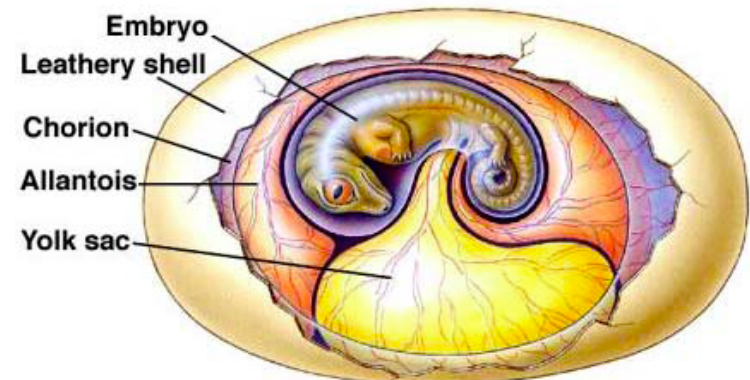




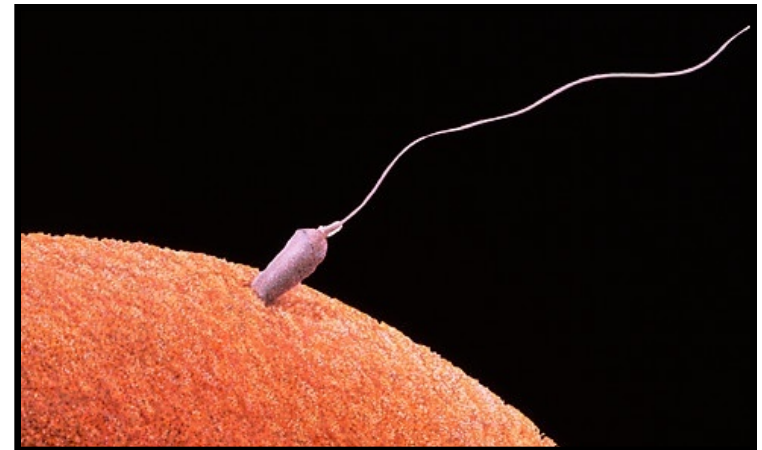
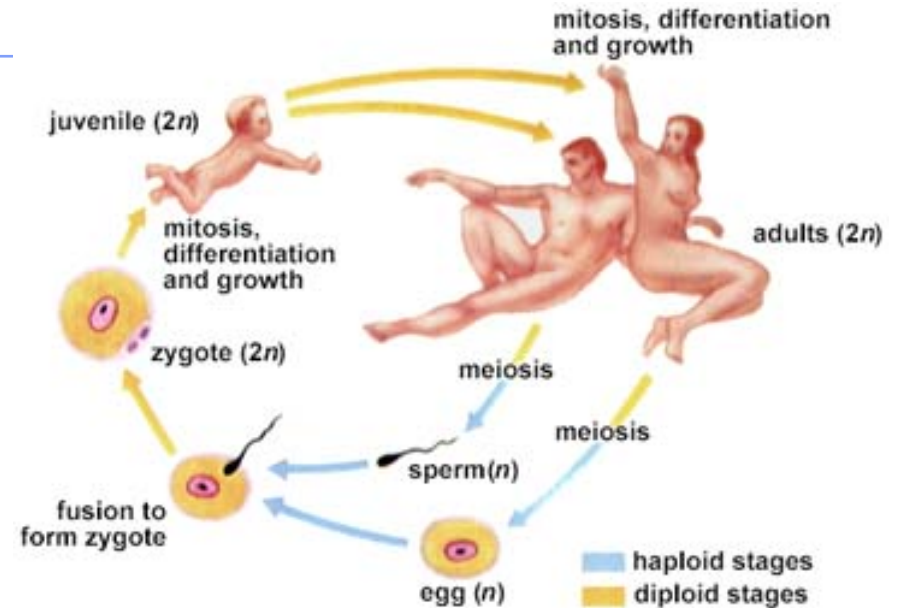
Animal Reproduction



Sexual & asexual reproduction

■ Sexual Reproduction

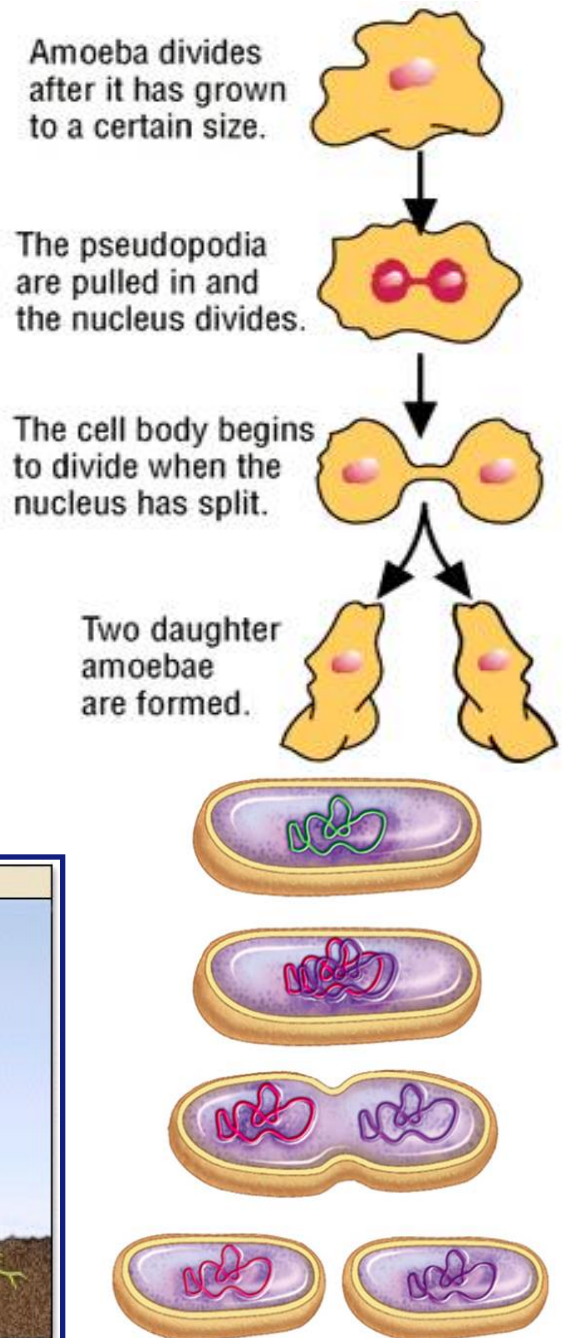
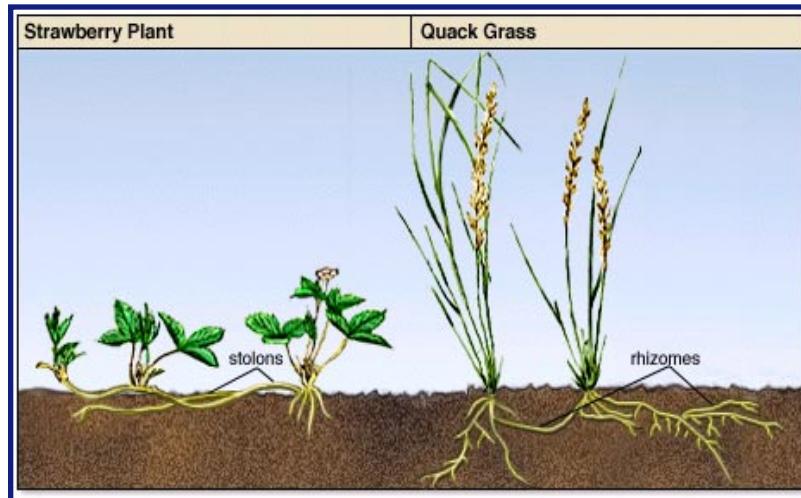
- ◆ Specialized cells in gonads divide by meiosis to produce haploid cells or gametes
 - Female Gamete = egg = large, nonmotile cell
 - Male Gamete = sperm = small, motile cell
- ◆ Gametes fuse to form a diploid cell, the zygote → fertilization
 - mixing of genes → genetic variation



Sexual & asexual reproduction

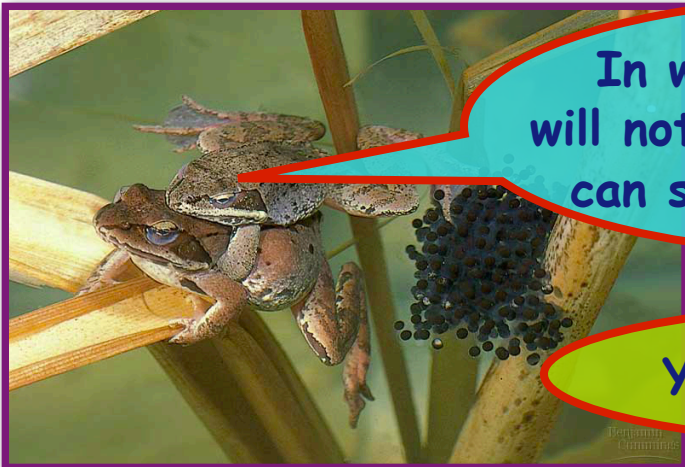
■ Asexual Reproduction

- ◆ **New individuals are generated without the fusion of egg and sperm**
 - In asexual animals, reproduction relies on mitotic cell division
 - In bacteria, reproduction relies on binary fission
- ◆ **offspring all have same genes (clones)**
 - no genetic variation



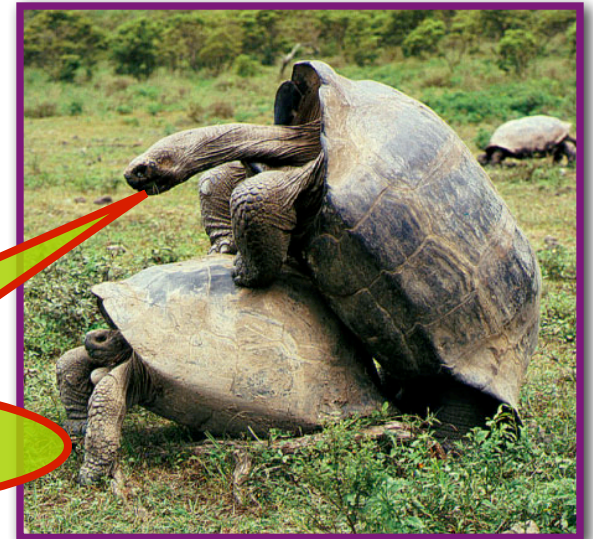
Fertilization

- **Joining of egg & sperm of the same species**
 - ◆ **External fertilization**
 - Female releases egg into environment
 - Male later fertilizes the eggs external to the female's body
 - ◆ usually aquatic animals
 - ◆ **Internal fertilization**
 - Sperm deposited in or near the female reproduct tract
 - Fertilization occurs within the tract
 - ◆ usually land animals



In water, my gametes
will not dry out & my sperm
can swiiiiiiim to the egg.

You spawn, I copulate...

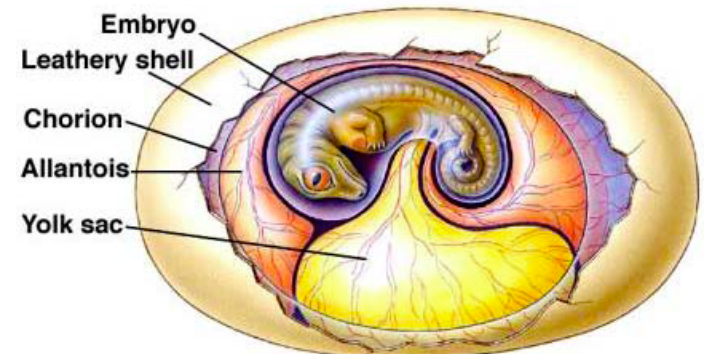


Development of embryo

■ External Development

◆ Development in eggs

- fish & amphibians in water
 - ◆ soft eggs allowing exchange across membrane
- birds & reptiles on land
 - ◆ hard-shelled amniotic eggs
 - Structures present for exchange of food, O₂ & waste
- Some sharks & some snakes
 - ◆ live births from eggs

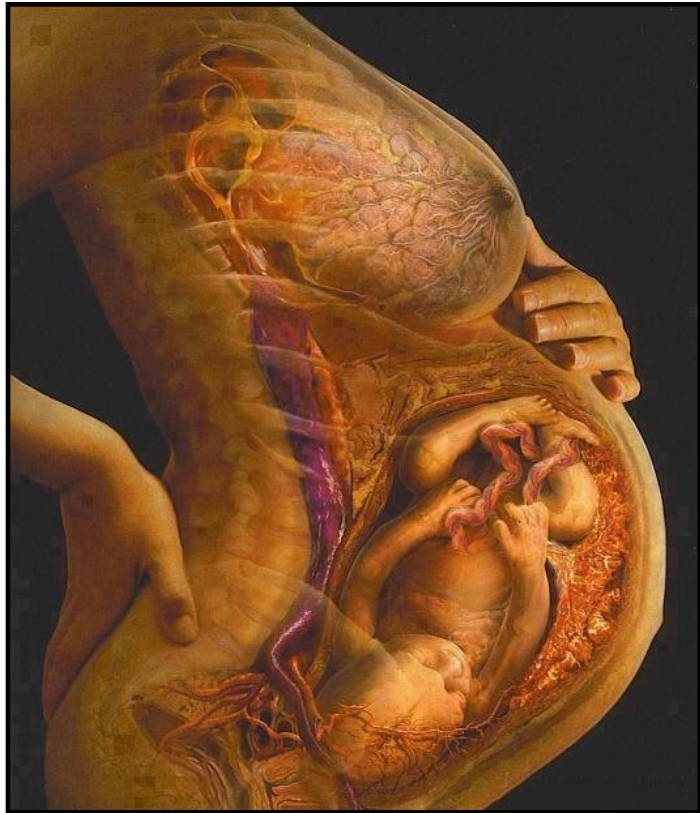


■ Internal Development

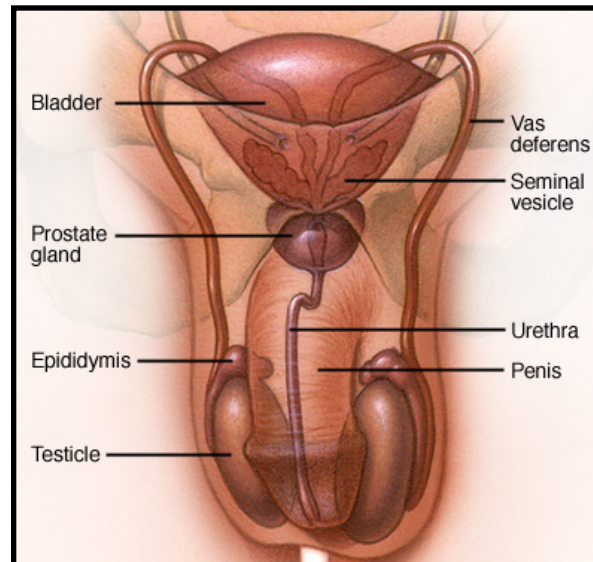
◆ Development inside female reproductive tract

- In placental mammals, embryos remain in uterus and are nourished mother's blood supply through specialized organ called the placenta
 - ◆ Site exchanging food, gases, & waste
- Live birth



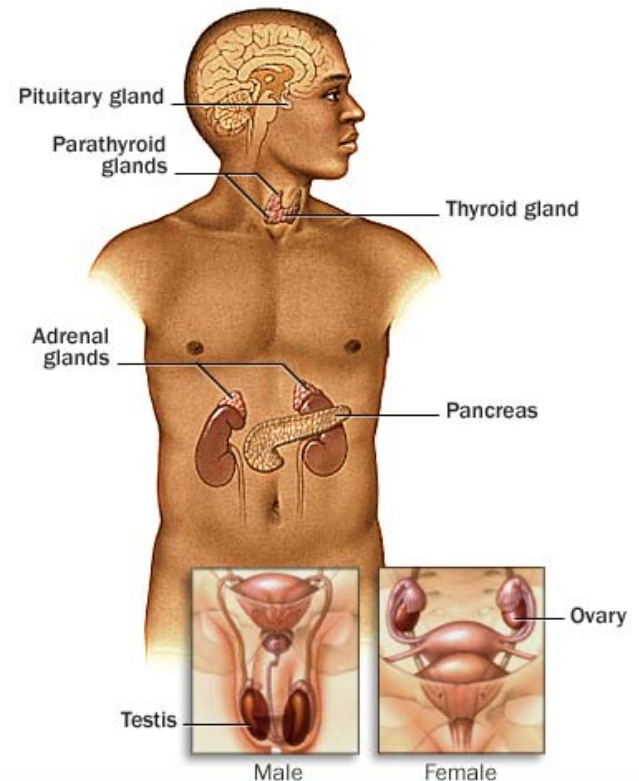


Human Anatomy

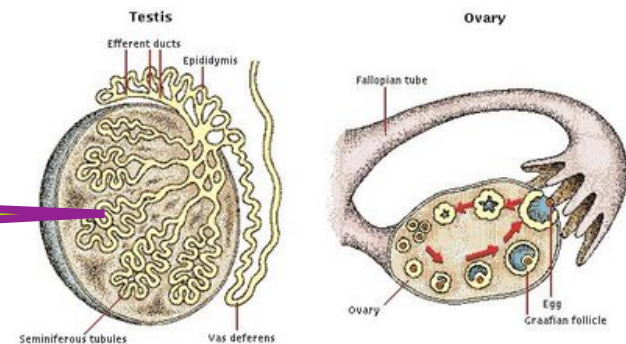


Gamete Production

- Humans have sets of cells that serve as precursors for making the ova and sperm
 - ◆ Humans have discrete gonads
 - Organs that produce gametes
 - ◆ Ovaries in females
 - ◆ Testes in males
 - ◆ Ovaries and testes are also a part of the endocrine system because they produce and release testosterone and estrogen, respectively.



Bring on the meiosis!



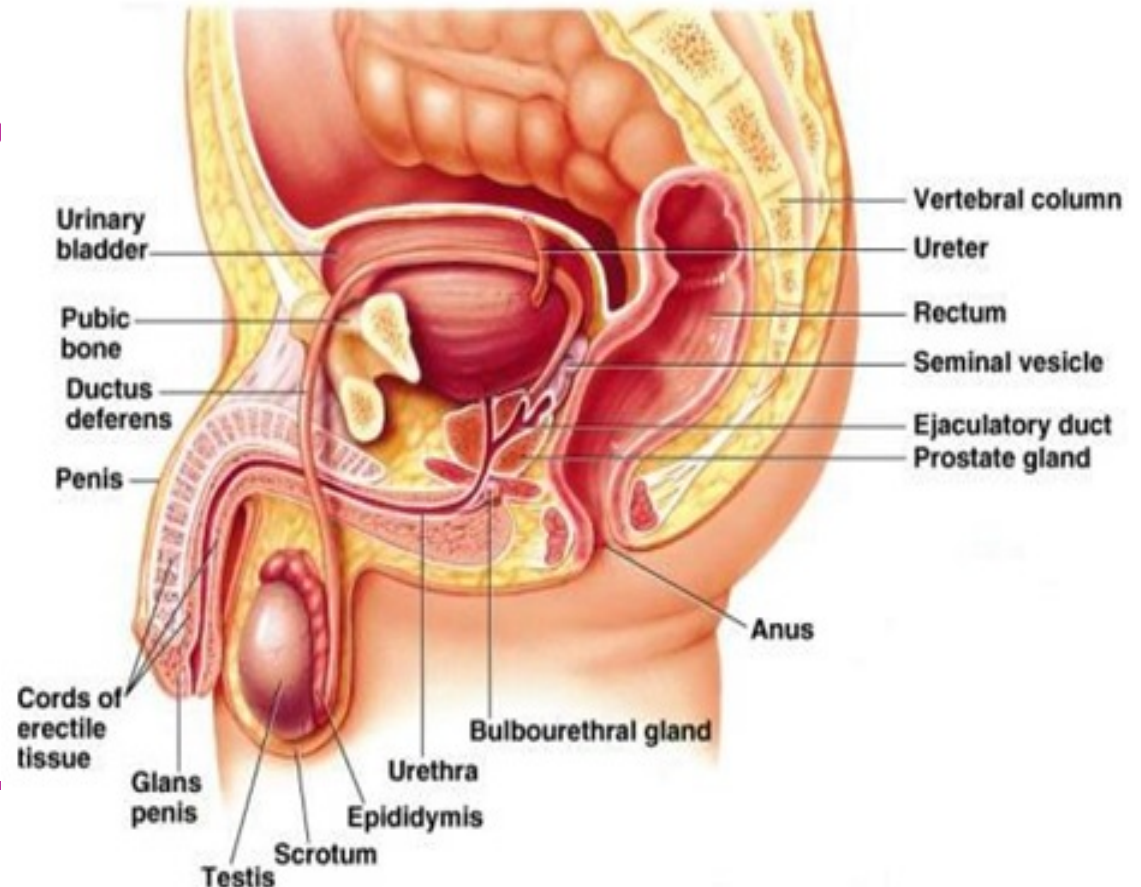
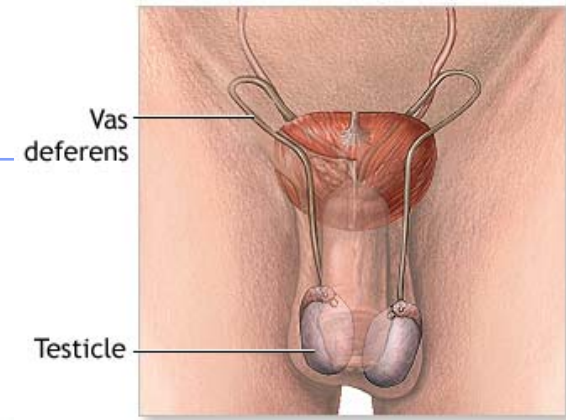
Male Reproductive Anatomy

■ External Reproductive Organs

◆ Scrotum & Penis

■ Internal Reproductive Organs

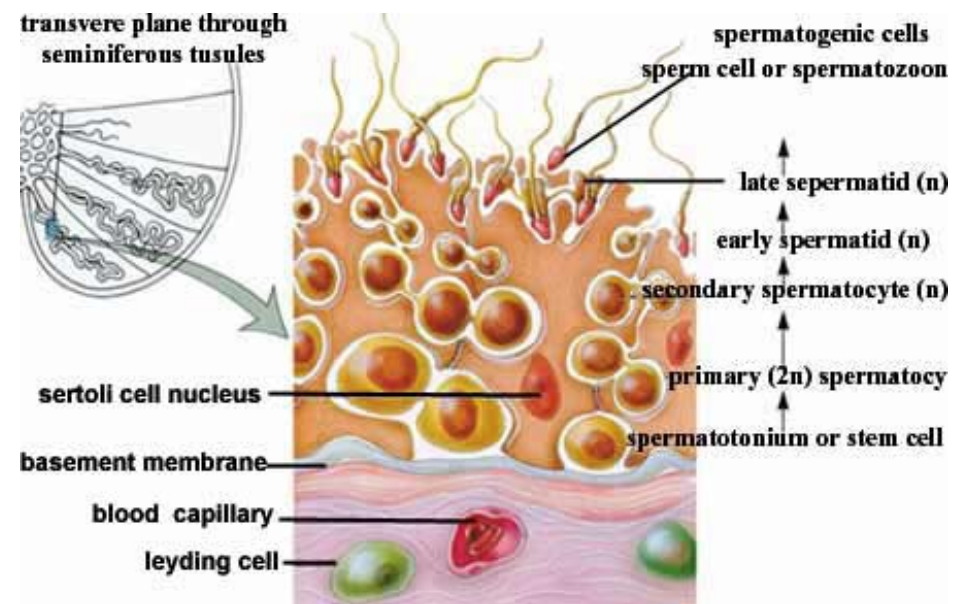
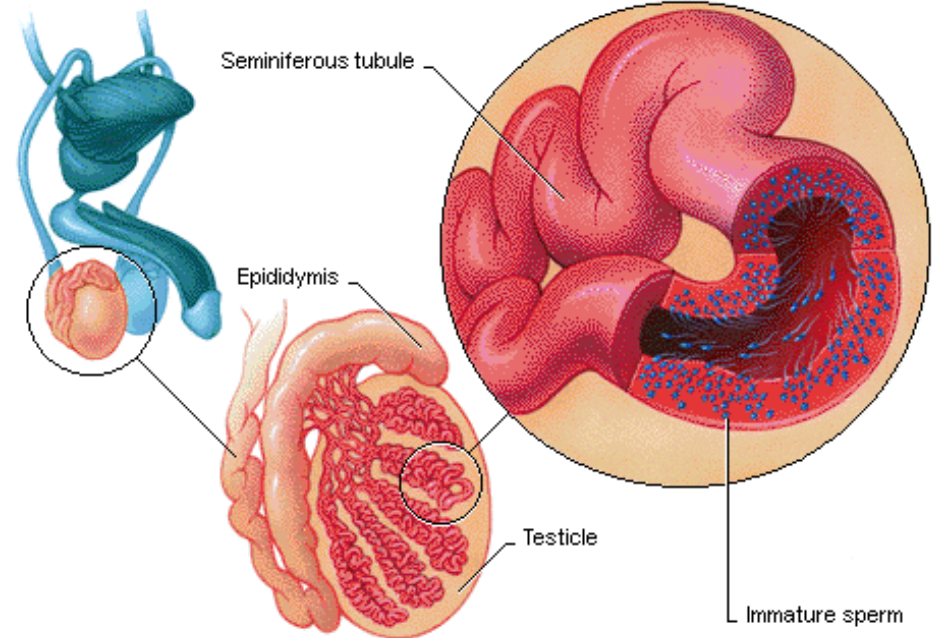
1. Gonads that make sperm & reproductive hormones
2. Accessory glands that secrete fluids essential to sperm movement
3. Ducts that carry sperm and glandular secretions



Male Anatomy

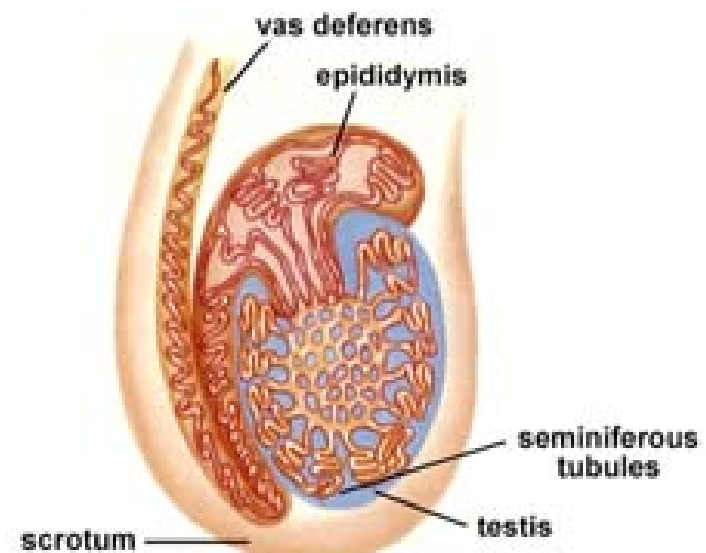
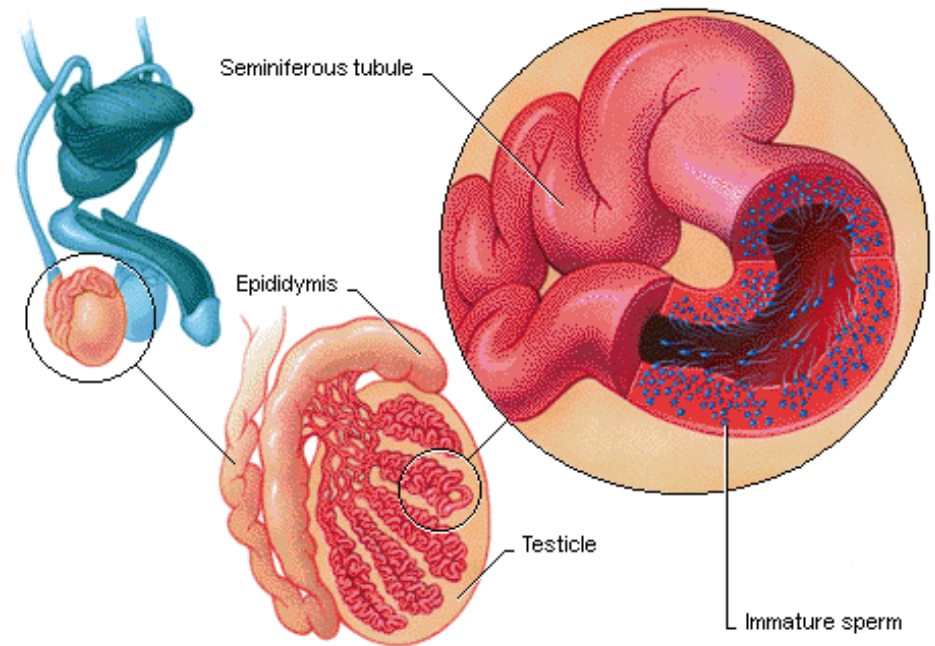
Testes

- ◆ **Seminiferous Tubules**
 - Many highly coiled tubes where sperm is made surrounded by layers of connective tissue
 - ◆ Sites of Spermatogenesis
- ◆ **Leydig Cells**
 - Scattered in between these tubules
 - ◆ Produce testosterone and other androgens
- ◆ Sperm production requires temperature of 2 C° below that of the body
 - Scrotum = fold of body wall keeps testicles cooler



Male Anatomy

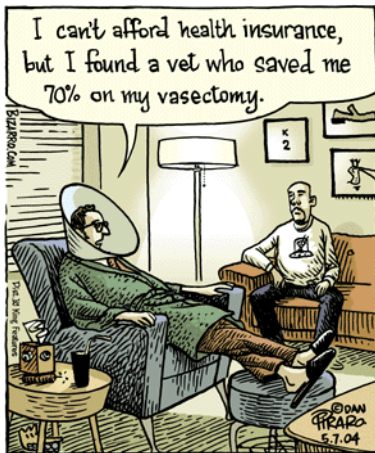
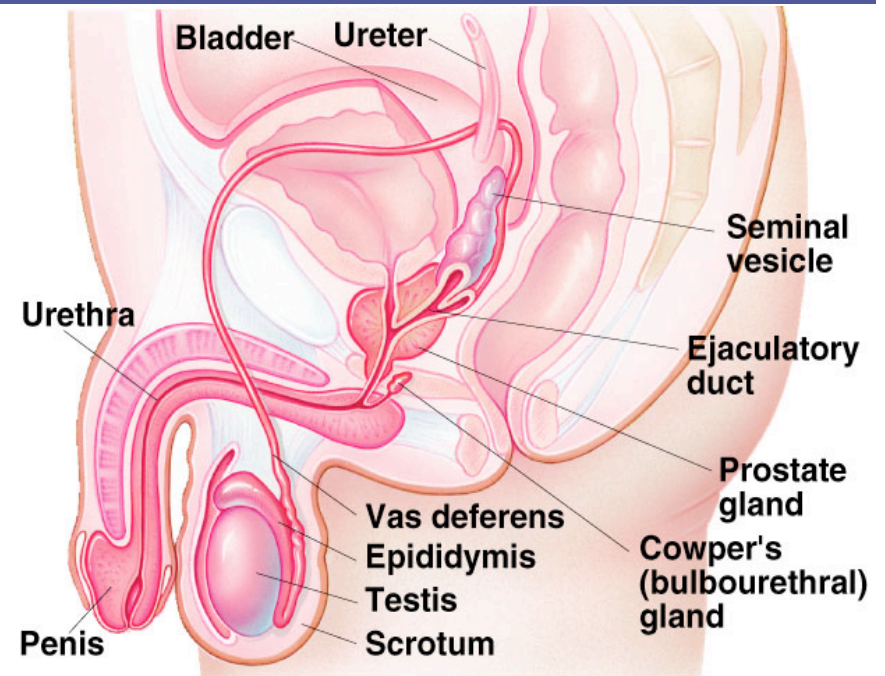
- Ducts: Epididymis
 - ◆ Sperm moves from seminiferous tubules of testes into coiled tubules called the epididymis.
- Human Epididymis = 6 m long!
 - ◆ Sperm takes 3 weeks to travel through it
- Here, sperm matures and becomes motile



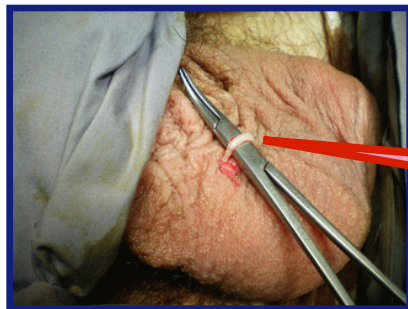
Male Anatomy

■ Ducts: Vas Deference

- ◆ During ejaculation, sperm is propelled through muscular ducts called the vas deference

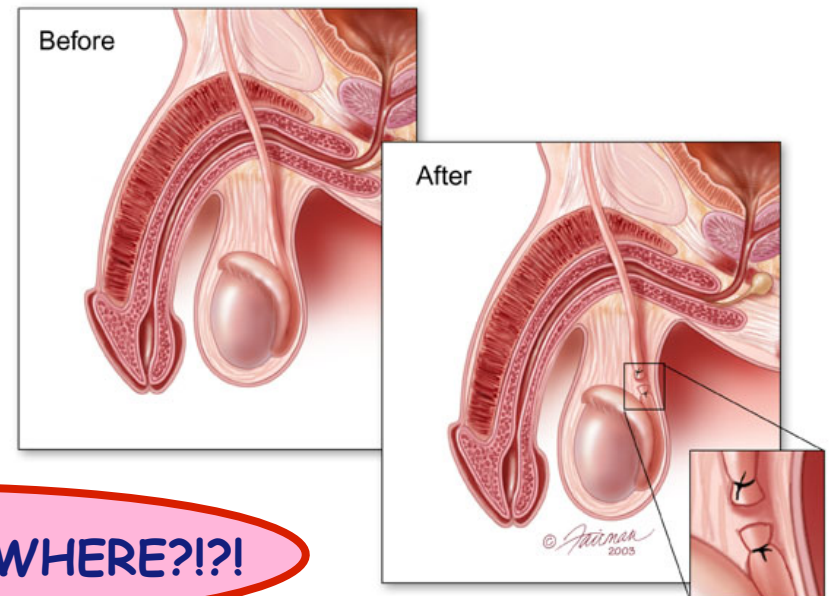


Vas deference joins duct from seminal vesicle glands to form short ejaculatory duct. Ejaculatory duct open into urethra, the tube through the penis



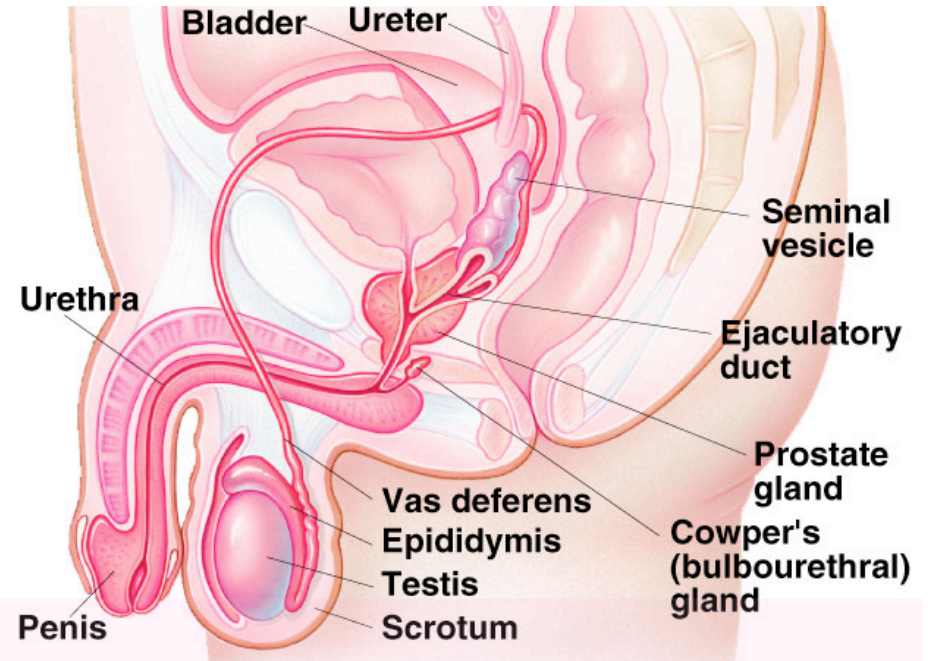
- Used by excretory and reproductive system

You want to snip **WHERE?!?!?**



Accessory Glands

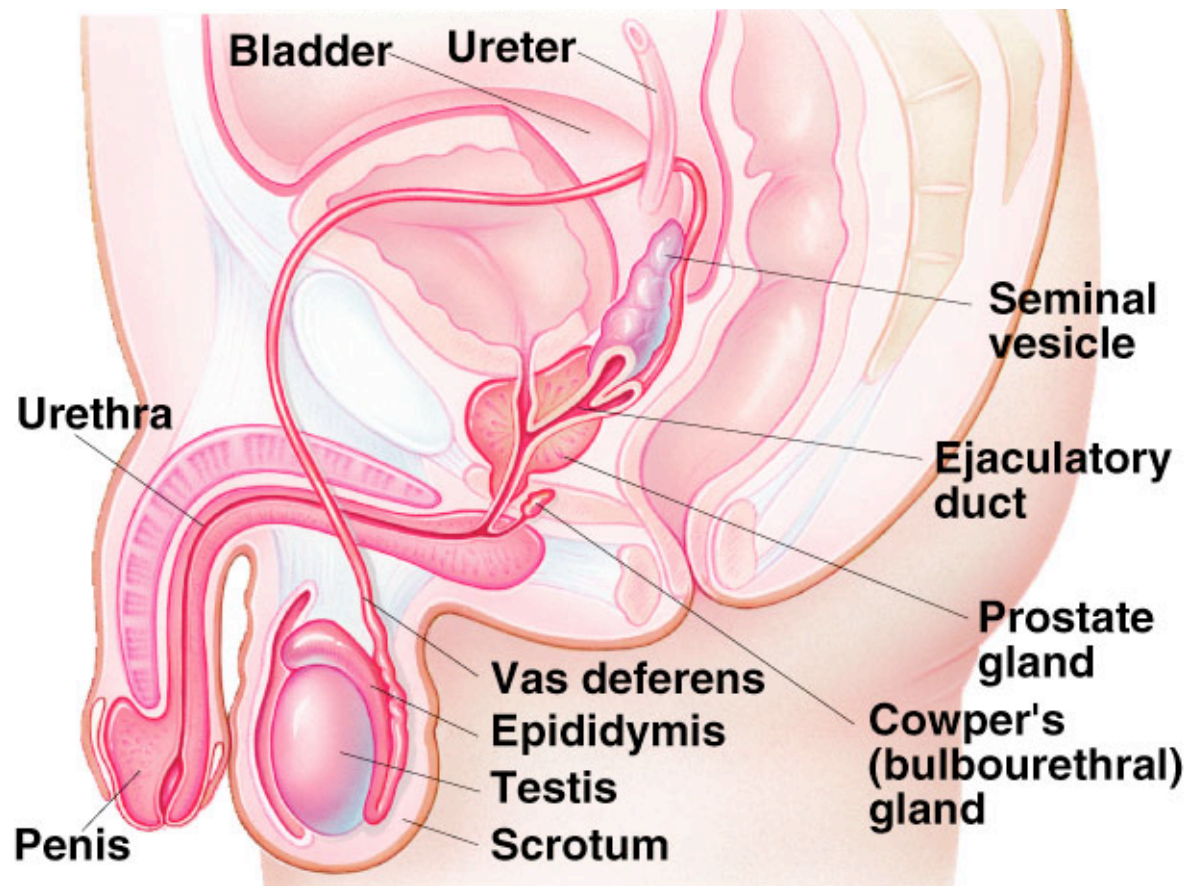
- Produce seminal fluids protect
- Sperm+Seminal fluids = semen



1. Seminal Vesicle
 - ◆ Fluid is thick, yellow, alkaline
 - Contains mucus, sugar fructose for sperm's energy, a coagulating enzyme, ascorbic acid, regulators called prostaglandins
2. Prostate gland
 - ◆ Fluid is thin and milky
 - Contains anticoagulant enzymes and citrate, a sperm nutrient
3. Bulbourethral (Cowper's) gland
 - Pair of glands below prostate
 - ◆ Fluid is clear mucus that neutralizes any acidic urine still in urethra
 - Also carries sperm released before ejaculation (in preejaculate)

Sperm Production

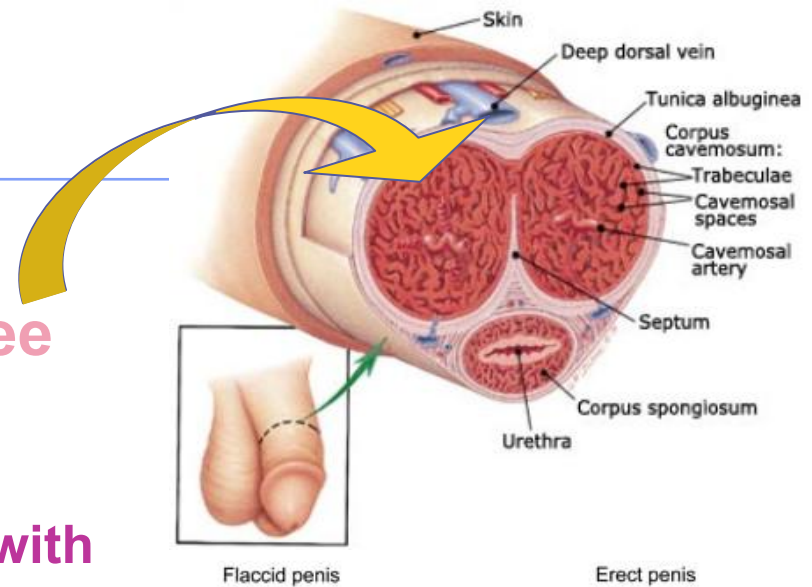
- **over 100 million produced per day!**
 - ◆ **~2.5 million released per drop!**



Male Anatomy

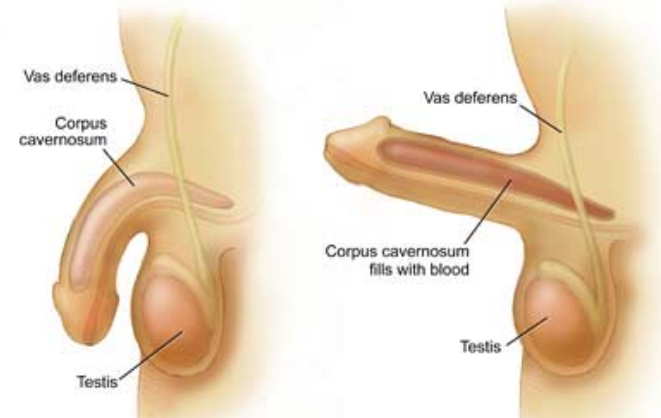
■ Penis

- ◆ Contains urethra & three cylinders of spongy erectile tissue
- Veins and capillaries fill with blood from arteries
- ◆ Increased pressure seals off veins that drain the penis so penis engorges with blood
- Erection allows penis to be inserted into vagina



Flaccid penis

Erect penis



The Proper Punctuation of Viagra®



Hey Baby!
Wanna release NO and
Vasodialate??!??

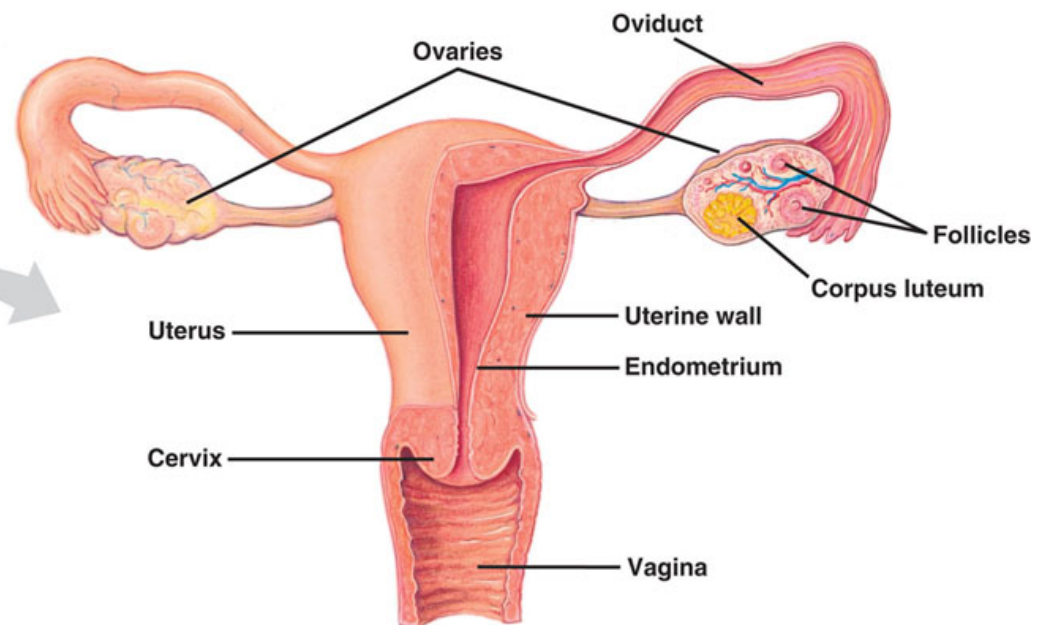
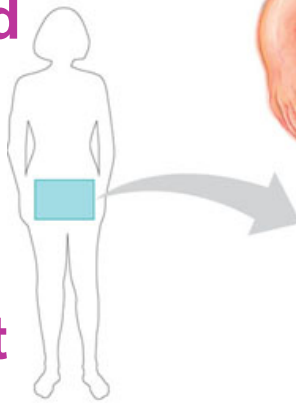
Female Reproductive Anatomy

■ External Reproductive Organs

- ◆ Clitoris
- ◆ Two sets of labia that surround the vaginal opening

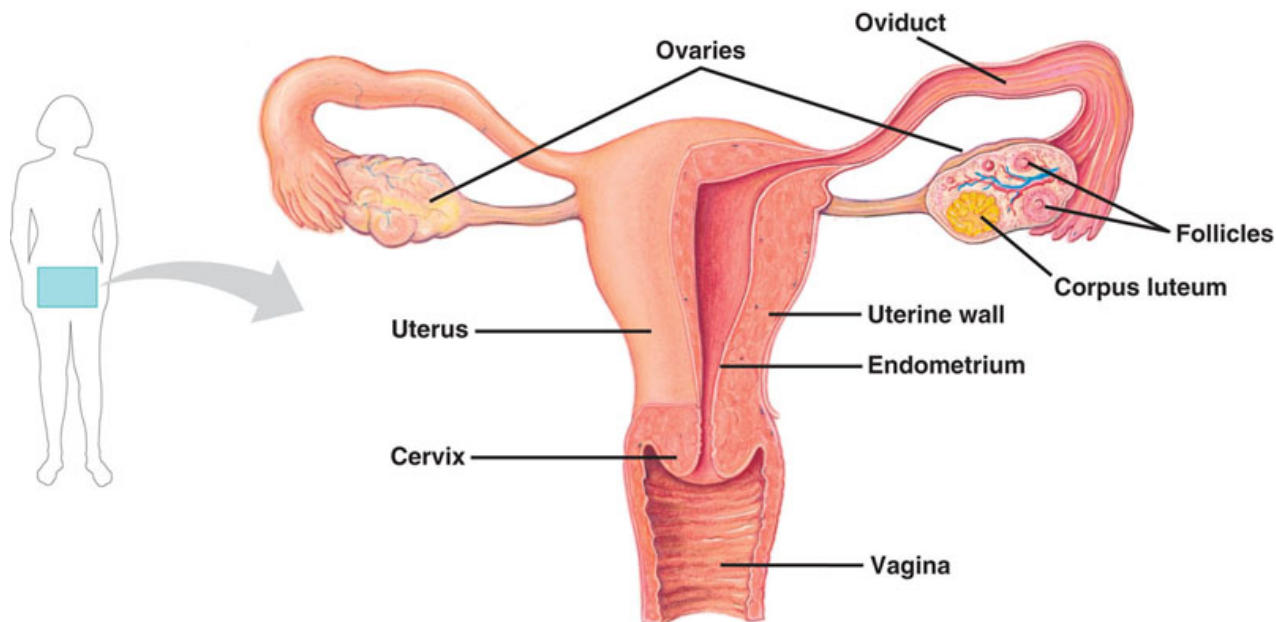
■ Internal Reproductive Organs

1. Gonads that make eggs and reproductive hormones
2. Ducts & Chambers that receive and carry egg and sperm & house the embryo



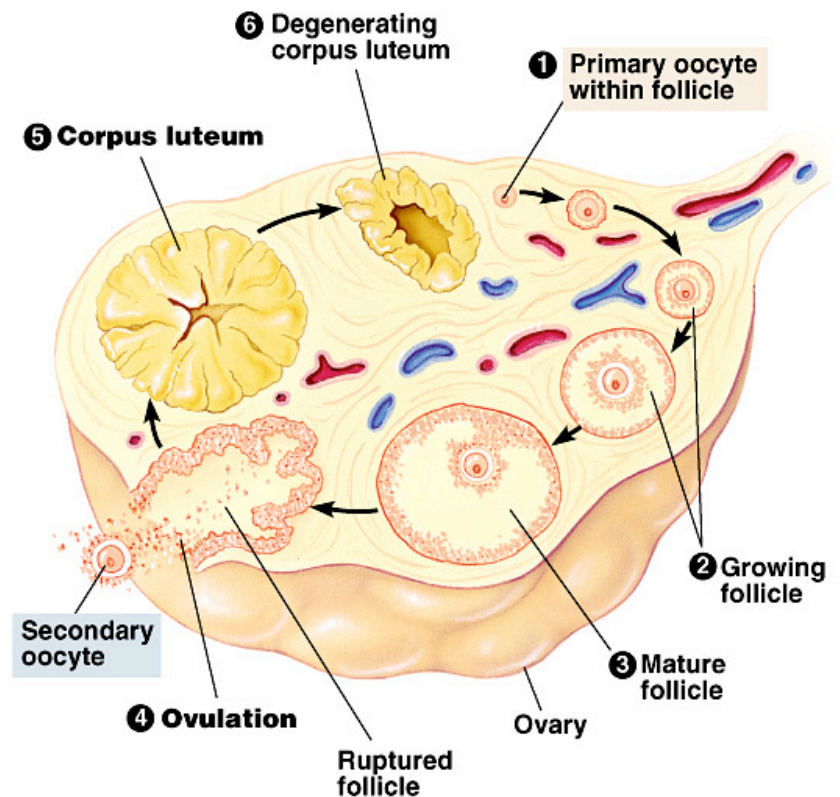
Female Gonads

- A pair of ovaries that flank the uterus
 - ◆ Outer layer packed with follicles
 - Each follicle contains an oocyte
 - ◆ Partially developed egg surrounded by a group of support cells that nourish and protect it
 - ◆ At birth, ovaries contain 1-2 million follicles
 - Only 500 fully mature between puberty and menopause



Female Gonads

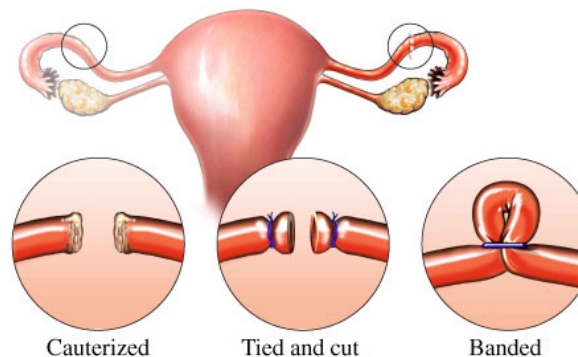
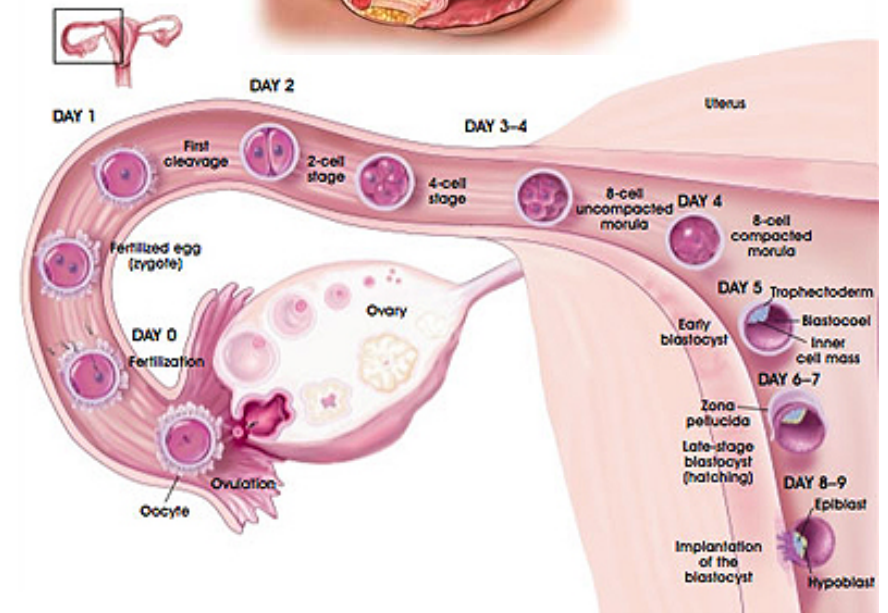
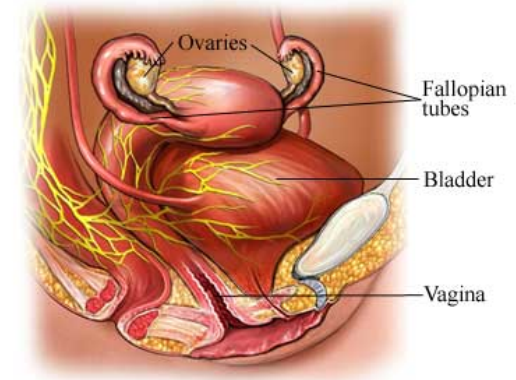
- During Ovulation, during each 4-week menstrual cycle, one follicle matures and expels its egg
 - ◆ Before Ovulation = cells of the follicle produce estradiol, a type of estrogen
 - ◆ After Ovulation = left over follicular tissue grows in ovary forming a mass called the corpus luteum
- **Corpus luteum secretes estradiol & progesterone**
 - ◆ **Hormones that maintain the uterine lining during pregnancy**
 - **If cell is not fertilized, corpus luteum degenerates and new follicle matures for the next cycle**



Female Anatomy

The Fallopian Tubes

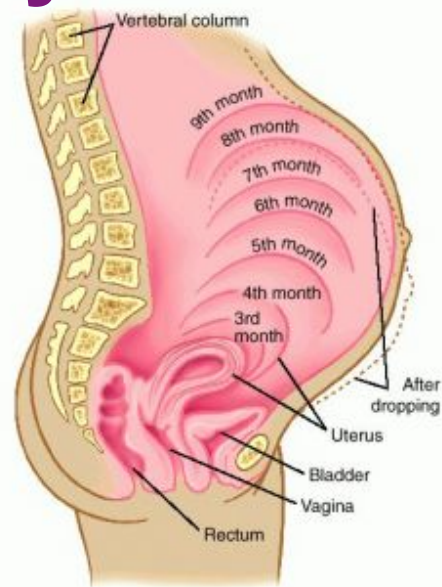
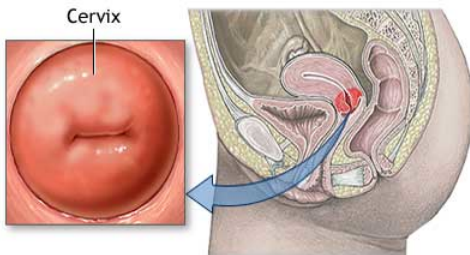
- ◆ An oviduct or the fallopian tube extends from uterus towards each ovary
- At ovulation, an egg is released into abdominal cavity
 - ◆ Cilia on epithelial lining of duct help collect the egg by drawing fluid in from the body cavity
 - ◆ The egg then starts to travel down the oviduct to the uterus or womb



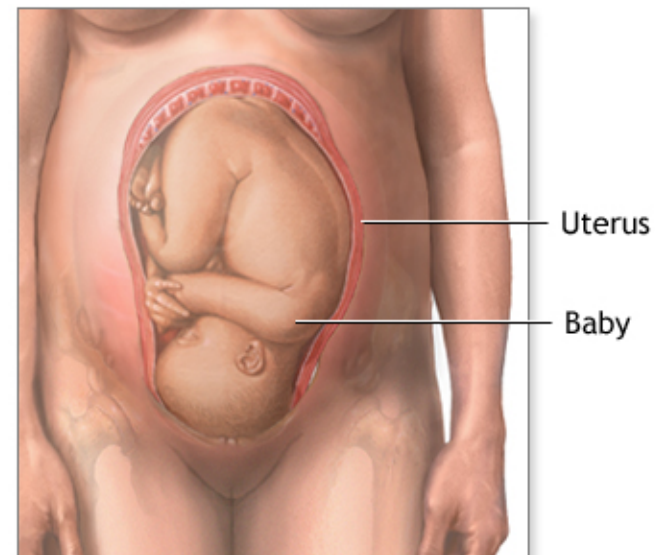
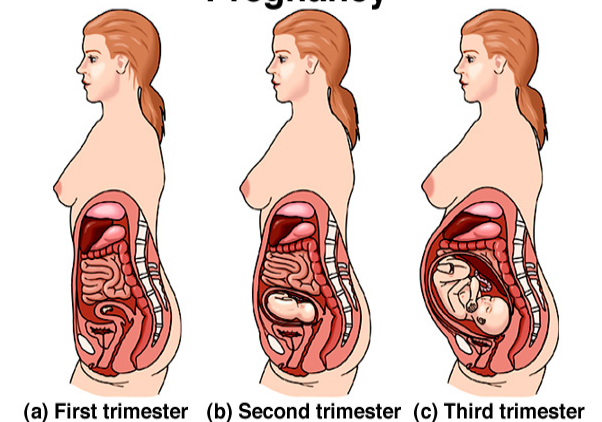
Female Anatomy

■ Uterus

- ◆ Thick muscular organ
- Expands during pregnancy
- Houses the fetus
- ◆ Inner lining is richly supplied with blood vessels



Changes in Woman's Body During Pregnancy



- Lining thickens each month in preparation for implantation & pregnancy

► **Cervix** is the opening of the uterus to the vagina

- Dilates 10cm for birthing baby

Female Anatomy

■ Vagina

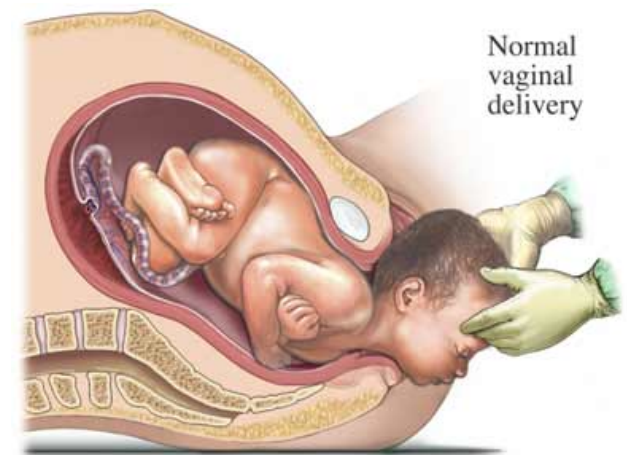
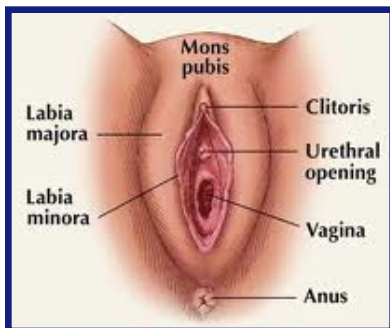
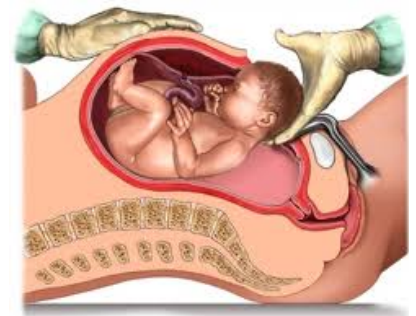
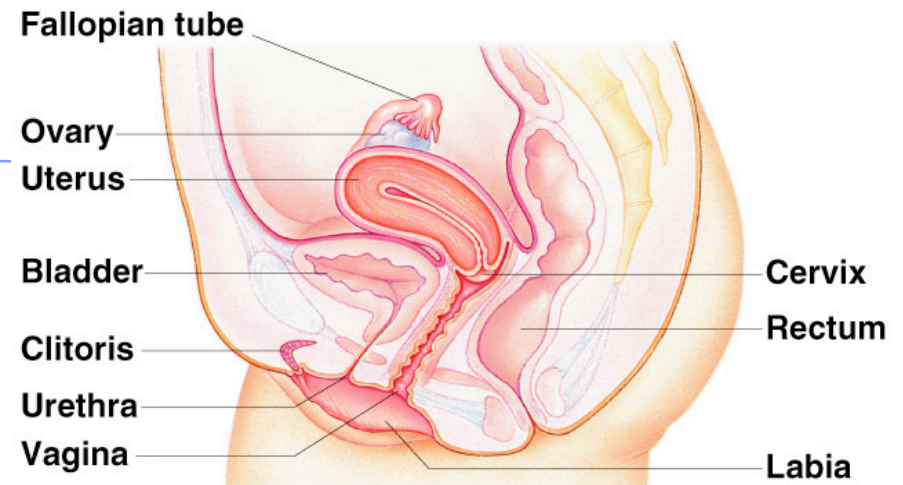
◆ Muscular but elastic chamber

- Site for insertion of penis
- Site for deposition of sperm during copulation
- Birth canal through which the baby is born

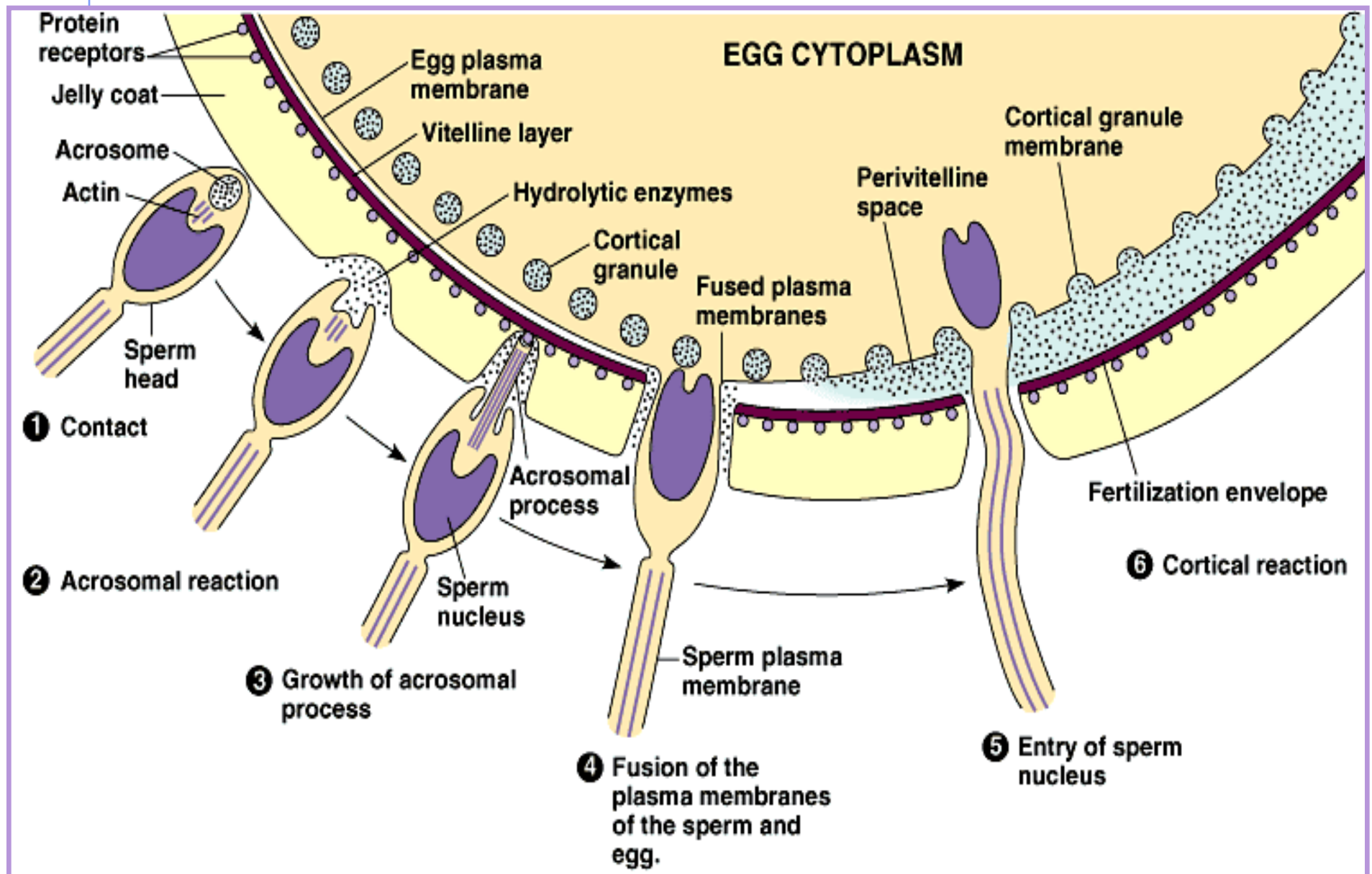
◆ Opens to the outside at the vulva, the external female genitals

- Includes the labia majora, labia minora, and clitoris

◆ Sexual arousal induces glands near vaginal opening to secrete lubricating mucus to facilitate intercourse

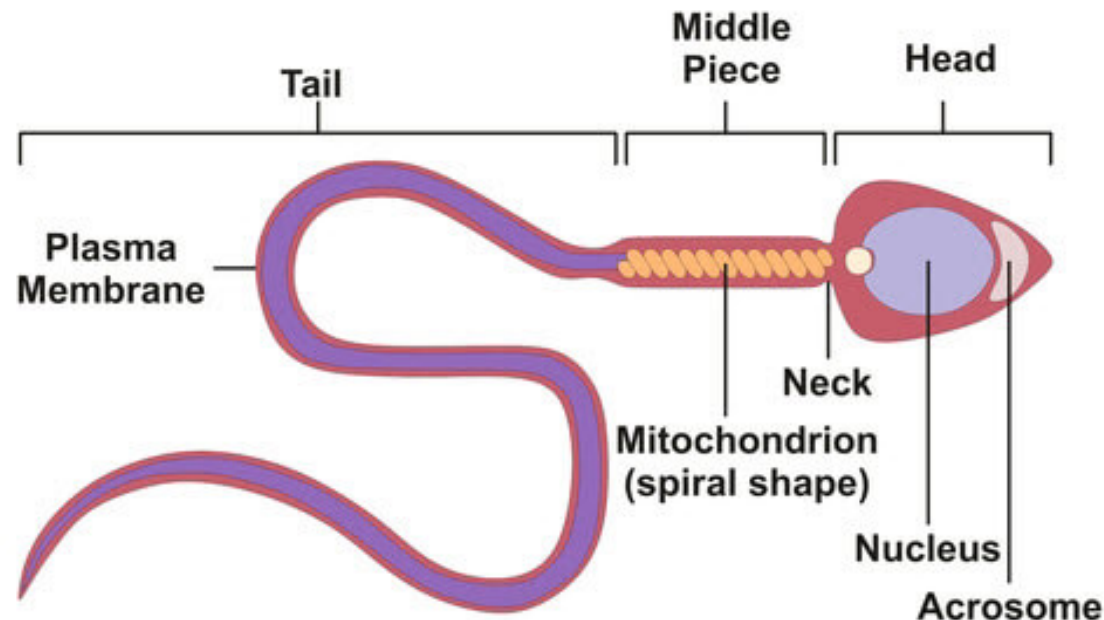


Fertilization - joining of egg and sperm

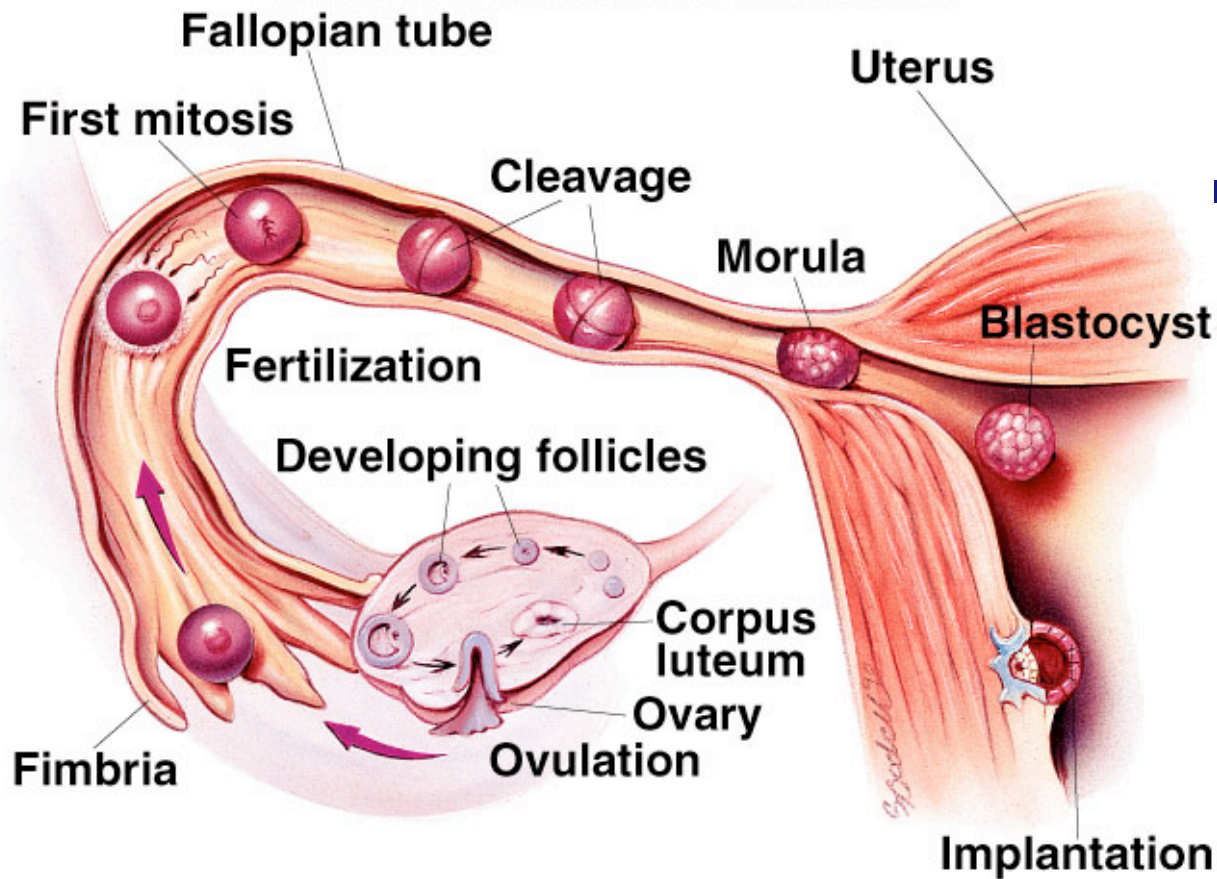


Fertilization - joining of egg and sperm

- ◆ Sperm squeezes through cells left over from the follicle to reach the egg cell
 - Acrosome releases enzymes to digest a hole in egg's external jelly coat that covers the egg's plasma membrane
 - ◆ Species-specific proteins of the sperm cell and receptors of the egg cell bind in the vitelline layer to ensure that gametes are of same species
 - Sperm and egg plasma membranes fuse & sperm nucleus enters
 - ◆ Hereafter, the plasma membrane becomes impenetrable to other sperm
 - Egg and sperm nuclei fuse, forming a diploid zygote

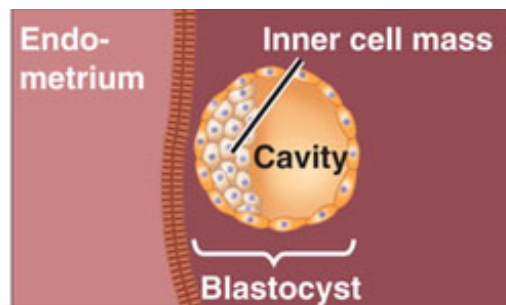


Fertilization - occurs in the oviduct nearer to ovary



Order of events:

1. Fertilization
2. Cleavage
3. Implantation
4. Gastrulation
5. Neurulation
6. Organogenesis



Pregnancy is divided into Trimesters

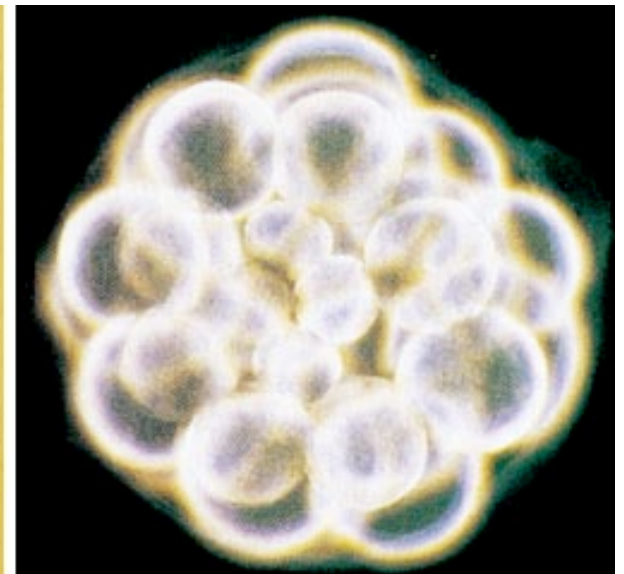
- **Childbirth usually occurs about 38-40 weeks after conception**
 - ◆ We refer to the developing offspring as the embryo in the first 8 weeks.
 - ◆ After that we use the term fetus is used until birth
- **Pregnancy is divided into three periods or trimesters, each of about three months**
 - The first trimester carries the highest risk of miscarriage (natural death of embryo or fetus).
 - During the second trimester, the development of the fetus can be more easily monitored and diagnosed.
 - The beginning of the third trimester often approximates the point of viability, or the ability of the fetus to survive, with or without medical help, outside of the uterus.



*First
Trimester*

Cleavage

- Repeated mitotic divisions of zygote
 - ◆ 1st step to becoming multicellular
 - ◆ unequal divisions establishes body plan
 - different cells receive different portions of egg cytoplasm & therefore different regulatory signals



Organization of tissues

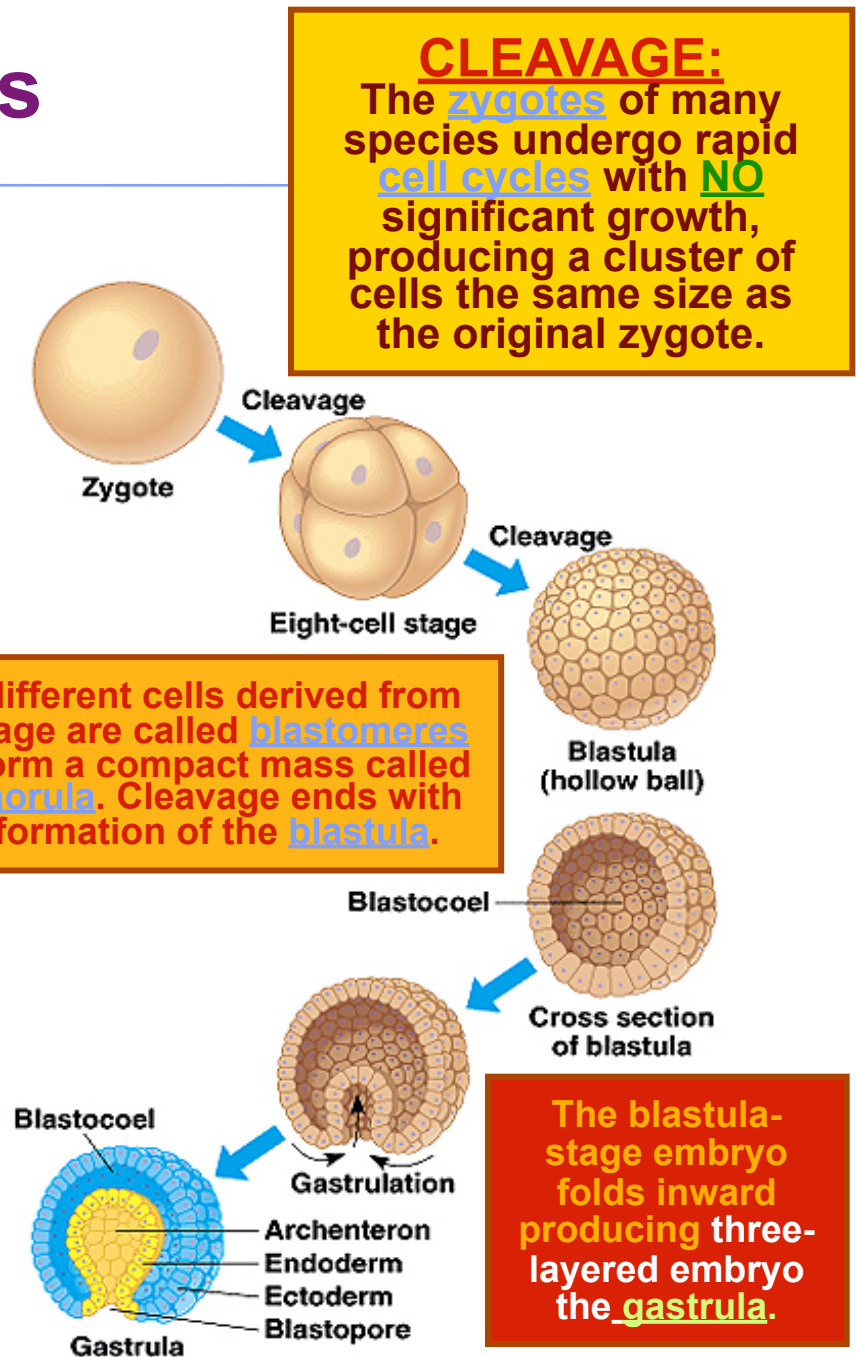
- **True tissues** are collections of specialized cells isolated by membranous layers

- ◆ Sponges are the only animal that lack true tissues

- All other animals' embryos become layered through a process known as **gastrulation**

- ◆ Resulting **germ layers** form ALL tissues and organs

- Ex: Ectoderm, Mesoderm, Endoderm



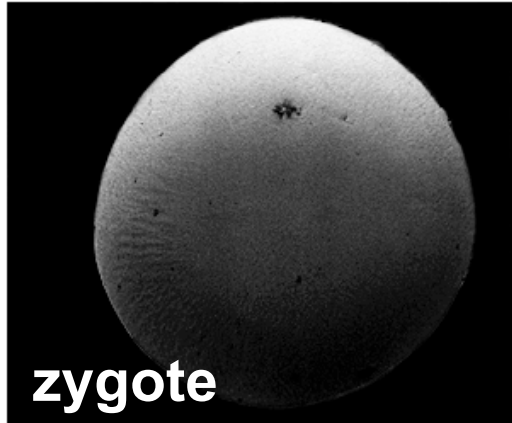
Cleavage

(right after fertilization)

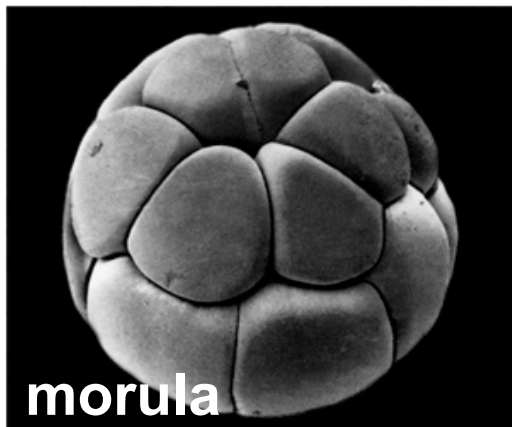
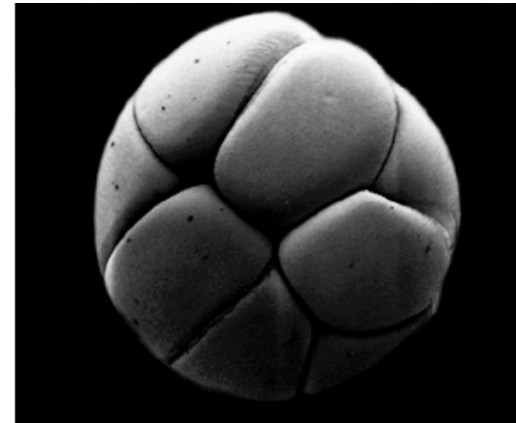
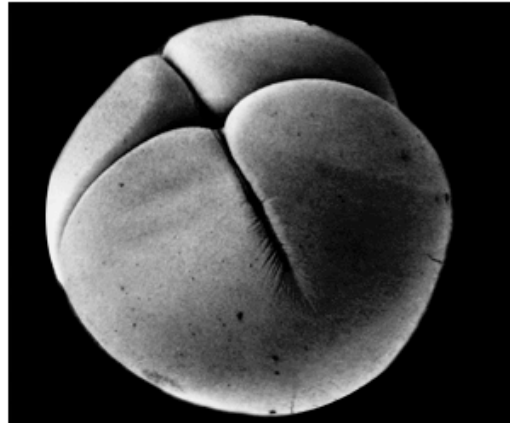


zygote → morula → blastula

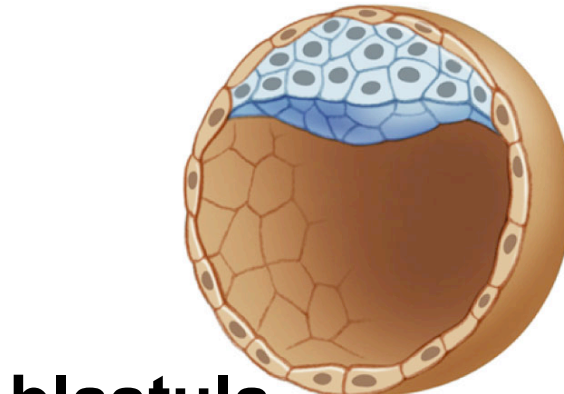
- ◆ establishes future development pathway of the cells



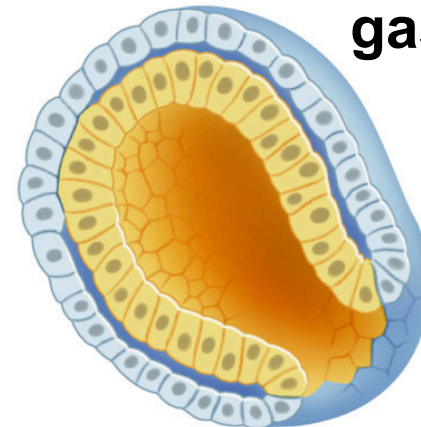
zygote



morula



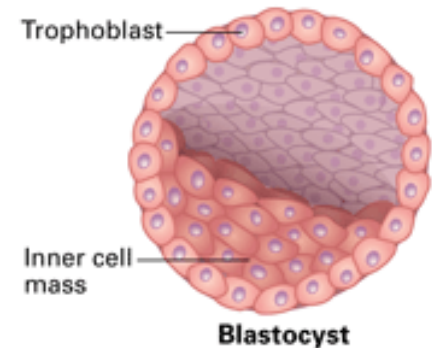
blastula



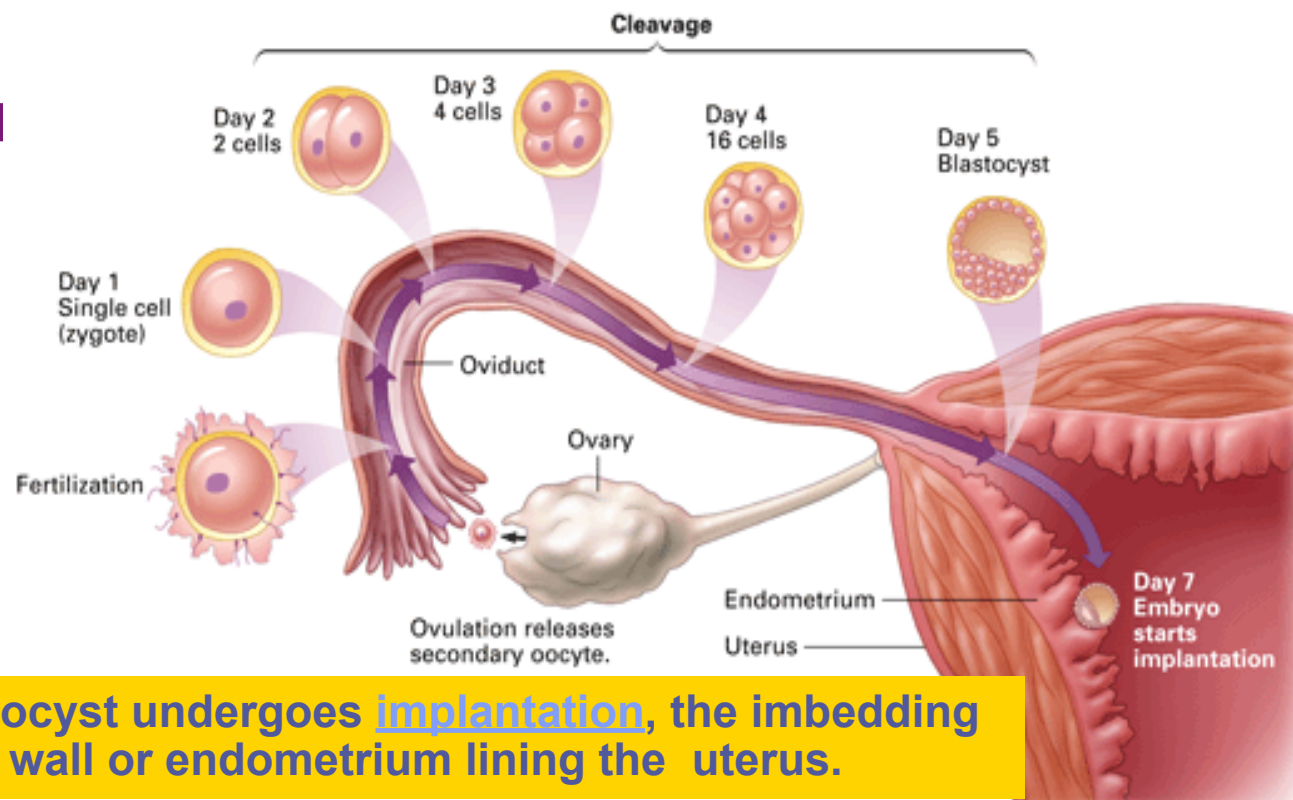
gastrulation

Cleavage and Implantation

- By day 5: cleavage has produced a ball of about 100 cells (Blastocyst) that has reached the uterus with the help of cilia in the oviduct.
- ◆ Blastocyst is a fluid-filled sphere consisting of an outer layer of cells and a group of cells inside the sphere



- The outer layer of cells is called the trophoblast, and the cluster of cells within sphere is called the inner cell mass.

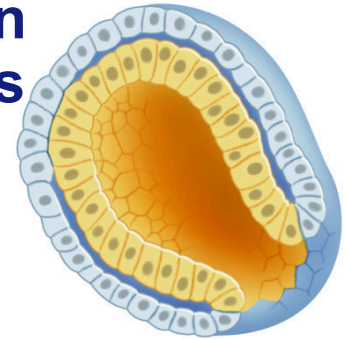


Within the uterus, the blastocyst undergoes implantation, the imbedding of it in the thickened wall or endometrium lining the uterus.

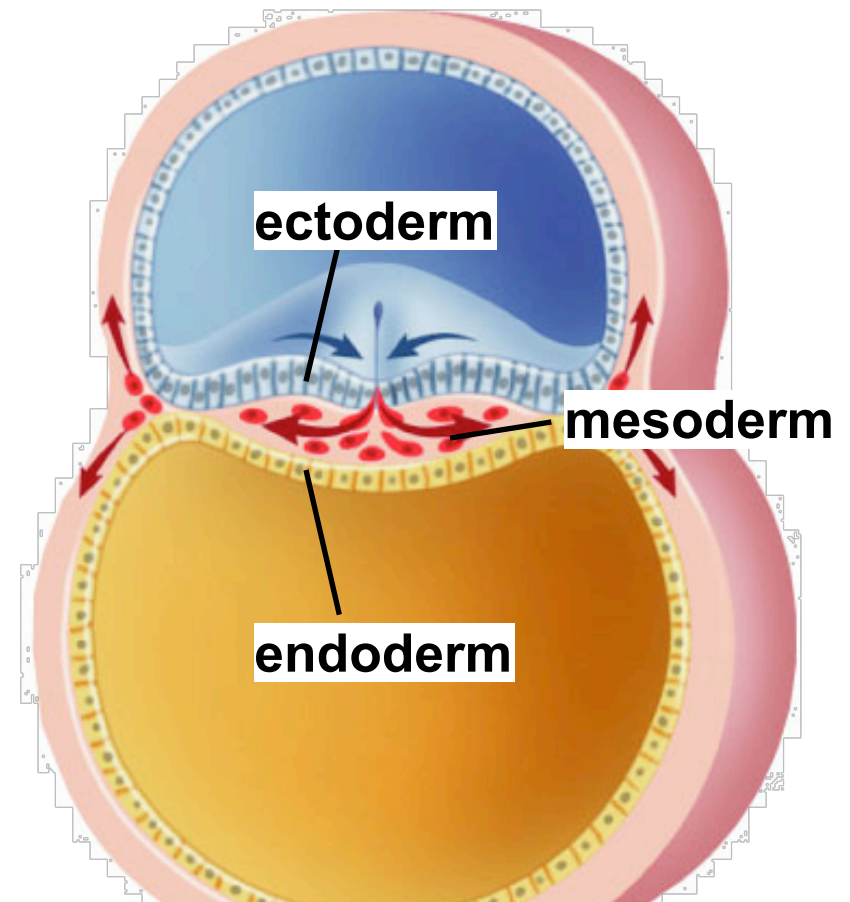
Gastrulation -

3 weeks after fertilization

gastrulation in
primitive chordates



- Establish 3 cell layers by the infolding of the blastula
 - ◆ ectoderm
 - outer body tissues
 - ◆ skin, nails, teeth
 - ◆ nerves, eyes, lining of mouth
 - ◆ mesoderm
 - middle tissues
 - ◆ blood & lymph, bone & notochord, muscle
 - ◆ excretory & reproductive systems
 - ◆ endoderm
 - inner lining
 - ◆ digestive system
 - ◆ lining of respiratory, excretory & reproductive systems

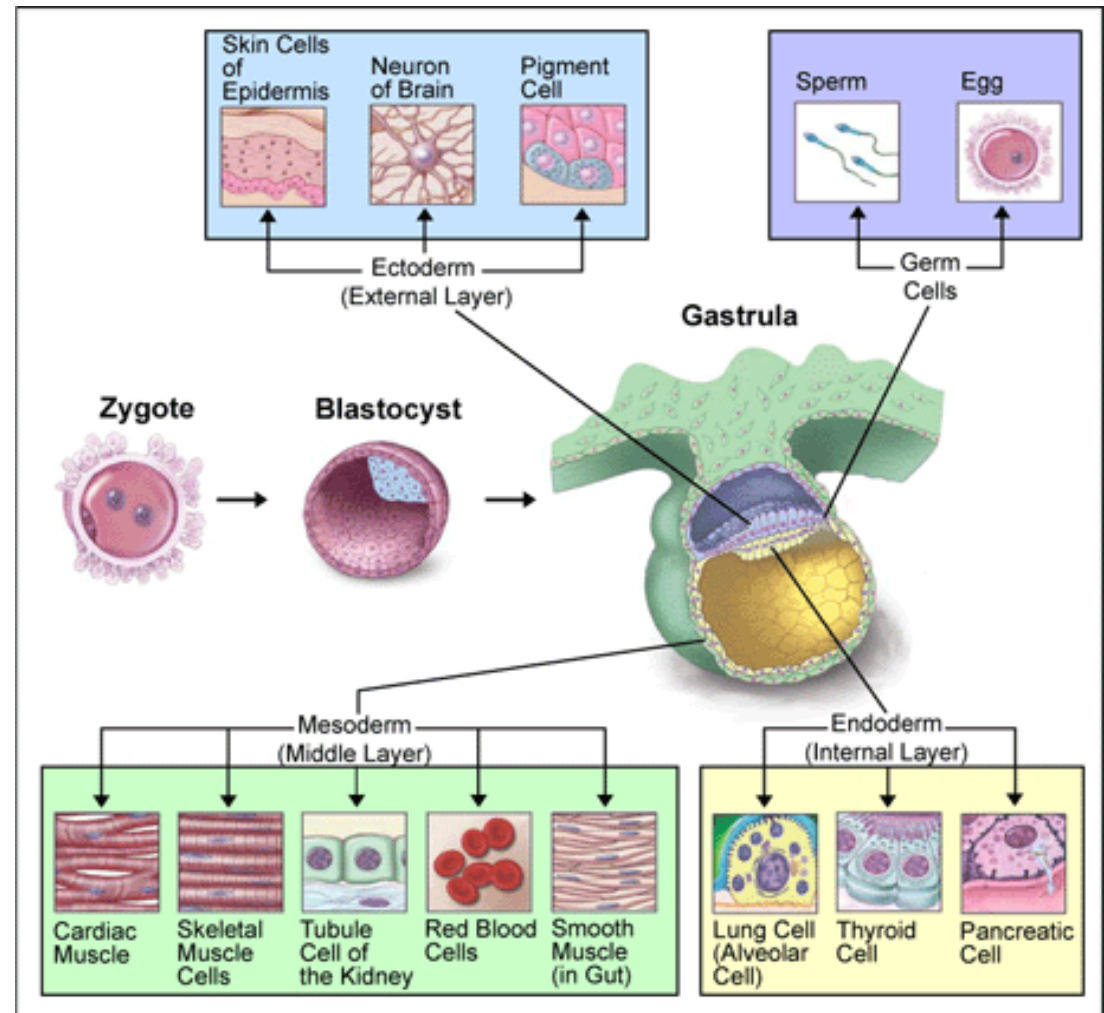


protostome vs. deuterostome - do you remember AP from your animal evo slides?

Organogenesis

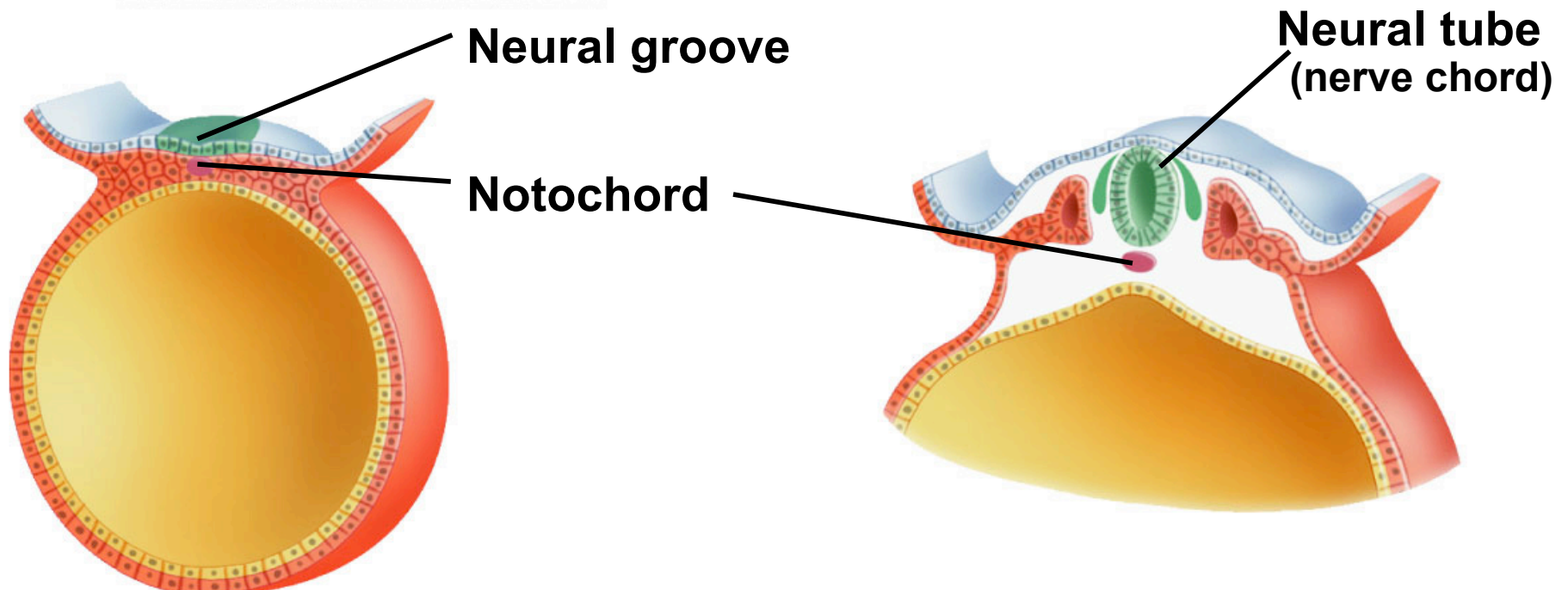
- The process by which the organs form from the three germ layers

◆ Week 3 - 8



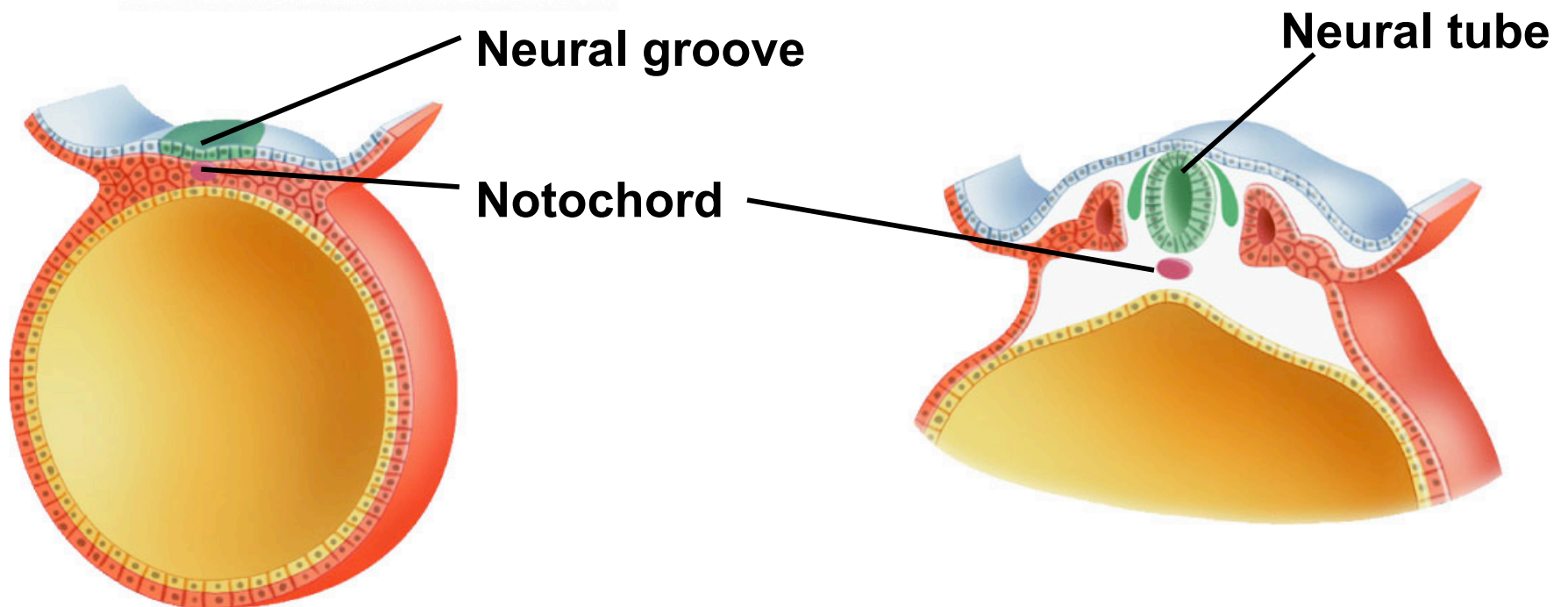
Organogenesis includes Neurulation

- 1st organ to form is notochord & nerve chord
 - ◆ The ectoderm start to form a groove known as the neural groove (green cells in picture)
 - ◆ The hollow nerve chord (a.k.a. neural tube) develops when the ectoderm fully rolls into a tube on the dorsal (back) side of the embryo
 - This tube develops into the Central Nervous System (spinal cord and brain)

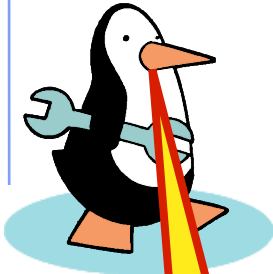


Neurulation

- ◆ The notochord is a dorsal longitudinal flexible rod around which the vertebrae (back) bones develop.
 - It runs along the backside of the embryo under the hollow neural tube.
 - The notochord becomes the gelatinous disks between the vertebrae for cushioning and allow the spine to be flexible



Phylum Chordata (has a nerve cord), Subphylum Vertebrata (vertebrae bones)



Oh, look...
your first
baby picture!



Becomes Gills in fish or
Eustachian tube &, in humans,
cells of the Middle ear, Thyroid
gland & Larynx (voice box)

pharyngeal
pouches

becomes tail in fish/
other tetrapods
(animals with four
extremities) or
tailbone in humans

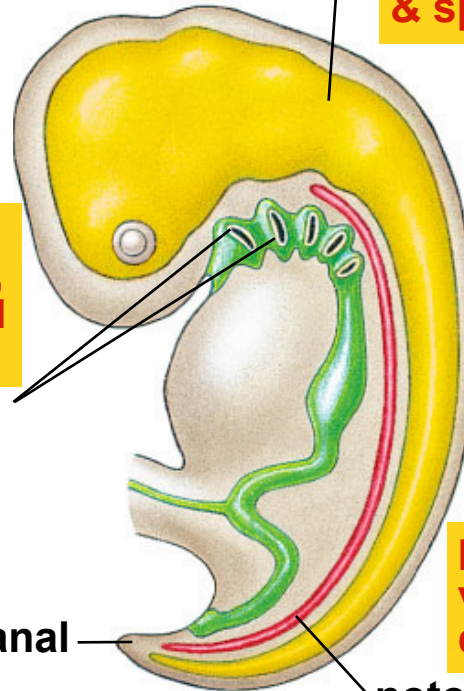
postanal
tail

hollow dorsal
nerve cord

becomes brain
& spinal cord

becomes
vertebral
disks

notochord

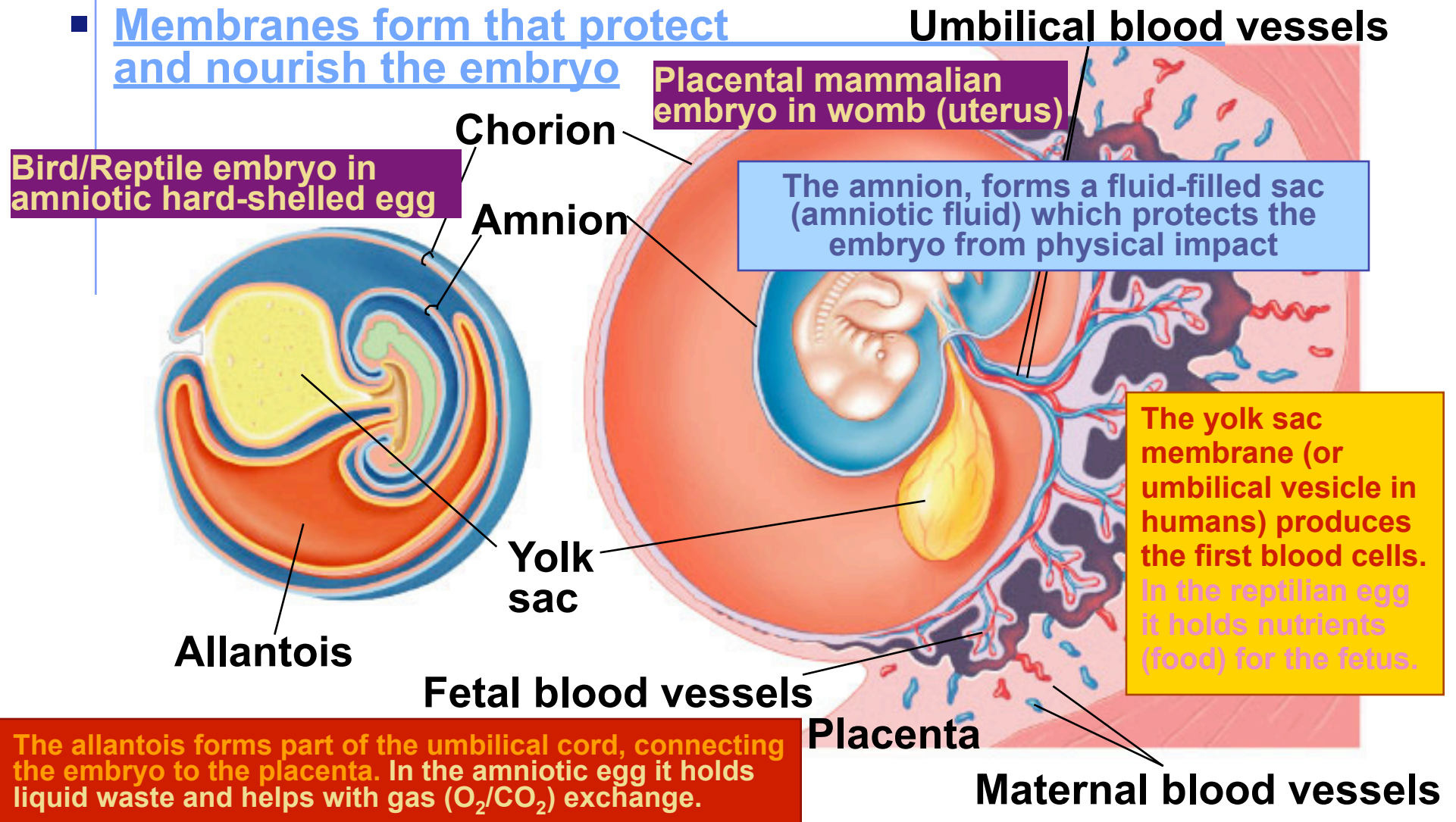


Membranes

The chorion is a third membrane that becomes the embryo's portion of the placenta which helps for the transfer of nutrients and gas exchange. In the amniotic egg it helps O_2/CO_2 exchange.

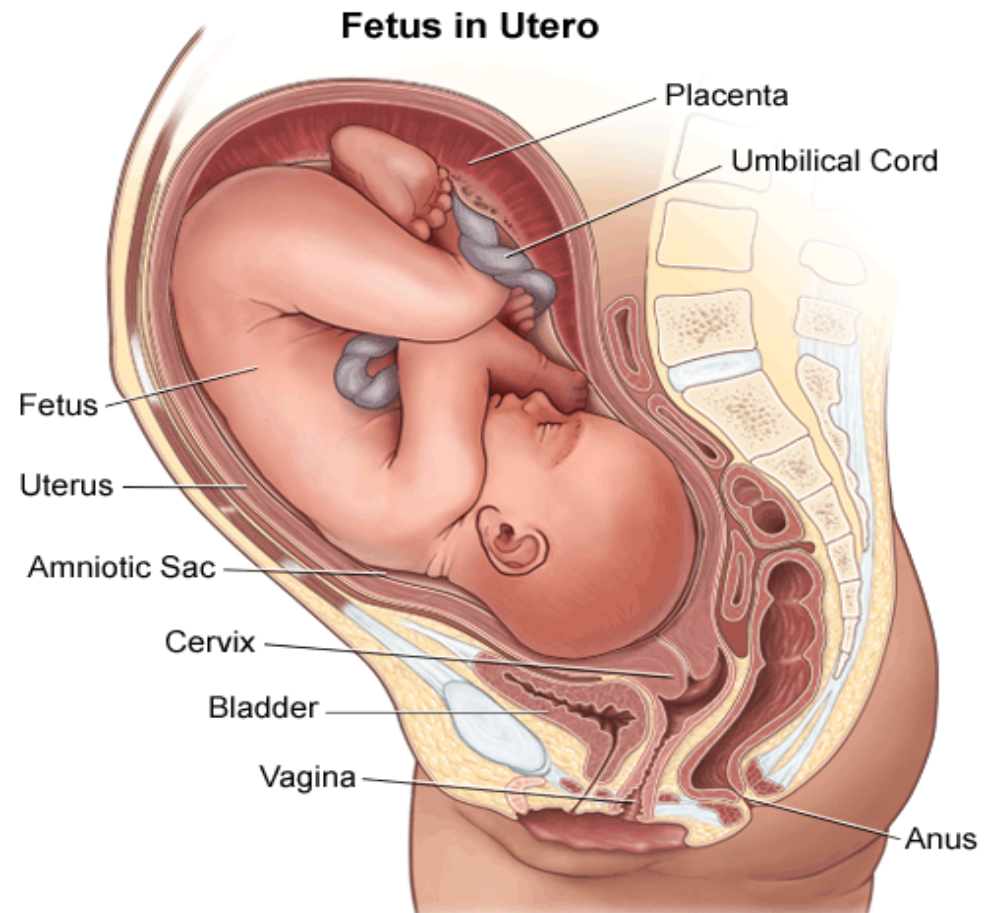
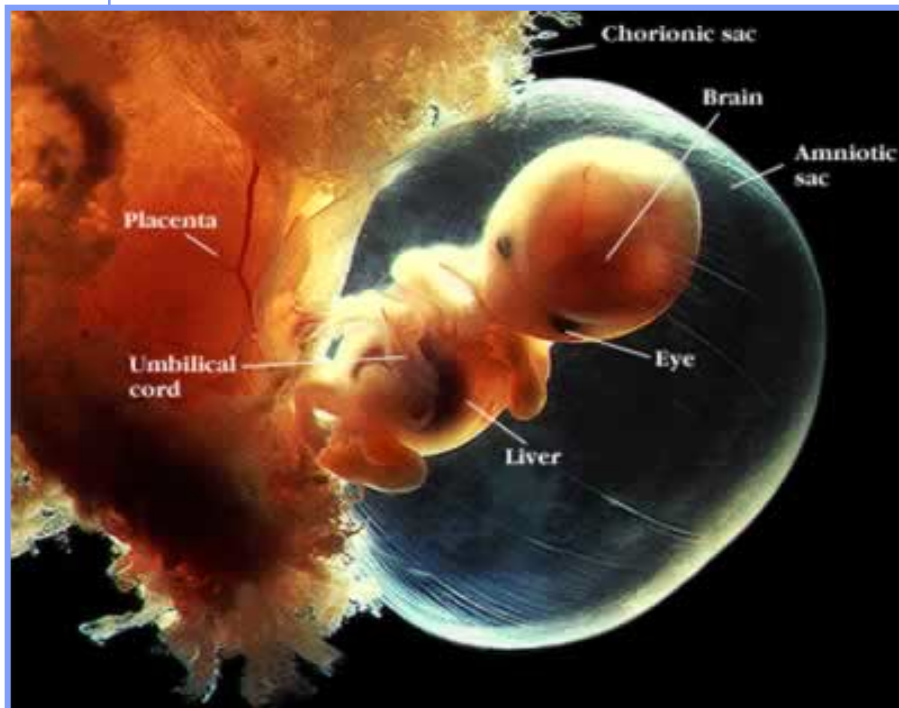
(amphibian (frogs) and fish do NOT make amniotic eggs but air breathing vertebrates like birds (dinosaurs), mammals, and reptiles do and are, therefore, called amniotes)

- Membranes form that protect and nourish the embryo



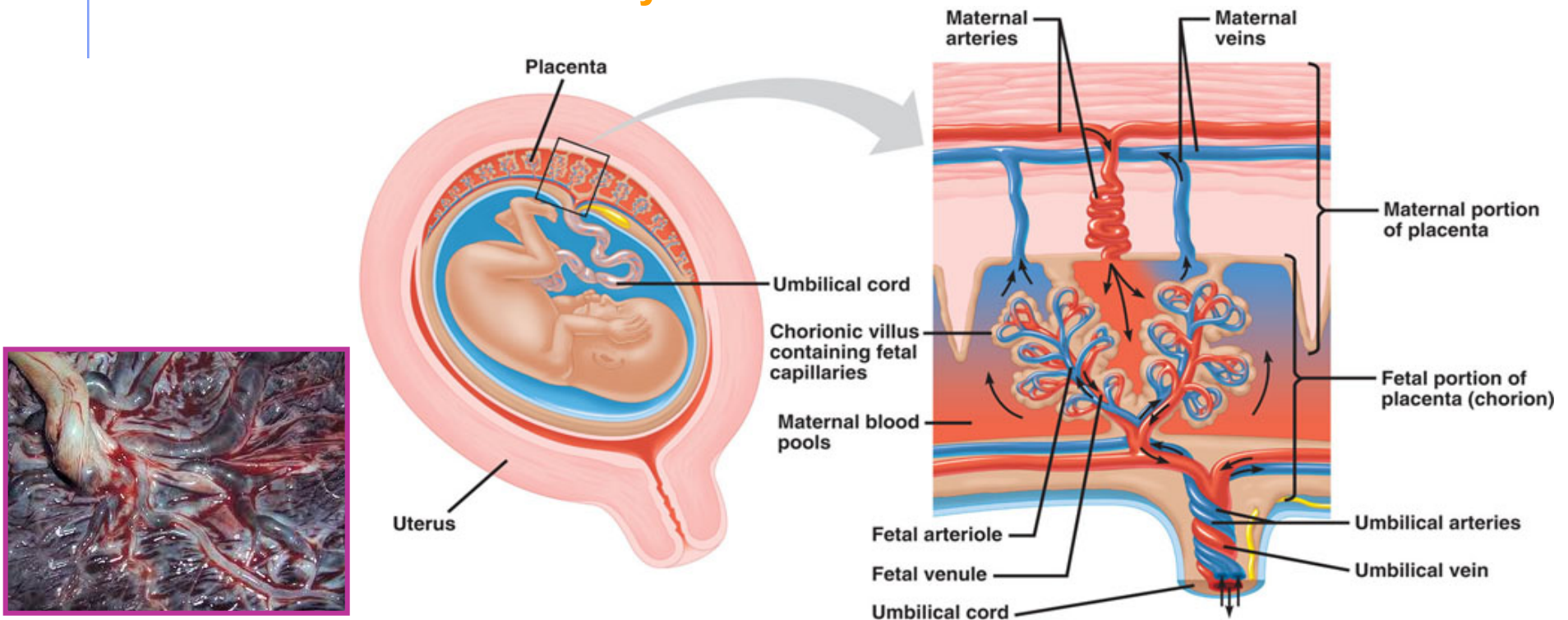
Placenta formation *(Complete by week 9)*

- Soon after implantation, the embryo and cells from the uterus form an important structure called the placenta.
 - ◆ This structure enables nutrients and waste products to be transferred between the mother and developing baby.



Placenta - nutrient & waste exchange system

- In the placenta, the mother's blood and baby's blood remain isolated in separate circulatory systems.
 - ◆ However, the mother's blood vessels release pools of blood very close to the baby's blood vessels.
 - Nutrients and waste products are able to diffuse back and forth from one blood system to the other.

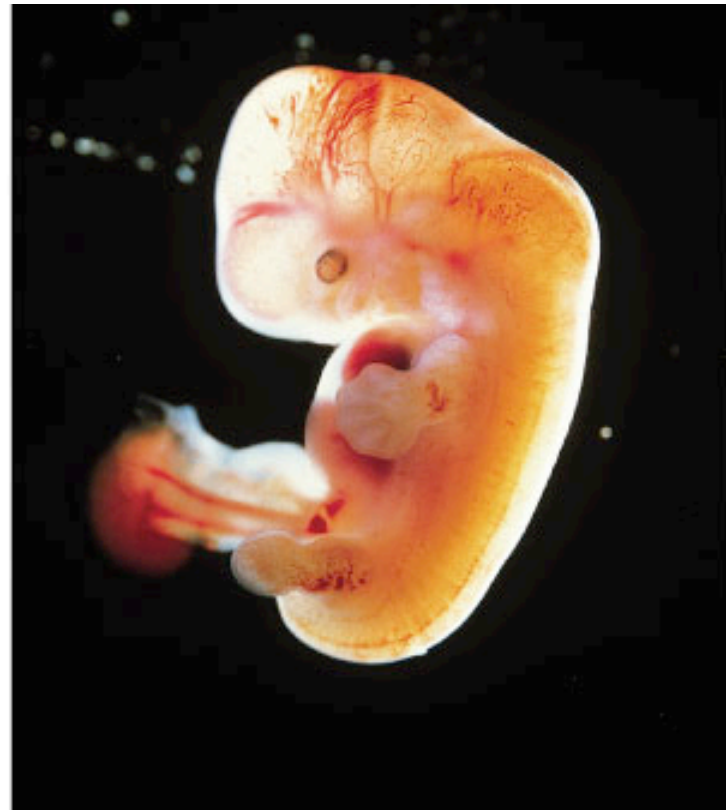


Human fetal development

4 weeks



7 weeks



By the end of the first trimester, the fetus can move its arms and legs, turn its head, frown, and make sucking motions. It's heart is also beating away!

Second Trimester

Second Trimester

■ Week 12 through 23

- The fetus increases in length to about 25 cm.
- ◆ By the end of this period, the fetus has the face of an infant, complete with eyebrows and eyelashes.
- ◆ At this point, the fetal heartbeat is easily detected and the fetus can be quite active
 - The mother can usually feel this activity, which ranges from flutters to kicks & pokes.
 - ◆ Because the fetus is now filling up much of the space in the uterus, it curls forward into what is referred to as the "fetal position"



Human fetal development

10 weeks



Human fetal development

- The fetus just spends much of the 2nd & 3rd trimesters just growing
...and doing various flip-turns & kicks inside amniotic fluid



12 weeks



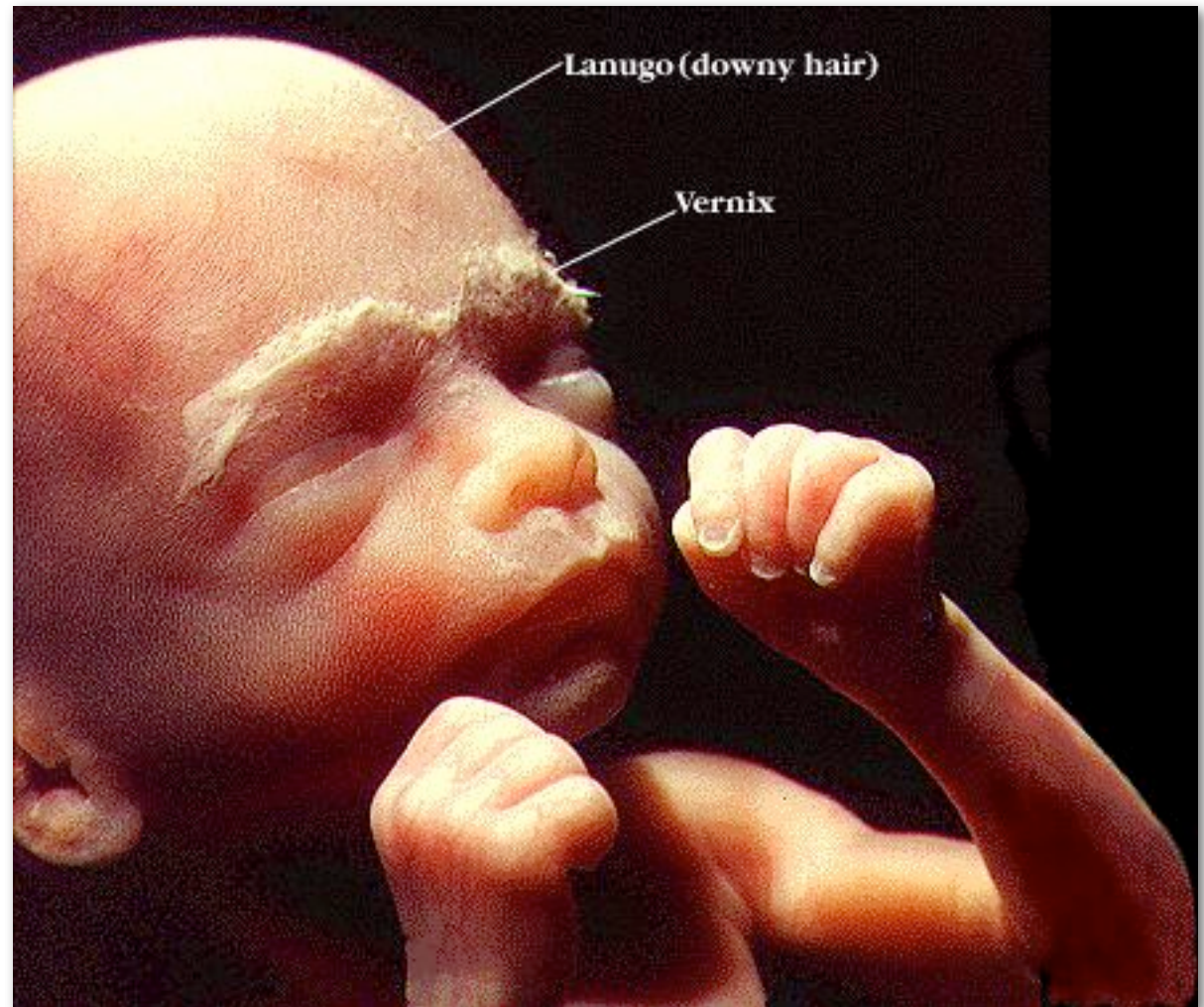
20 weeks

Human fetal development

- 24 weeks (6 months; 2nd trimester)

Fetus is covered with fine, downy hair called lanugo.

Its skin is protected by a waxy material called vernix



*Third
Trimester*

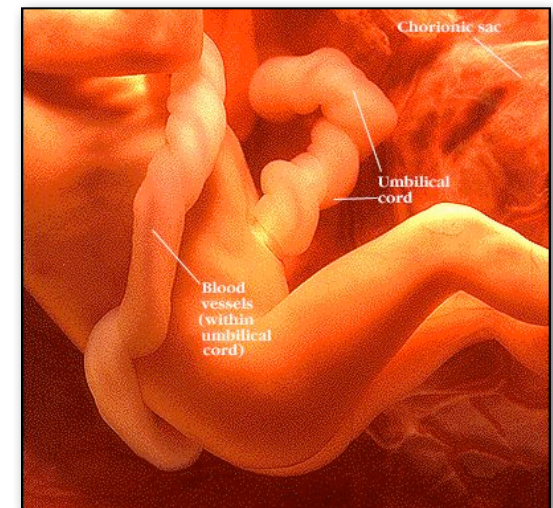
Human fetal development

■ Week 24 until birth

- ◆ The fetus experiences rapid growth, becoming larger and gaining stronger bones and muscles.
- The respiratory and circulatory systems undergo changes that will enable the baby to start breathing air and perform other vital functions outside the mother's uterus when it is born.
- ◆ As it fills more and more of the available space in the uterus, the fetus becomes less active.



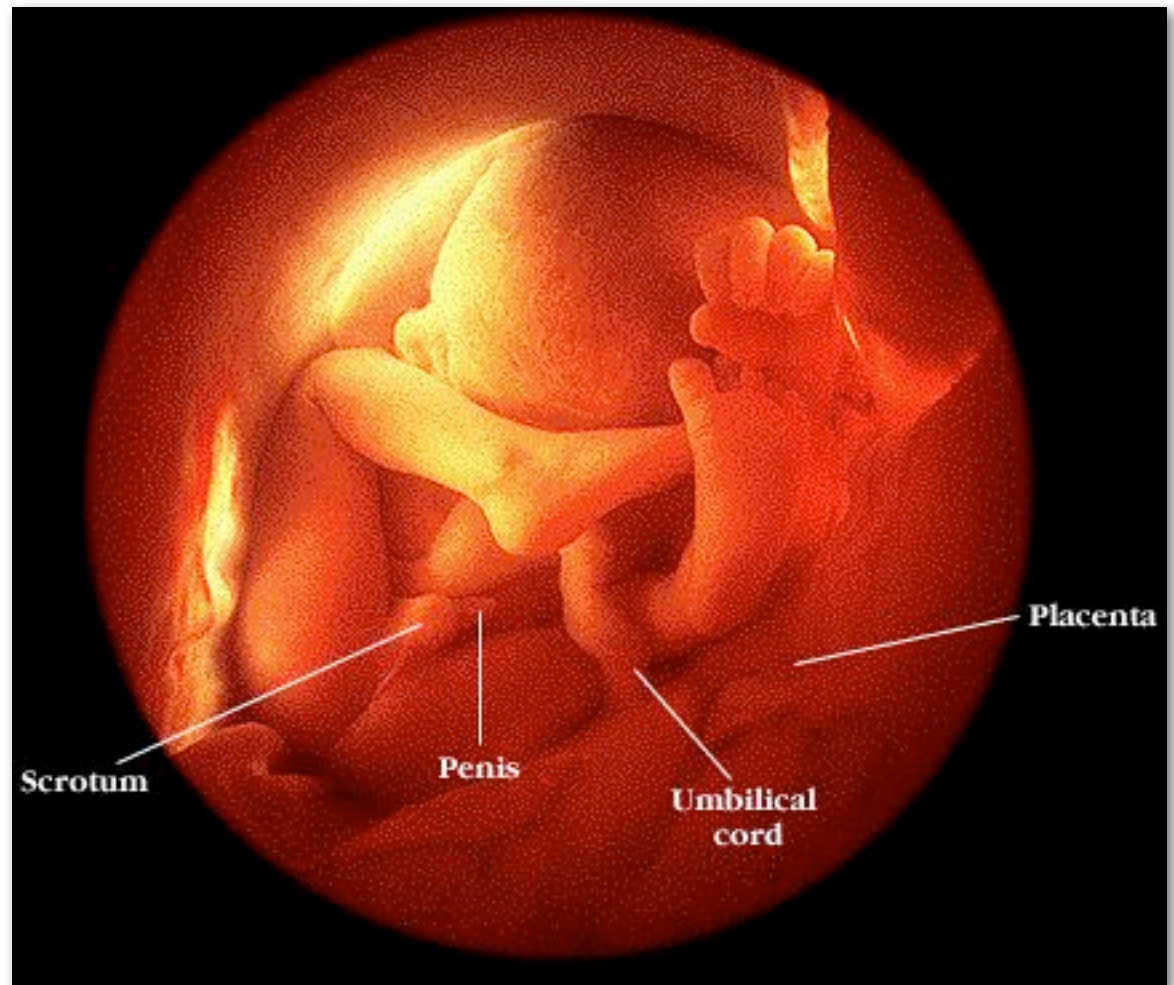
human foetus: 28 weeks



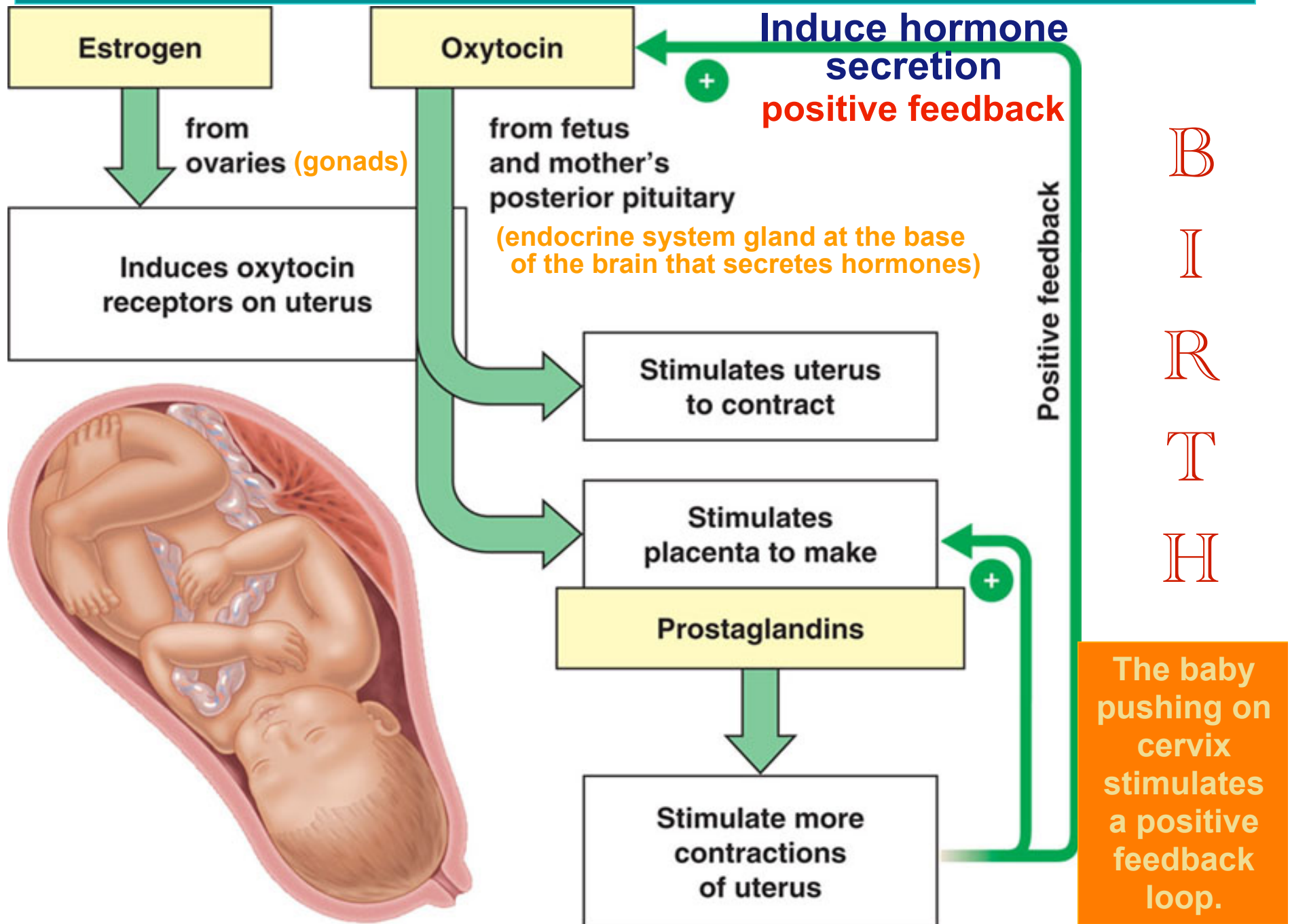
Getting crowded in there!!

- 32 weeks (8 months)

The fetus sleeps 90-95% of the day & sometimes experiences REM sleep, an indication of dreaming



Hormones = chemical messages which are secreted by cells & travel by blood to target cells

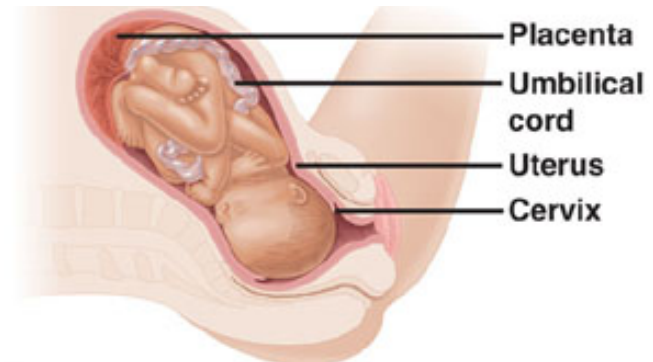


Birth (36-40 weeks)

As it reaches the final stages of development, the fetus and the mother pituitary gland in the brain start to secrete oxytocin.

This secretion causes the muscles of the uterus to begin contracting = LABOR

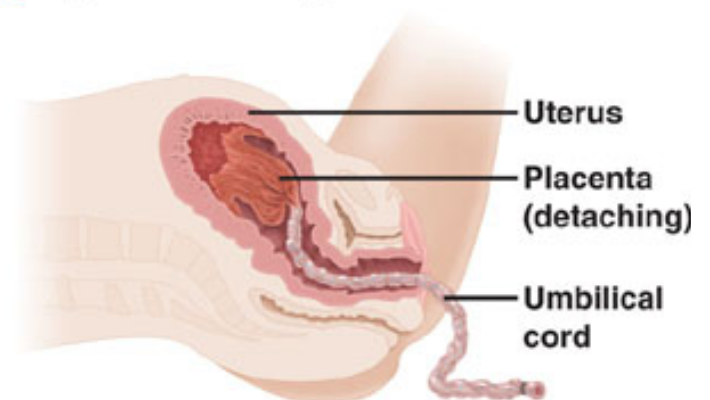
These muscle contractions stimulate the secretion of more oxytocin, which causes more contractions, in an increasingly intense cycle that results in the baby being forced out of the uterus.



1 Dilation of the cervix



2 Expulsion: delivery of the infant



3 Delivery of the placenta

The end of the journey!



And you think
9 months of
Bio is hard!