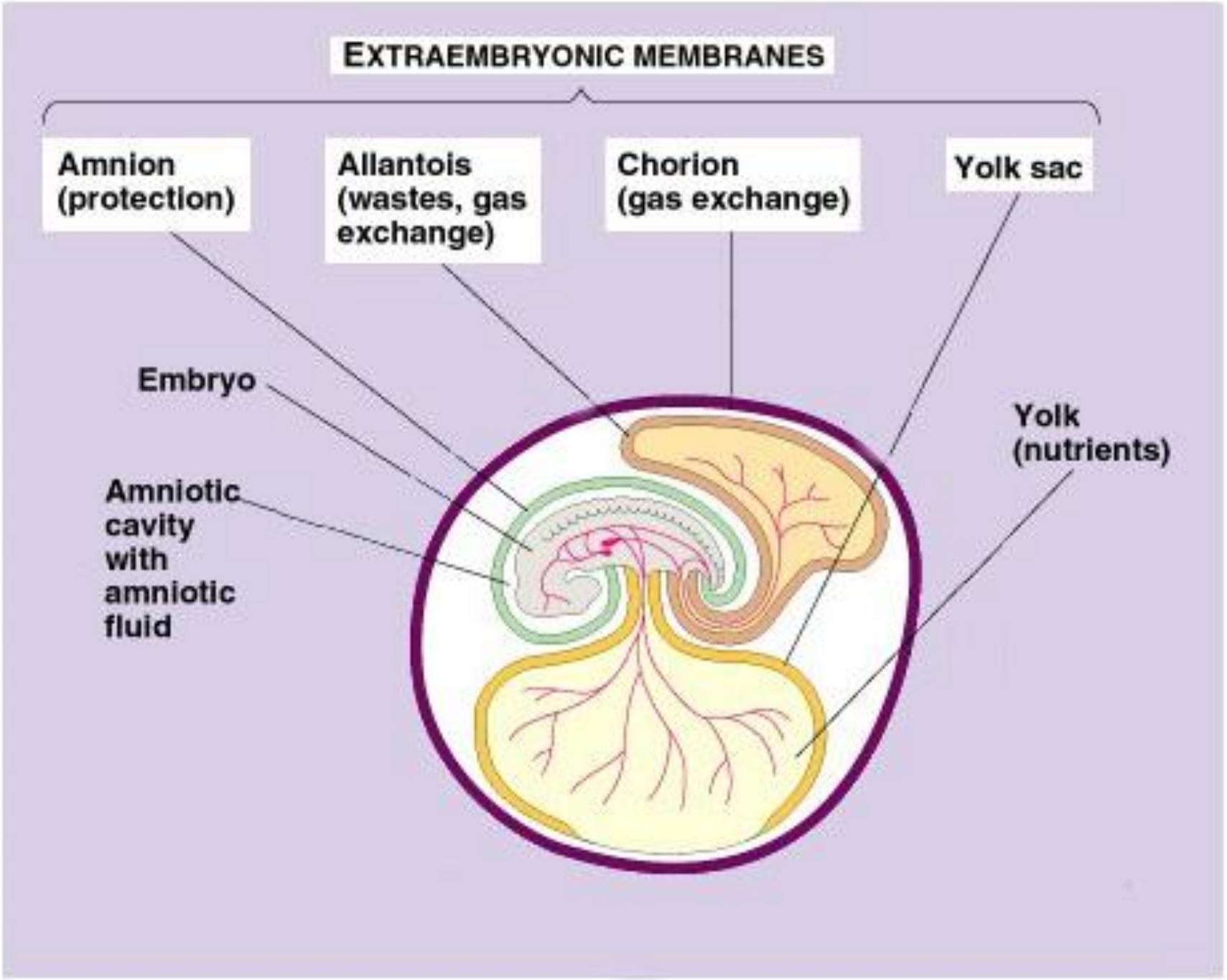
Metamorphosis –

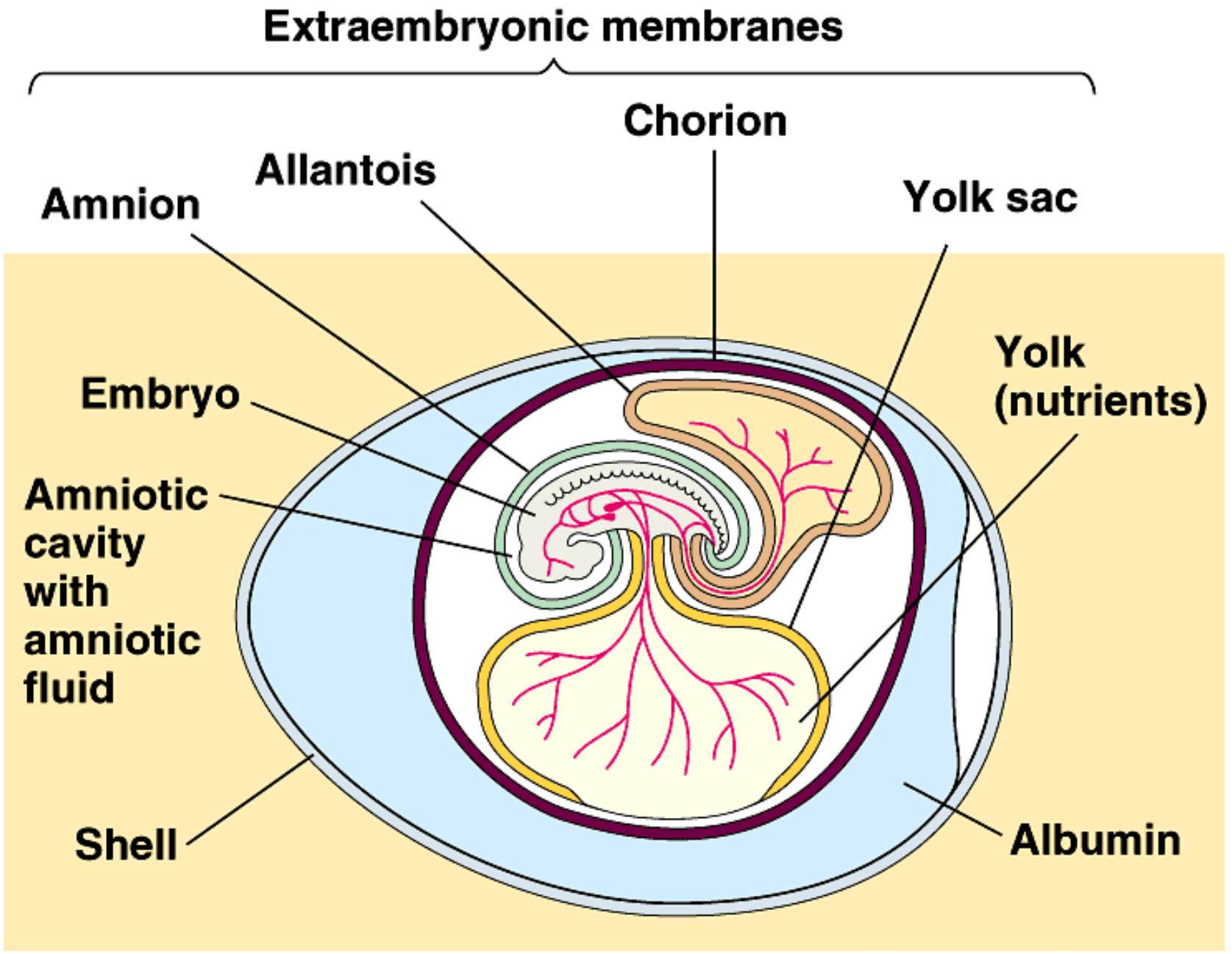
- **A series of form changes in development**
    1. **Amphibians**
    2. **Insects**

Amniotic Egg

- **Tough leathery shell or brittle shell**
- **Membranes**
  - **Amnion**
    - **fluid sac that surrounds the embryo**
  - **Allantois - a membrane sac connected to the digestive region of the embryo**
    - **Embryonic garbage bag**
    - **Also allows gas exchange**
  - **Yolk sac - also attached to the digestive tract to provide food to the embryo**
  - **Chorion - the membrane just below the shell allows gas exchange**




EXTRAEMBRYONIC MEMBRANES
Amnion (protection)
Allantois (wastes, gas exchange)
Chorion (gas exchange)
Yolk sac
Embryo
Amniotic cavity with amniotic fluid
Yolk (nutrients)



Internal development

- **A placenta – formed instead of allantois for food gas and waste exchange between mother and embryo**

Development of the Placenta p 530

- **Implantation**
- **Amnion - begins to form around the embryo**
- **Chorion begins to grow into the uterine wall.**
- **Small blood vessels, & capillaries develop from the allantois and become part of the placenta**
- **The rest of the placenta is uterine tissue**

Function of the placenta

- **Provides food and oxygen for the embryo that is removed by diffusion from the mothers blood**
  - **Crosses a membrane and goes into the embryos blood without the two blood systems coming into contact with each other.**
- **Removes wastes from the embryos blood into the mothers blood**
- **The umbilical cord is a blood vessel filled chord that attaches the embryo to the placenta**l
- **Blood from the embryos right ventricle goes directly into the umbilical cord and to the placenta**

- The placenta allows for a variety of substances to pass from mother to fetus
  - Protective antibodies
  - German measles virus
  - HIV
  - Drugs (prescription and nonprescription)
  - Alcohol
  - Chemicals in tobacco smoke

Human Development

- Human development begins with fertilization in the oviduct

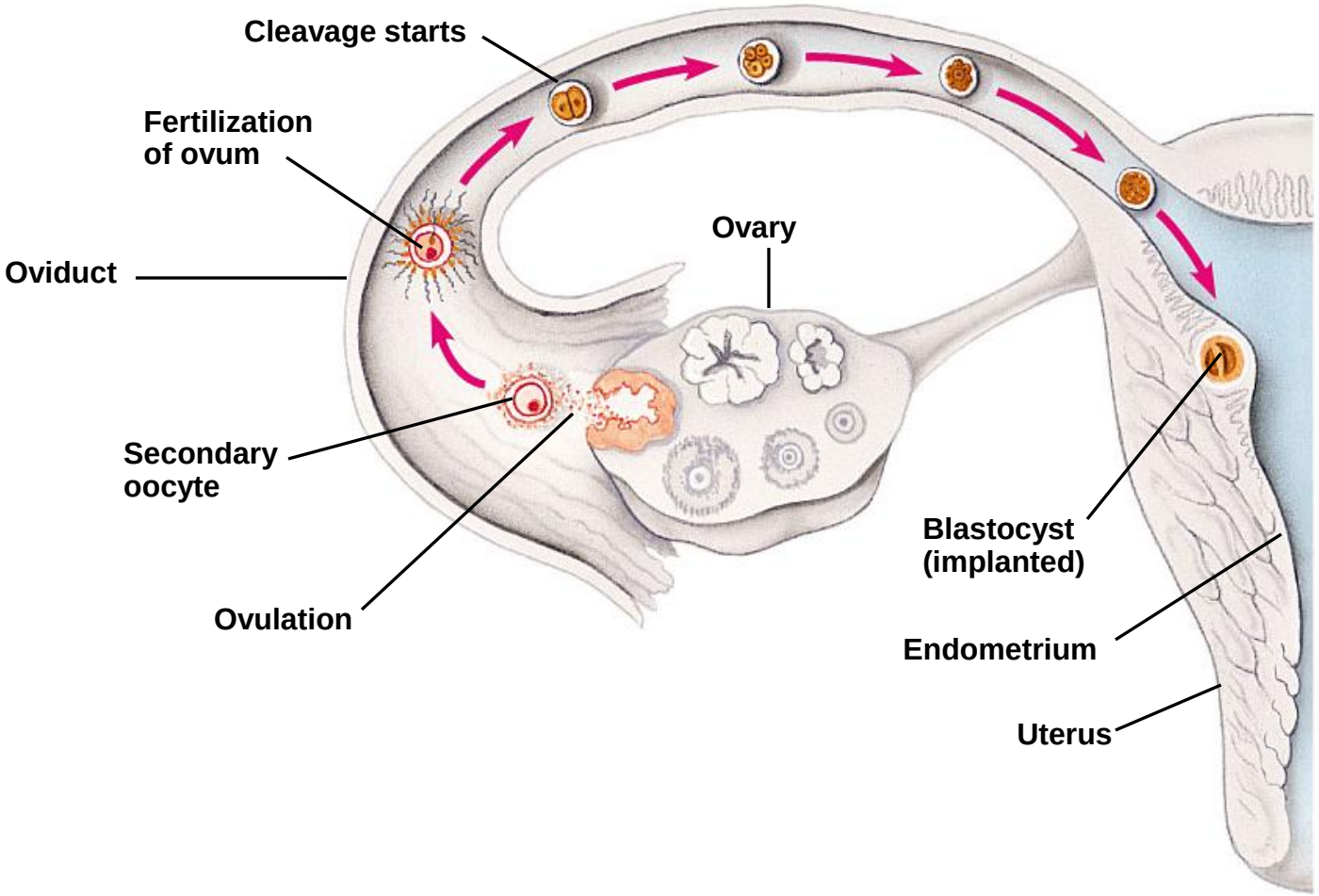


Figure 27.16A

HUMAN DEVELOPMENT
The embryo and placenta take shape during the first month of pregnancy

- Gestation is pregnancy
  - It begins at conception and continues until birth
  - Human gestation is 266 days (38 weeks or 9 months)
  - Mouse gestation is 1 month
  - Elephant gestation is 22 months

- The trophoblast secretes enzymes to enable the blastocyst to implant in the uterine wall

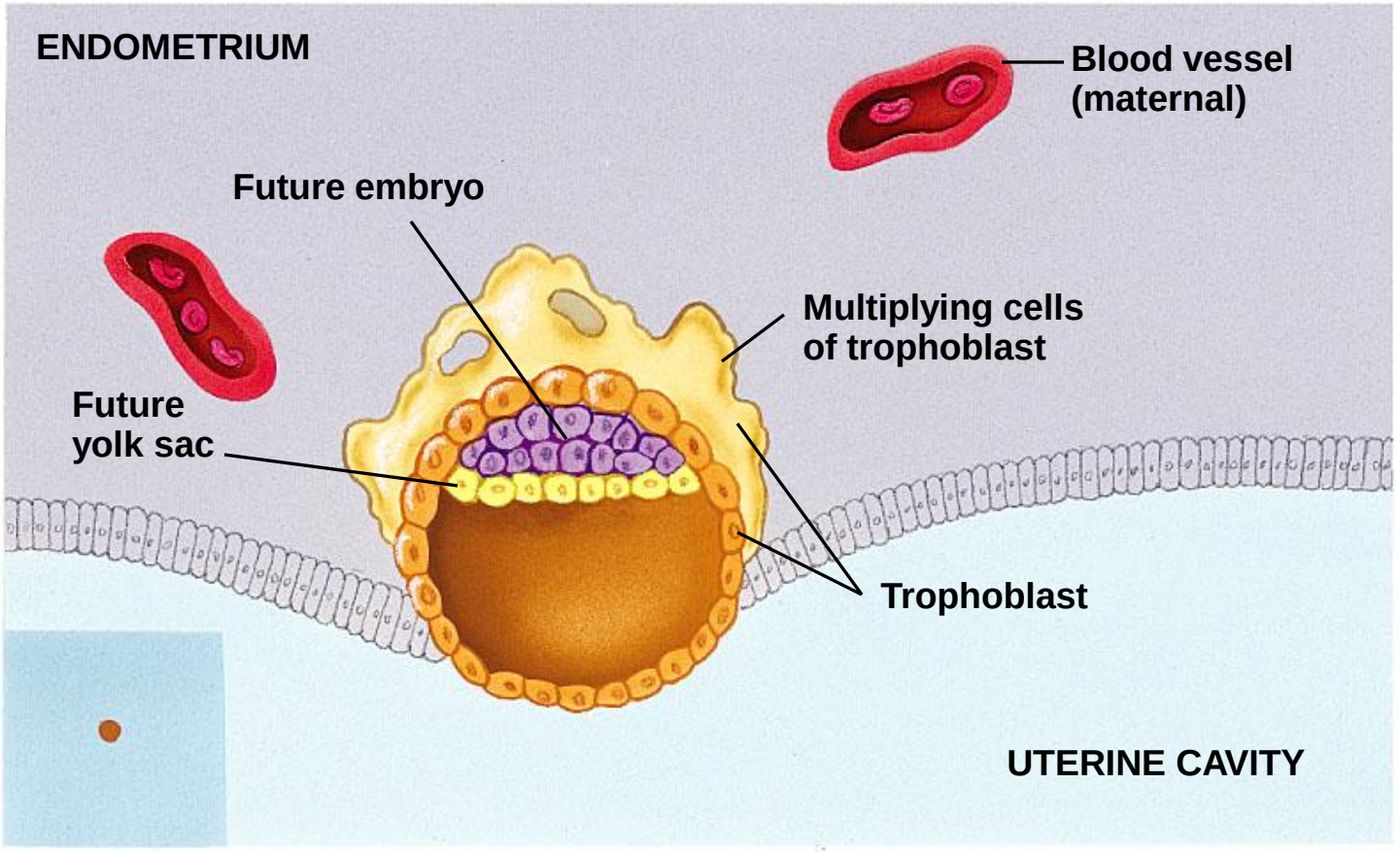


Figure 27.16C

- Gastrulation occurs and organs develop from the ectoderm, endoderm, and mesoderm

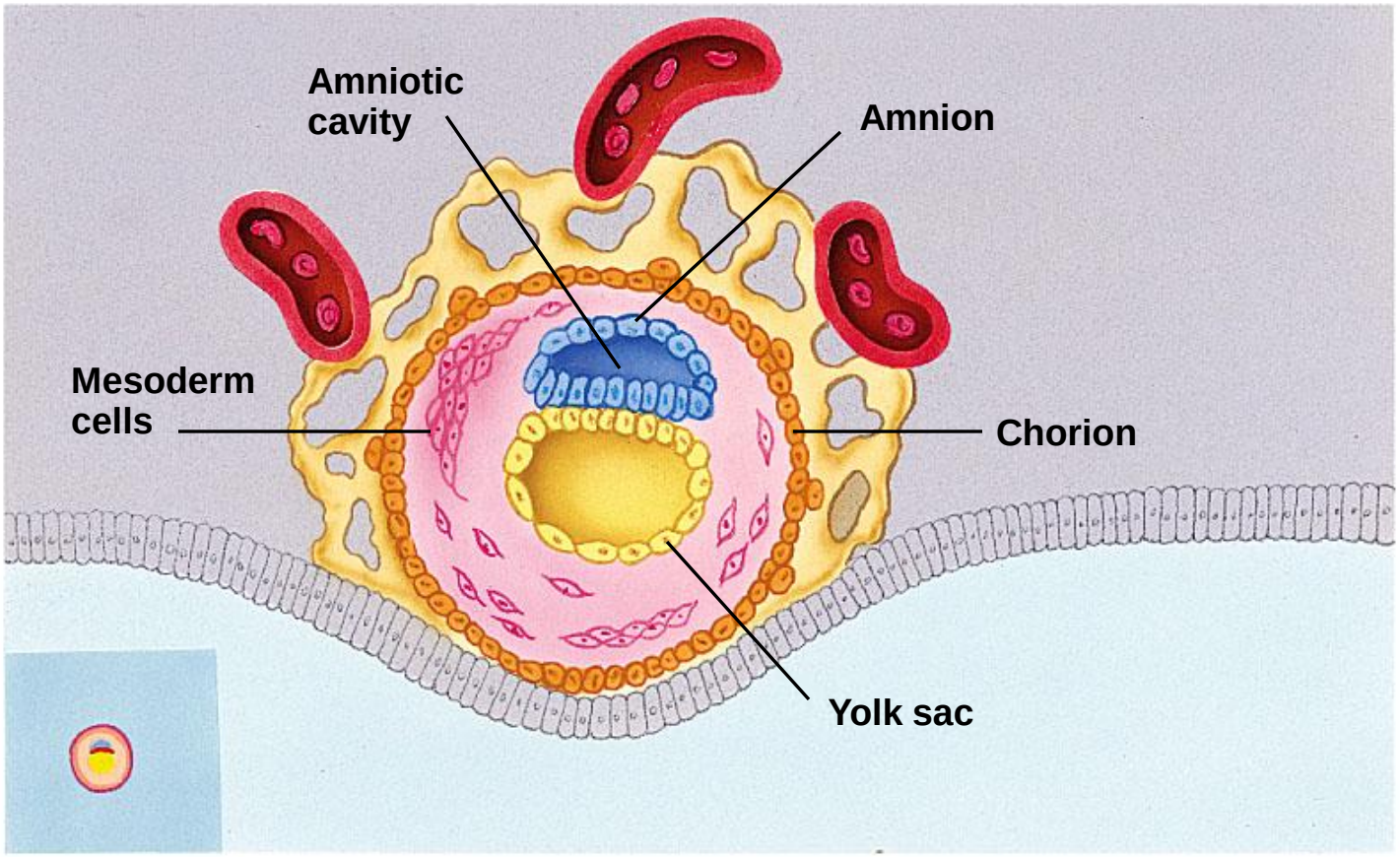


Figure 27.16D

- Meanwhile, the four embryonic membranes develop
  - Amnion
  - Chorion
  - Yolk sac
  - Allantois

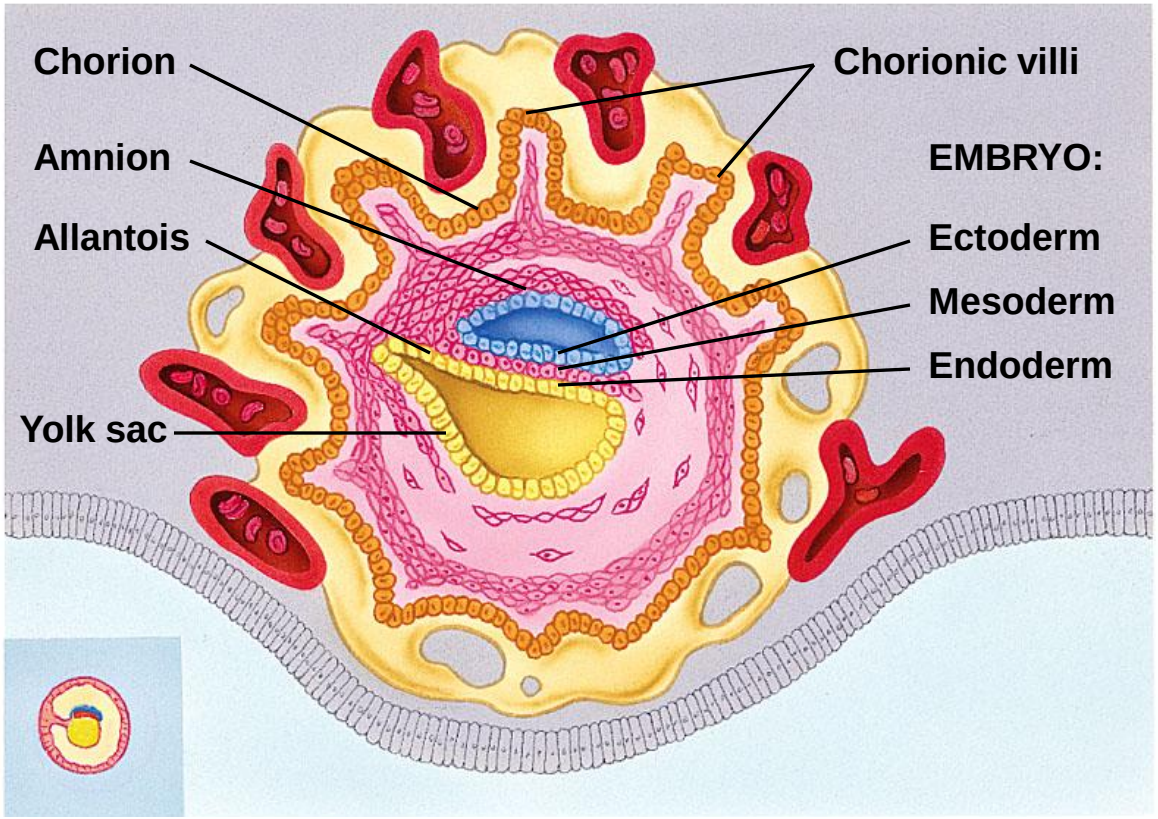
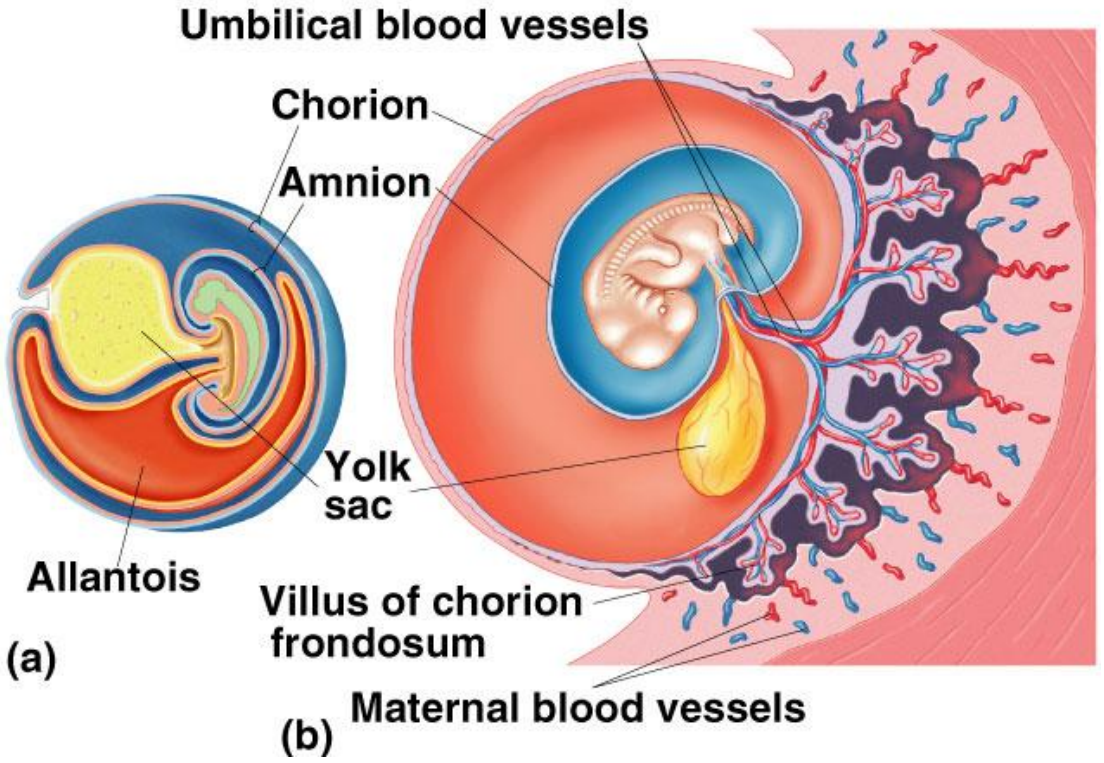


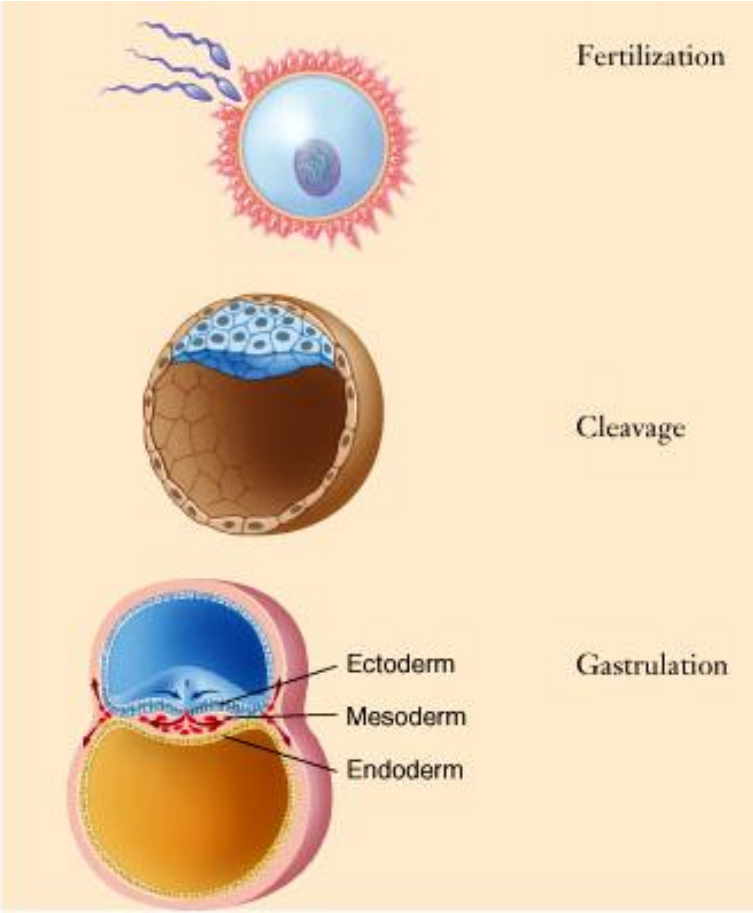
Figure 27.16E

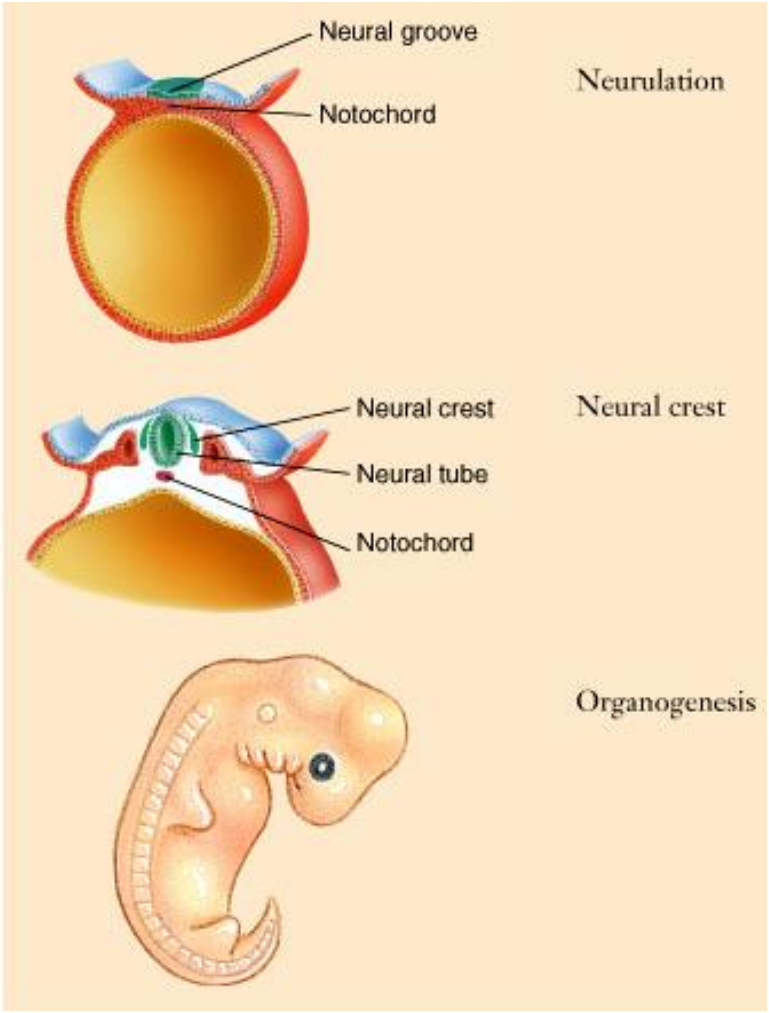
Extraembryonic Membranes

- **Fluid-filled amniotic membrane an adaptation to terrestrial life**
  - **amniotic membrane an extraembryonic membrane**
    - **Extraembryonic membranes, later to become fetal membranes, include the amnion, chorion, yolk sac, and allantois.**



Stages of Development





- The embryo floats in the fluid-filled amniotic cavity, while the chorion and embryonic mesoderm form the embryo's part of the placenta

- The placenta absorbs food and oxygen from the mother's blood

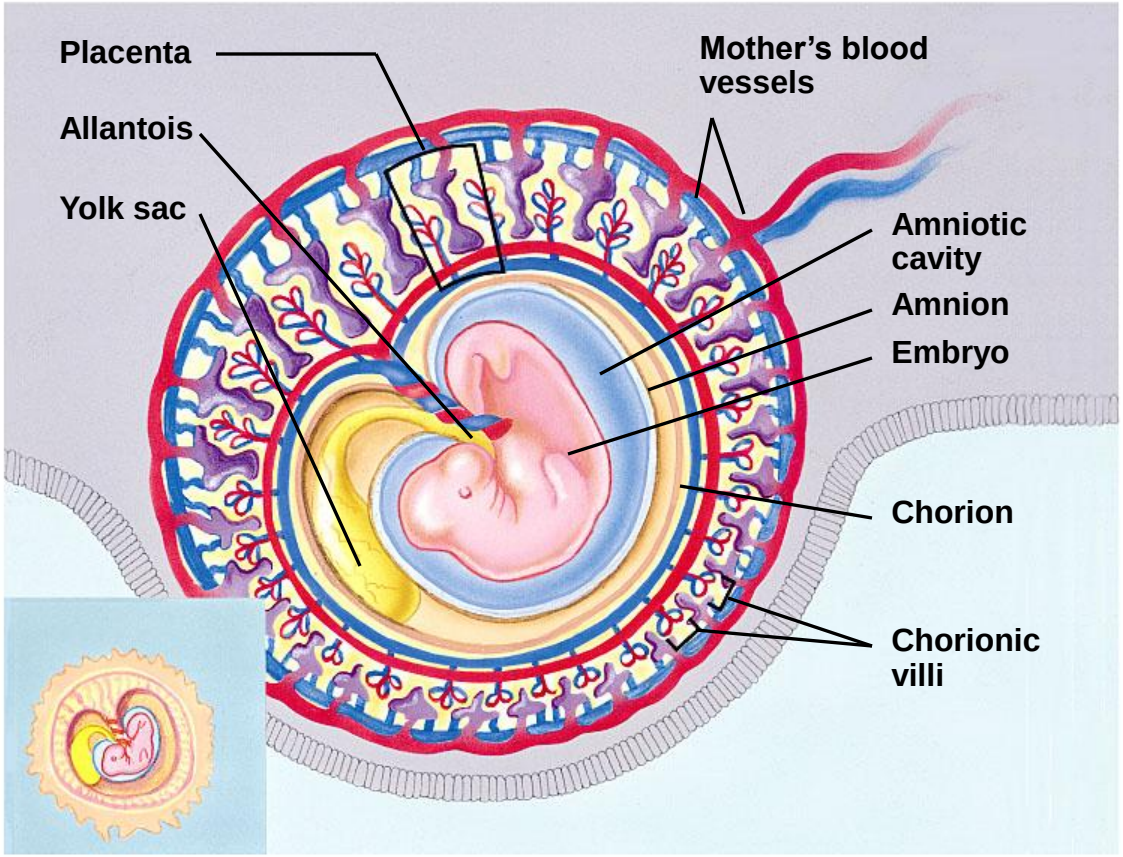
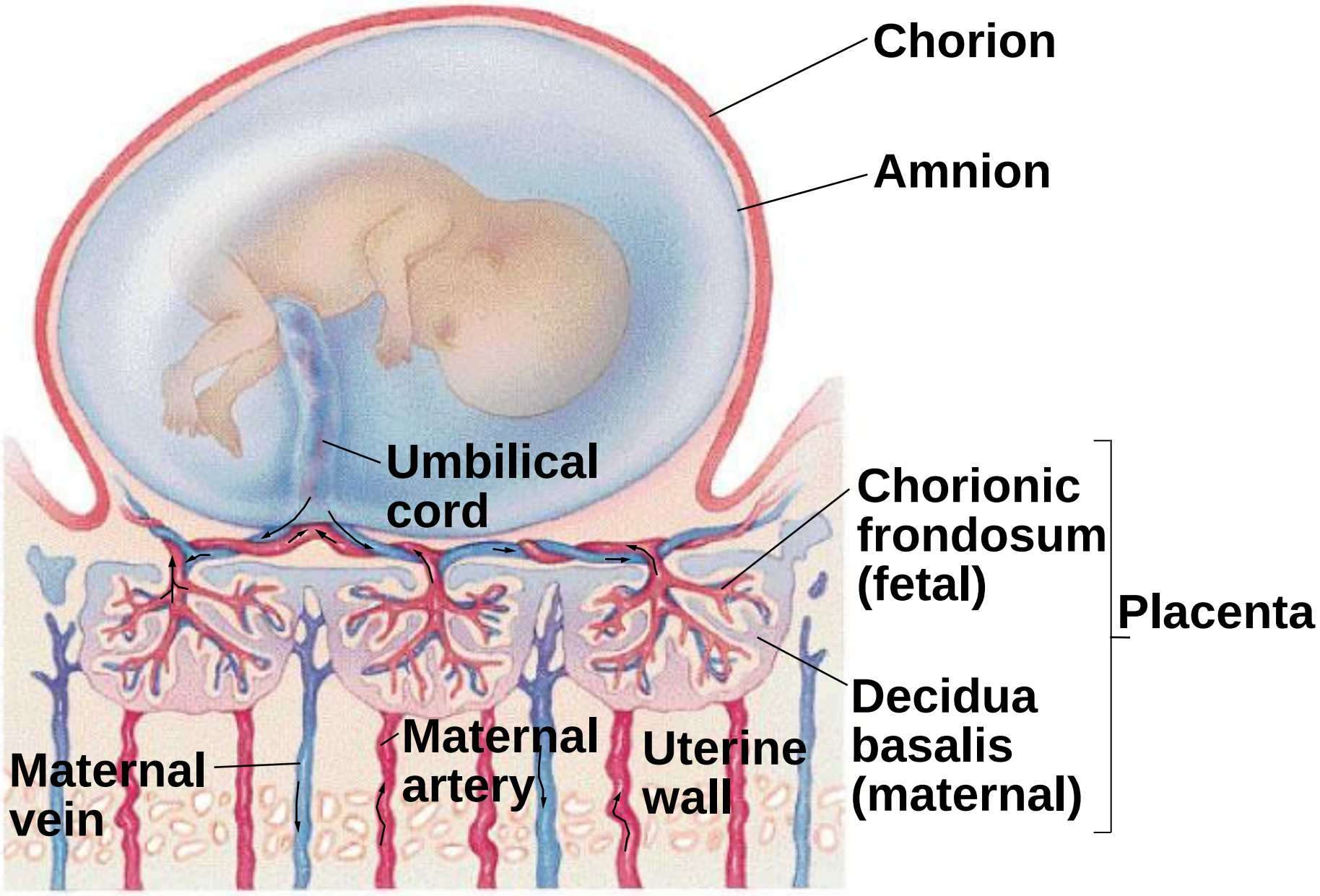


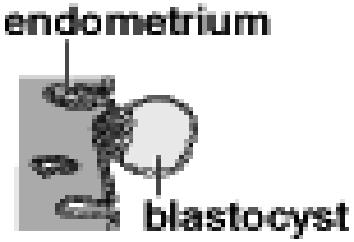
Figure 27.16F



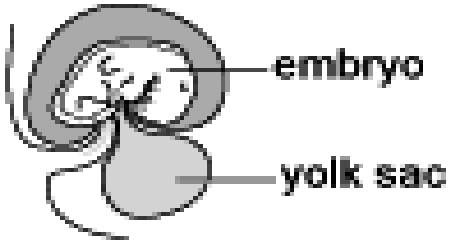
Trimesters

- **First trimester all systems form (12 weeks)**
- **Second trimester the fetus grows and develops (24 weeks)**
- **Third trimester triples in size (40 weeks)**

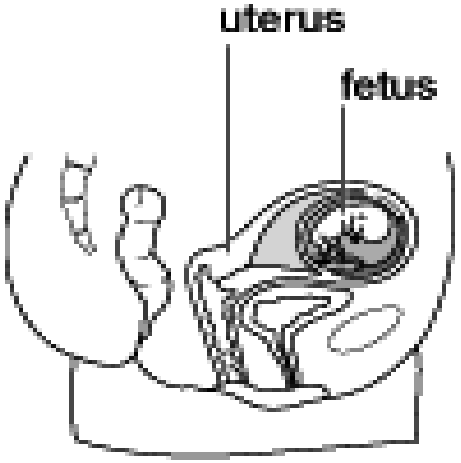
Inside the Womb



1 week (7 days)

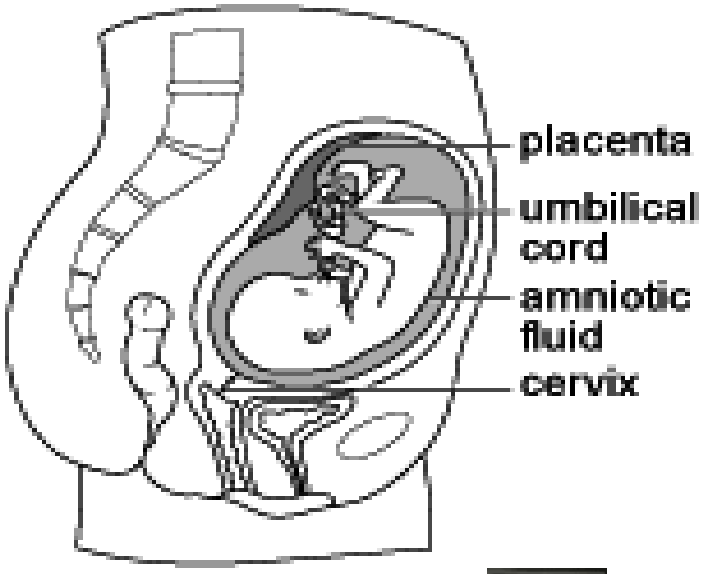


4 weeks (28 days)
7mm



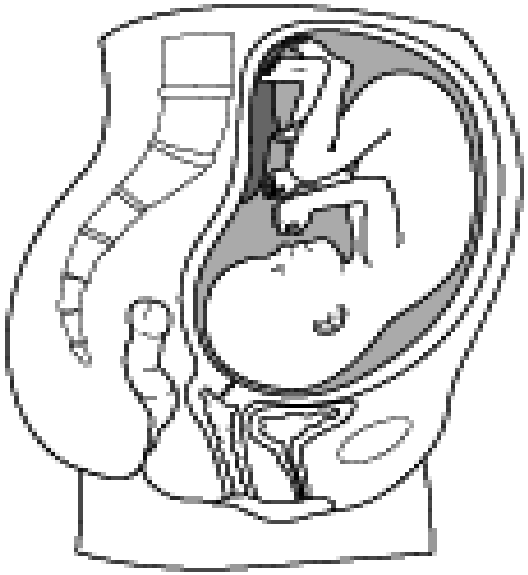
8 weeks (56 days)
40mm

First Trimester



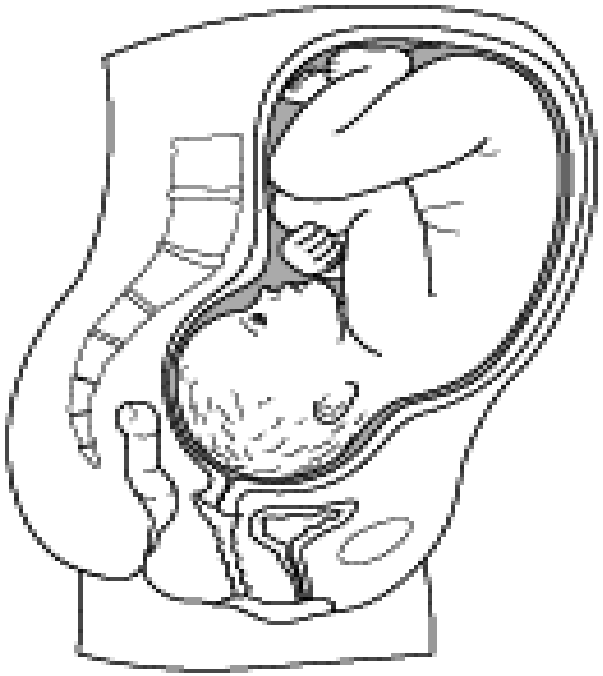
12 weeks (84 days)
100mm

Second Trimester



24 weeks (168 days)
330mm

Third Trimester



40 weeks (280 days)
550mm

- First trimester
  - First three months
  - The most rapid changes occur during the first trimester

Figure 27.17A, B

First Trimester

- First trimester
  - fourth week - organ development
    - organogenesis
      - most women not yet aware of pregnancy
        - » Fetal Alcohol Syndrome

First Trimester

- Second month - morphogenesis
  - limbs assume adult shape
  - major organs become evident
  - embryo is about one inch in length

First Trimester

- Third month - completion of development
  - now referred to as fetus
    - nervous system and sense organs develop
    - all major organs established

- Second trimester
  - Increase in size of fetus
  - General refinement of human features

Figure 27.17C, D

Second and Third Trimesters

Second trimester - growth

- bone formation occurs
- covered with fine hair (lanugo)
- by the end of the sixth month, baby is one foot in length

- Third trimester
  - Growth and preparation for birth

Third trimester - pace of growth accelerates

weight of fetus more than doubles

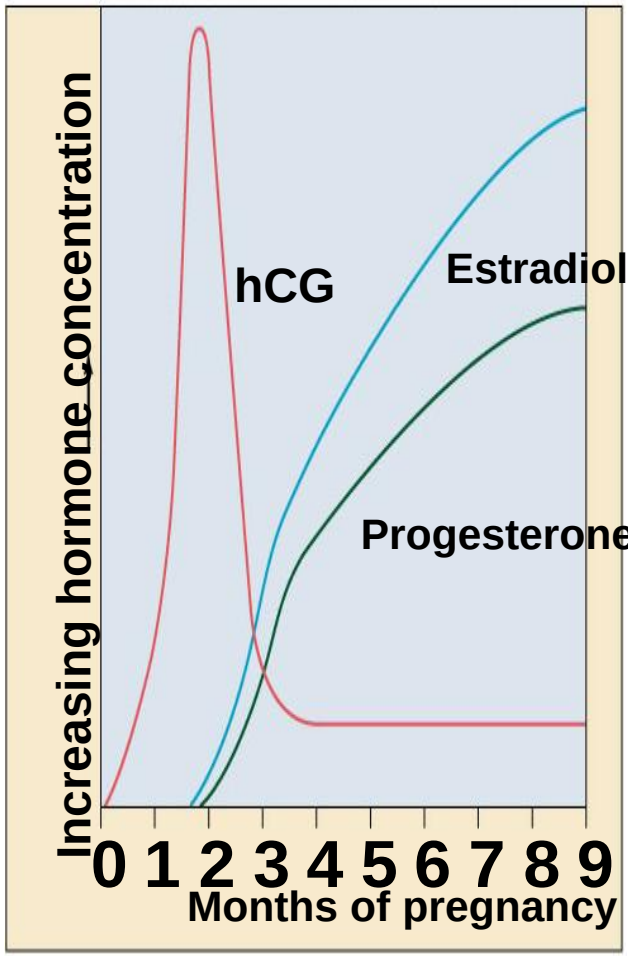
most major nerve tracts formed within brain

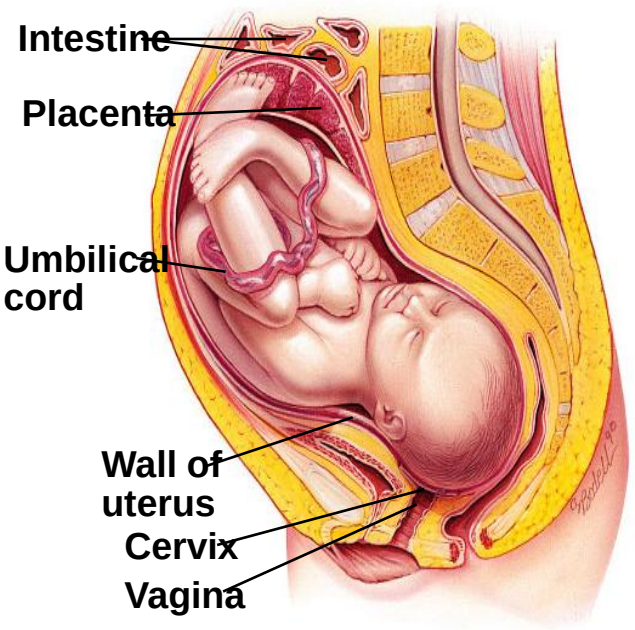
by end, fetus is able to survive on own

Figure 27.17E

Birth and Postnatal Development

- Uterus releases prostaglandins
  - begin uterine contractions, but then sensory feedback from the uterus stimulates the release of oxytocin from the mother's pituitary gland
    - rate of contraction increases to one contraction every two or three minutes
      - strong contractions, aided by the mother's pushing, expels the fetus





Childbirth is hormonally induced and occurs in three stages

- Hormonal changes induce birth
  - Labor is controlled by a positive feedback mechanism
  - Estrogen released from the ovaries increases the sensitivity of the uterus to oxytocin

- Oxytocin is a powerful stimulant for the smooth muscles of the uterus
  - Oxytocin also stimulates the placenta to make prostoglandins that stimulate the uterine muscles to contract even more
- Uterine contractions stimulate the release of more and more oxytocin and prostoglandins

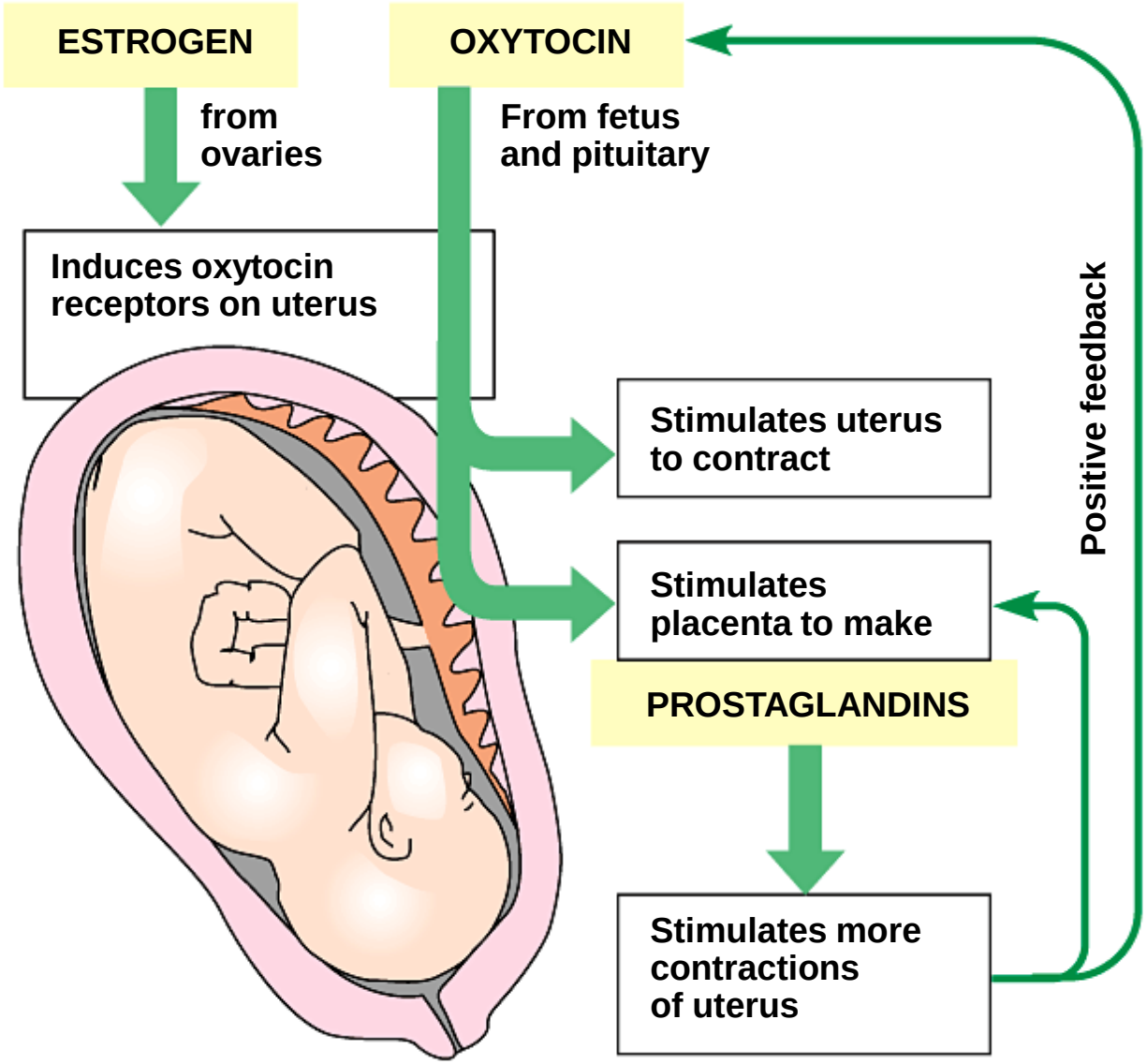


Figure 27.18A

There are three stages of labor

- Dilation of the cervix is the first stage
  - Cervix reaches full dilation at 10cm
  - Longest stage of labor (6-12 hours or longer)

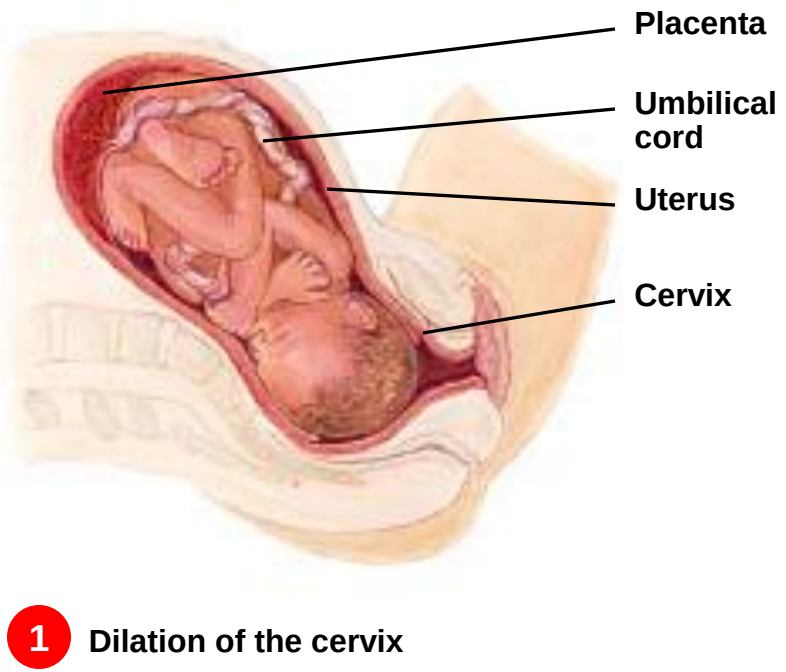


Figure 27.18B, part 1

- Expulsion is the second stage
  - Period from full dilation of the cervix to delivery of the infant
  - Uterine contractions occur every 2-3 minutes
  - Mother feels urge to push down with her abdominal muscles
  - Infant is forced down and out of uterus and vagina within a period of 20 minutes

2 **Expulsion: delivery of the infant**

Figure 27.18B, part 2

- The delivery of the placenta is the final stage of labor
  - Usually occurs within 15 minutes after the birth of the baby

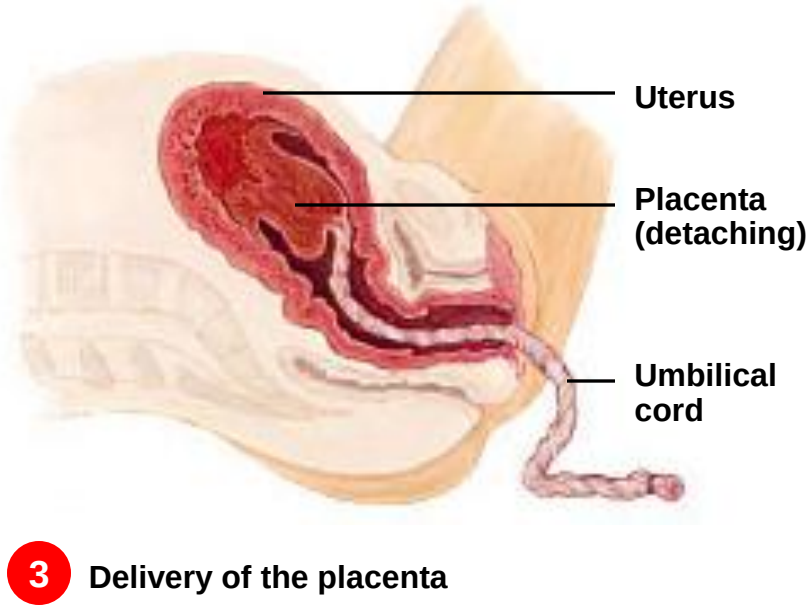
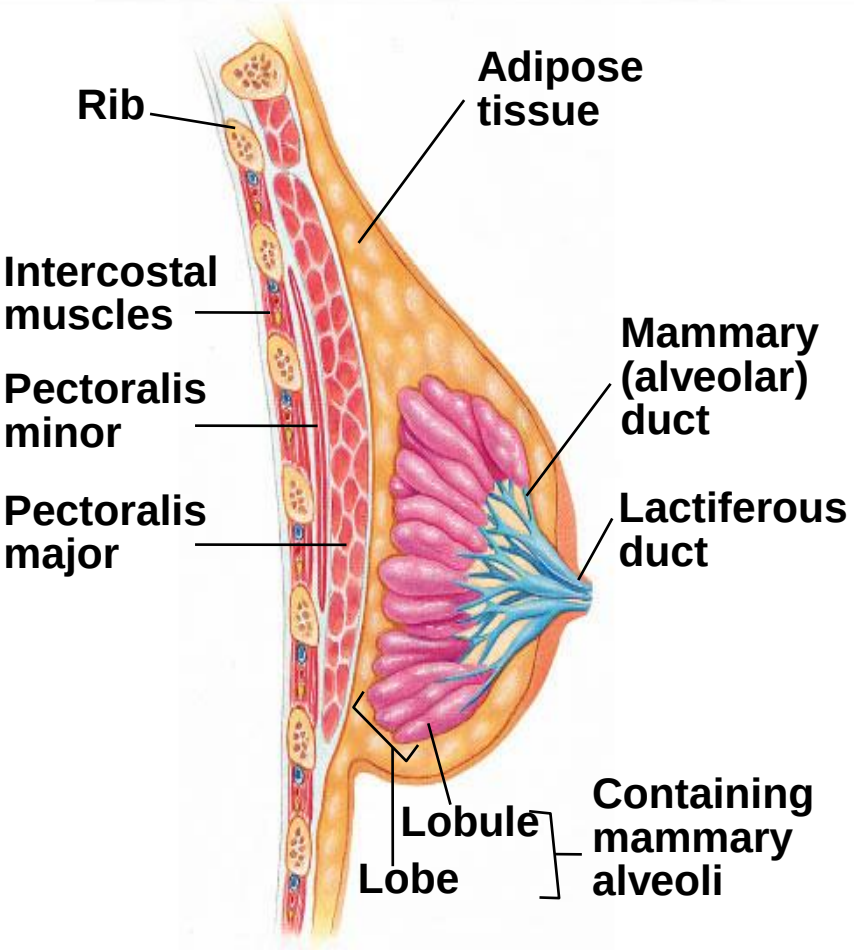


Figure 27.18B, part 3

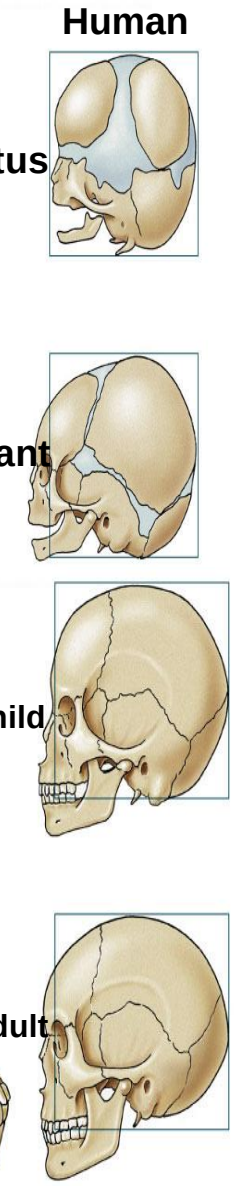
- Hormones continue to be important after the baby and placenta are delivered
  - Decreasing progesterone and estrogen levels allow the uterus to return to its pre-pregnancy state
  - Oxytocin and prolactin stimulate milk secretion

Birth and Postnatal Development

- Nursing
  - Milk production, lactation, occurs in the alveoli of mammary glands when they are stimulated by prolactin.
  - milk secreted in alveolar ducts which are surrounded by smooth muscle and lead to the nipple
    - first milk produced after birth called colostrum - rich in maternal antibodies
      - Milk synthesis begins about three days following birth.



Birth and Postnatal Development



- Postnatal development
  - Babies typically double their birth weight within a few months.
  - Neuron production occurs for six months.
  - allometric growth