

Animal Reproduction

Cellula e Cellula

- Cells divide to reproduce

I. Asexual Reproduction

offspring from single parent
(daughter cells have identical DNA as parent cell)

II. Sexual Reproduction

offspring from union of egg and sperm
(combine some DNA from both parent cells)
→ genetically varied offspring)



Budding Hydra



Sperm cells and egg cell

Biological Benefits of Asex

1. Eliminate problem to locate, court, & retain suitable mate.
2. Much greater population growth rate.
3. Avoid “cost of meiosis”:
 - genetic representation in later generations isn't reduced by half each time
4. Preserve gene pool adapted to local conditions.

Asexual Reproduction:

Fission / Budding

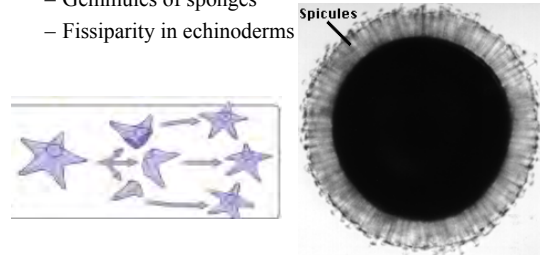
- Divide in two
 - protozoans, polyps, flatworms



Asexual Reproduction:

Clonal Fragmentation

- Adult breaks apart; pieces form new adults
 - Gemmules of sponges
 - Fissioniparity in echinoderms



Asexual Reproduction:

Parthenogenesis

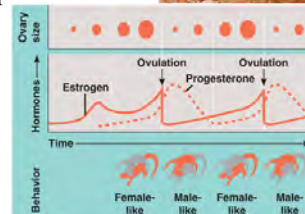
- Eggs develop w/o fertilization
 - some rotifers, fish, crustaceans, insects, & lizards.
- *Obligatory*
 - Whiptails
- *Facultative*
 - Snakes
 - Aphids



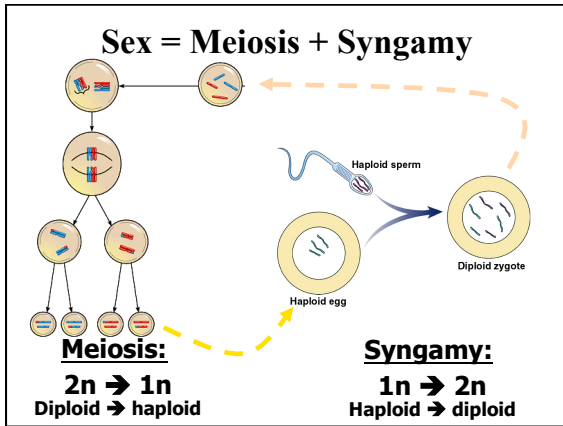
Whiptails — *Cnemidophorus uniparens*

Parthenogenesis

- Derived parthenogenesis & pseudocopulation in whiptail lizards

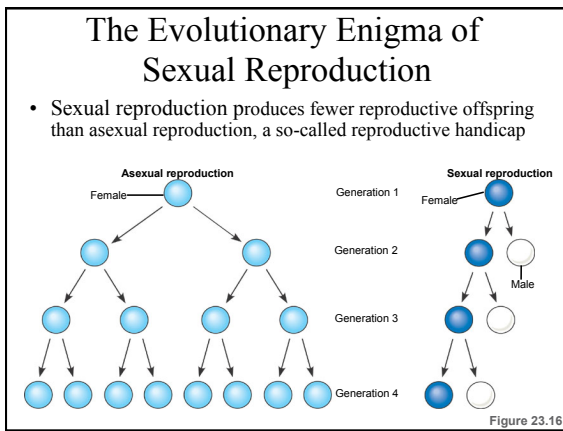


Animal Reproduction



Sexual Reproduction Produces Genetic Variation

- Variation arises from
 - Independent chromosome assortment in meiosis
 - Crossing-over between homologous chromosomes in meiosis
 - Random process of fertilization



Biological Benefits of Sex

- Reinforcement of social structure
- Variability in face of changing environment.
 - why buy four lottery tickets w/ the same number on them?

Relative benefits: Support from organisms both asexual in constant & sexual in changing environments

- aphids have wingless female clones & winged male & female dispersers
- ciliates conjugate if environment is deteriorating

Monoecious sex:

both sexes in one individual (Hermaphroditic)

- Advantageous if limited mobility and sperm dispersal and/or low population density
 - Guarantee that any member of your species encountered is the “right” sex
- Self fertilization still provides some genetic variation
- Or prevent self-fertilization by
 - copulation
 - producing sperm or eggs at different times

sponges, flatworms, snails, earthworms

Simultaneous sperm exchange


Dioecious: separate sexes

- Gametic sex determination
 - Heterogenic male determination (XY male; XX female)
 - Heterogenic female determination (ZW female; ZZ male)
 - Haplotypic male determination (XO male; XX female)
- Environmental determination
 - Temperature
 - Intrauterine position

Animal Reproduction


External Fertilization

- Only in water
 - gametes must be moist.
- Gamete release is synchronized.
 - **Broadcast spawning**
 - **Courtship spawning**



External Fertilization — Broadcast Spawning

- Esp. sessile marine inverts
 - larval mortality is very high.
- Release in response to:
 - smell of other gametes
 - environmental cues
 - Palolo Worm
- Make buoyant to concentrate at surface



External Fertilization — Courtship Spawning


- In fish & some marine inverts
- Behaviors stimulate gamete release
- Produce fewer eggs but add in parental care
 - it's a balance of investment strategy



Internal Fertilization


- Terrestrial forms need internal fertilization so gametes don't dry out
- Decreases energy spent on sperm production
- Ensure large amounts of *your* sperm are on target
- Allow females to store concentrated sperm

- **Spermatophores** are sperm packages
 - spiders, frogs
- **Adpressed Cloacas**
 - birds lack intromittive organs

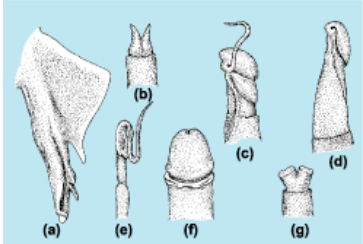


Copulatory Organs

- Legs
 - squids & spiders
- Claspers
 - sharks & rays
- Penises
 - insects
 - turtles, crocodiles
 - lizards, snakes w/ **hemipenes**
 - marsupials w/ bifurcated penis
 - eutherian mammals w/ penis & **baculum**.

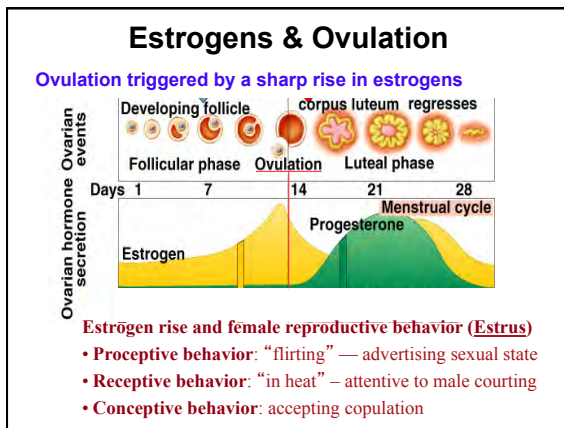
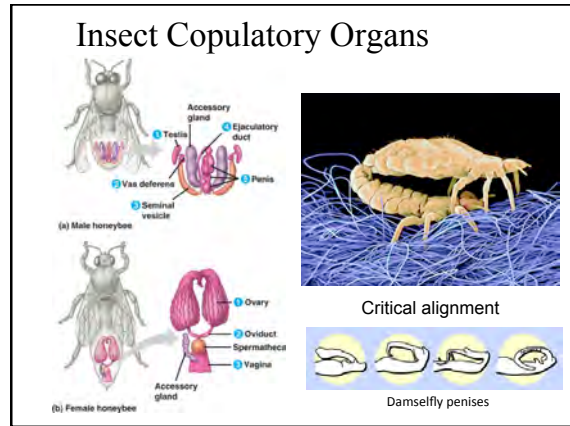
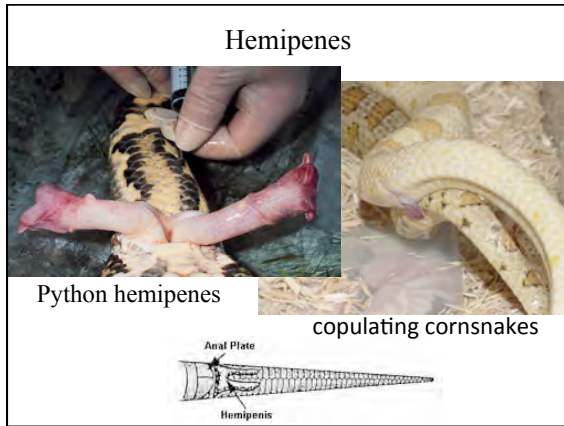


Copulatory organs of sharks & mammals



- Vertebrate copulatory organs. (a) Clasper of dogfish (*Squalus*).
- Glans penis of (b) opossum, (c) ram, (d) bull, (e) short-tailed shrew, (f) man, (g) Echidna.

Animal Reproduction



Oviparity: Egg Laying

- Yolk w/ protein & fats
 - Energetically *very* expensive!
- Protective Coating
 - jelly-like substance in aquatic forms
 - earthworm's cocoon
 - horny egg case of some sharks
 - calcareous or leathery shell of birds & reptiles

Continued Parental Investment

- Nest guarding
- Brooding
- **Resource allocation**
 - Less energy spent on egg production
 - Use energy insuring development of fewer offspring
 - Often, females spend energy on egg production
 - Males do the parental care

Ovoviviparity: Retain Eggs Internally

- “Mobile nest”
- Keeping eggs warmer speeds development.
 - Cold climate reptiles retain eggs rather than laying them.

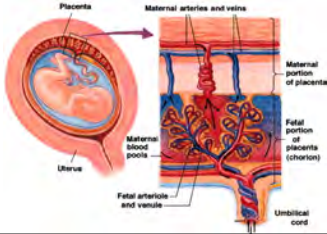
Dogfish shark “candle” from female’s uterus

“Candle” opened to show small embryos with large yolk

Animal Reproduction

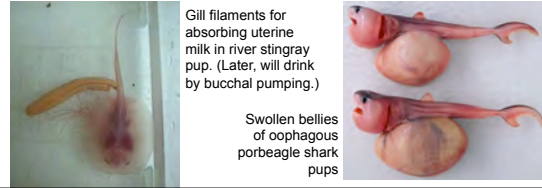
Viviparity: Maternal Nourishment

- **Maternal Nourishment**
 - Spreads maternal energy demand over longer time period
 - Allows embryo to grow beyond original egg size
- **Placenta** connects embryo to mother for nutrition & gas exchange.
 - Placental mammals
 - Reptiles (rattlesnakes & sea snakes)
 - Fish (sharks, guppies, surf perch)



Viviparity: Maternal Nourishment

- **Maternal Nourishment**
 - Spreads maternal energy demand over longer time period
 - Allows embryo to grow beyond original egg size
- **Aplacental viviparity: intra-uterine feeding.**
 - “Uterine milk” – rays
 - Oophagy (& adelphophagy!) – mackerel sharks



Delayed Fertilization & Delayed Implantation

	AUTUMN	WINTER	SPRING
(a) Hedgehog			MF G B
(b) Red deer	MF	G	B
(c) Badger	MF	3-9 mo. Delayed implantation	G B
(d) Noctule bat	M	7 mo. Delayed Fertilization	F G B

- How the reproductive cycles of four mammals native to Britain are related to the winter.
 - Figure 1.2 Reproductive cycles of (a) hedgehog, (b) red deer, (c) badger and (d) noctule bat, in relation to the winter.
 - M=mating; F=fertilization of the egg(s); G=gestation; B=birth.

Aphids — a little bit of everything!

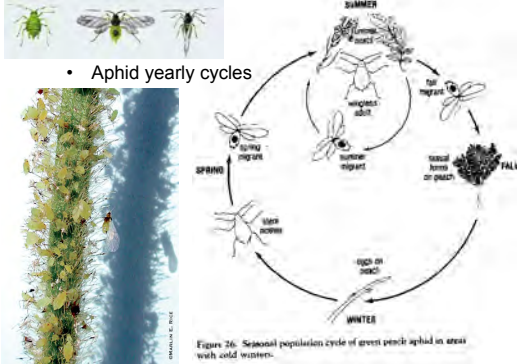
1. **Asexual** (parthenogenic) **viviparity**
 - And “telescoping generations” (born pregnant!)
2. Seasonally alternating with a dioecious generation having:

Sexual oviparity

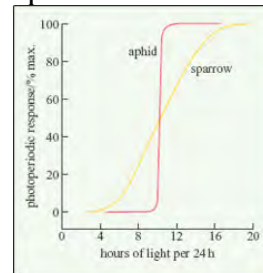


- Parthenogenic live birth (all females)
- And the baby being born already has a baby!

Aphids — a little bit of everything!




Photoperiod & Seasonal Sex



- Figure 1.1 Critical photoperiodic responses in two species: transition from sexual to asexual reproduction in the vetch aphid (*Megoura viciae*) and testicular development in the white-crowned sparrow (*Zonotrichia leucophrys*).

Animal Reproduction

Human Reproduction



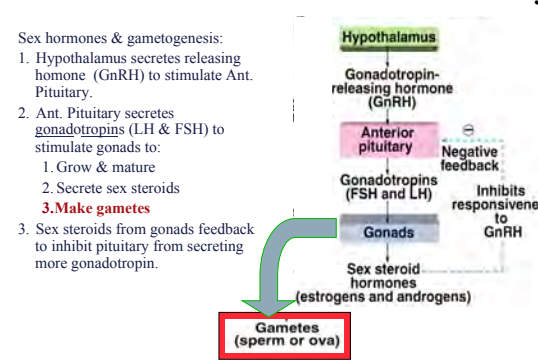
Reproductive Anatomy

- Gonads — make gametes
 - ›Female: ovaries — make ova
 - ›Male: testes — make sperm
- Sexual Accessories — ducts
 - ›Female: oviducts [fallopian tubes] / uterus / vagina
 - ›Male: epididymus / vas deferens
- Genitalia — external
 - ›Female: clitoris / labia minora / labia majora
 - ›Male: penis / scrotum
- Secondary sexual characteristics
 - ›Female: enlarged breasts & mammaries / broad pelvis / ↑ cutaneous fat
 - ›Male: ↑ muscle & skeletal mass / beard

Feedback Control of the Anterior Pituitary

Sex hormones & gametogenesis:

1. Hypothalamus secretes releasing hormone (GnRH) to stimulate Ant. Pituitary.
2. Ant. Pituitary secretes **gonadotropins** (LH & FSH) to stimulate gonads to:
 1. Grow & mature
 2. Secrete sex steroids
 3. **Make gametes**
3. Sex steroids from gonads feedback to inhibit pituitary from secreting more gonadotropin.



Spermatogenesis

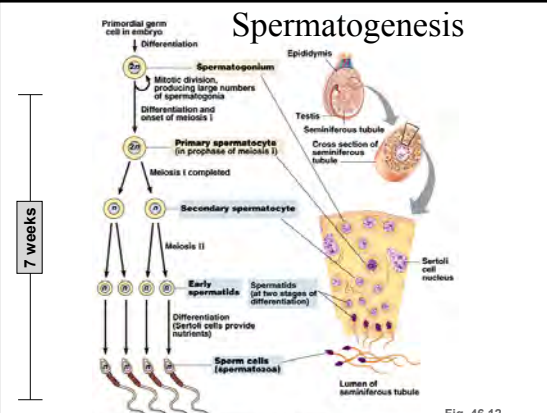
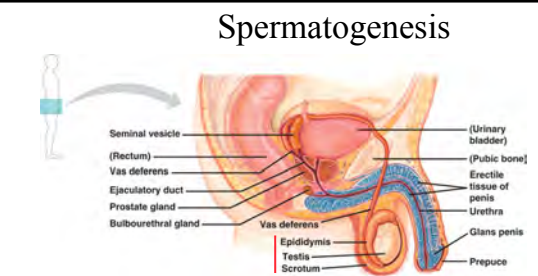


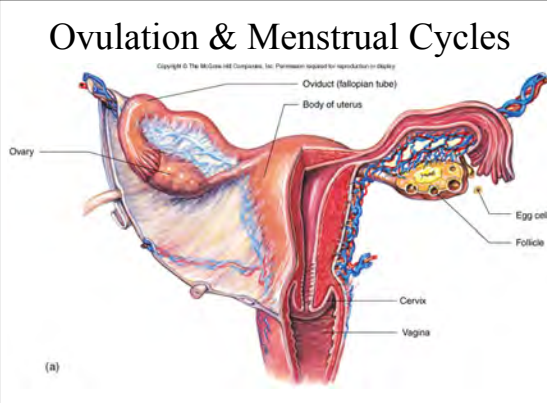
Fig. 46.12

Spermatogenesis



- From seminiferous tubules, sperm pass to **epididymis**
 - Mature for another 3 weeks
 - Become motile
 - Non-ejaculated sperm reabsorbed

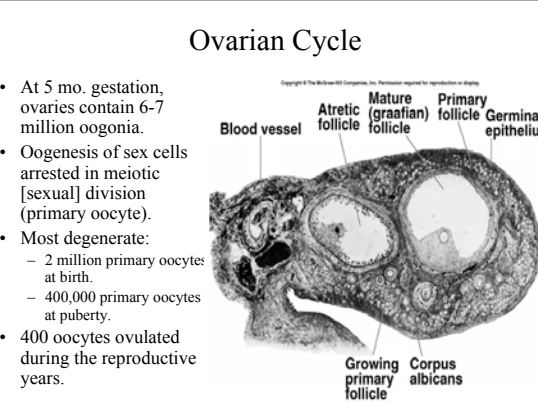
Ovulation & Menstrual Cycles

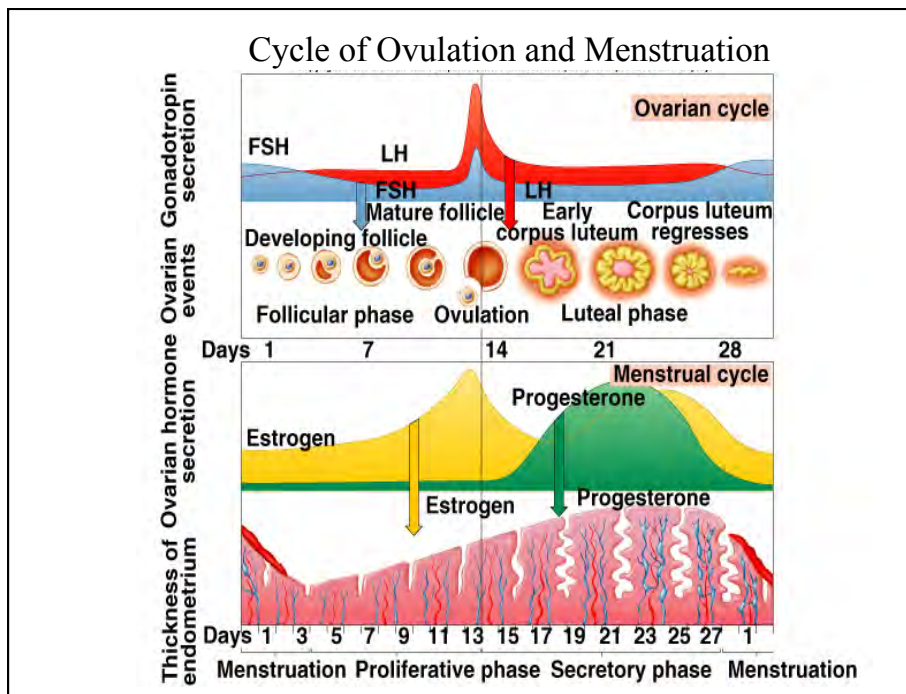
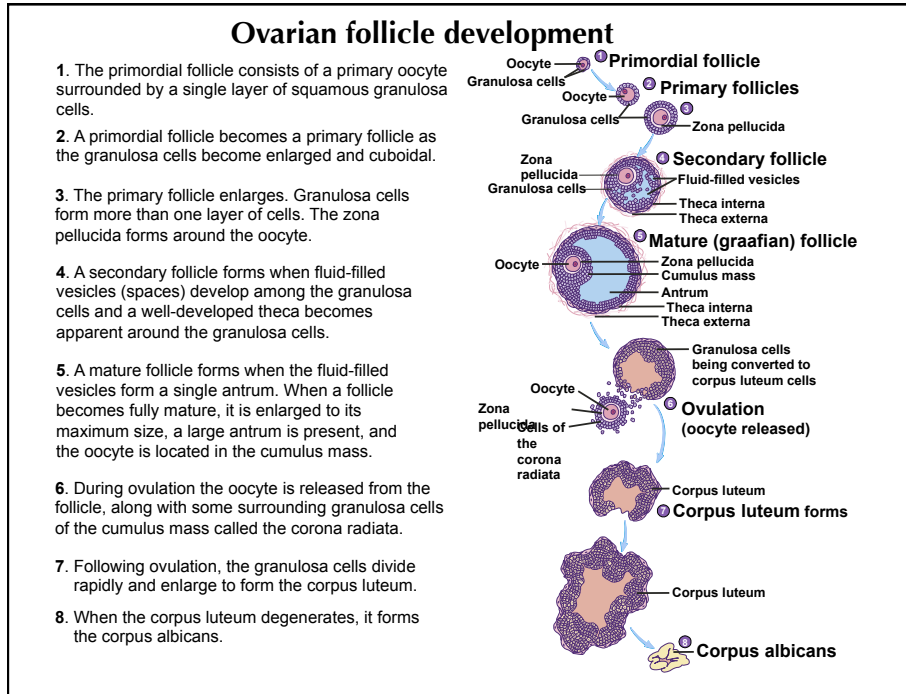


(a)

Ovarian Cycle

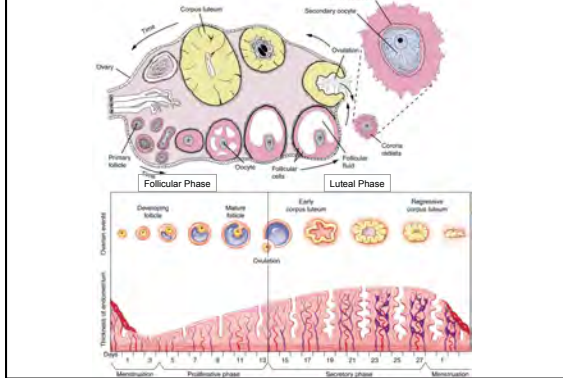
- At 5 mo. gestation, ovaries contain 6-7 million oogonia.
- Oogenesis of sex cells arrested in meiotic [sexual] division (primary oocyte).
- Most degenerate:
 - 2 million primary oocytes at birth.
 - 400,000 primary oocytes at puberty.
- 400 oocytes ovulated during the reproductive years.





Animal Reproduction

Ovarian Cycle drives the Uterine Cycle



Menstrual Cycle

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

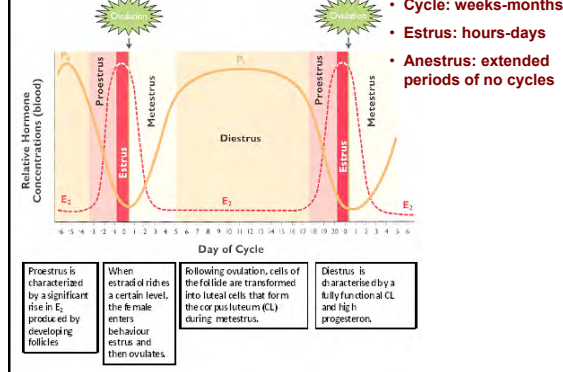
Table 20.6 Phases of the Menstrual Cycle

Phase of Cycle	Endometrial	Follicular	Hormonal Changes	Ovary	Tissue Changes
Ovulation	Menstrual	Flutary	FSH and LH secretion low	Estradiol and progesterone remain low	Over two-thirds of endometrium is shed with accompanying bleeding
Follicular (days 1-4)	Menstrual	Flutary	FSH and LH secretion low	Estradiol and progesterone remain low	Over two-thirds of endometrium is shed with accompanying bleeding
Follicular (days 5-13)	Proliferative	Proliferative	FSH slightly higher than LH secretion in early follicular phase	Estradiol secretion rises (due to FSH stimulation of follicles)	Mitotic division increases thickness of endometrium; spiral arteries develop (due to estradiol stimulation)
Ovulatory (day 14)	Proliferative	Proliferative	LH surge (and increased FSH) stimulated by positive feedback from estradiol	Estradiol secretion falls	Granulosa follicle ruptures and secondary oocyte is extruded into uterine tube
Luteal (days 15-28)	Secretory	Secretory	LH and FSH decrease (due to negative feedback from steroids)	Progesterone and estrogen secretion increases, then fall	Development of corpus luteum (due to LH stimulation); regression of corpus luteum

Menstrual vs. Estrous Cycles

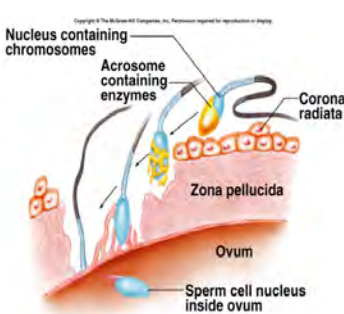
- Human – menstrual (“monthly”) ~28 days
 - Day 1 = first day of menses
 - Menses → follicular phase → luteal phase → menses
- Non-human mammal – estrous cycle
 - Length varies by species
 - Less endometrial thickening – reabsorbed instead of shed
 - No menses
 - Day 1 = first day of estrus
 - (proceptive/receptive/conceptive behaviors)
 - Estrus → luteal phase → follicular phase → estrus

Estrous Cycles

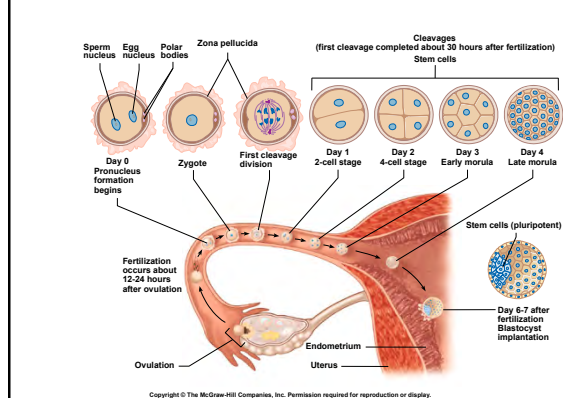


Fertilization

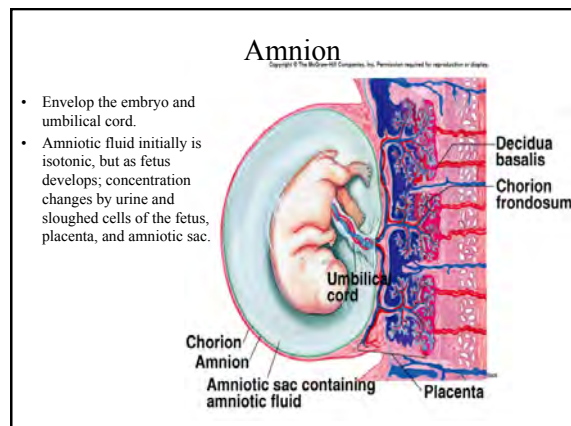
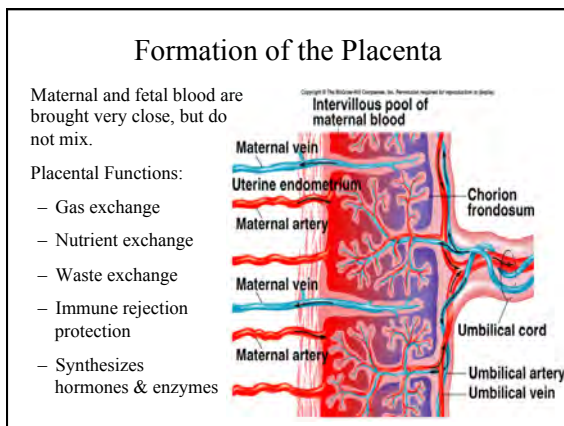
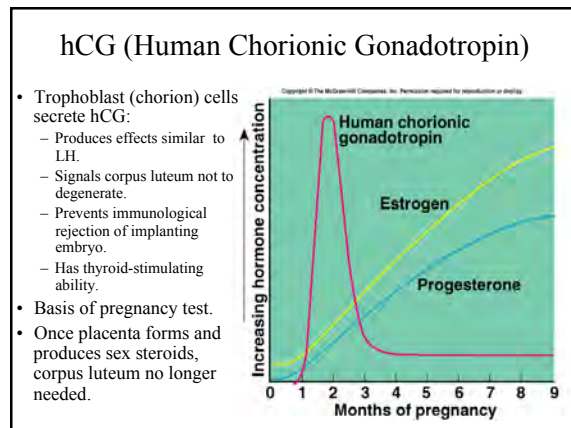
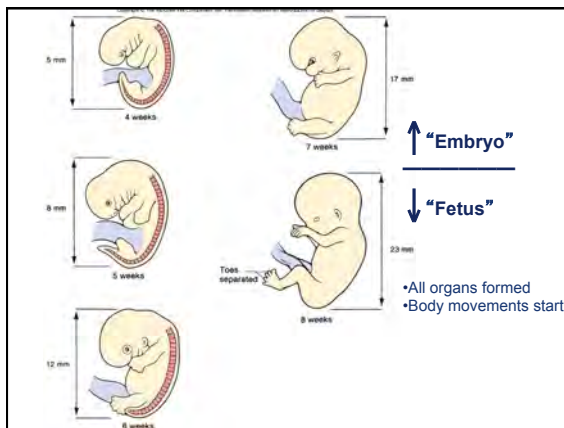
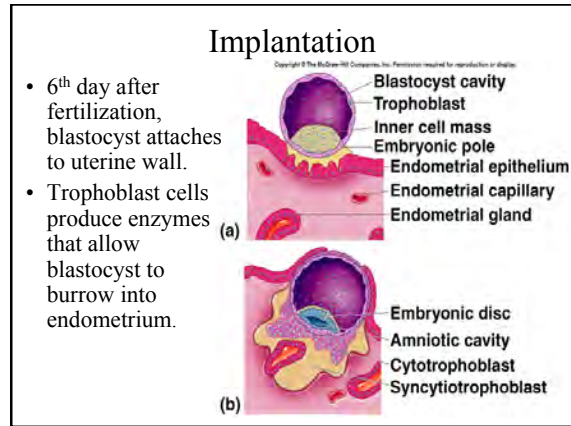
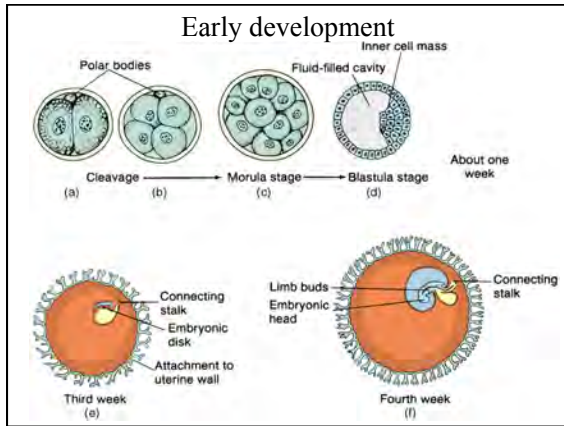
- Ejaculation 300 million sperm, 100 reach (uterine) fallopian tube.
 - Capacitation occurs.
 - Fertilization occurs in the uterine tubes.
- Acrosome of sperm contains hyaluronidase, an enzyme that digests a channel through zona pellucida.
 - Sperm fuses with ovum cell membrane.



Stages of early human development



Animal Reproduction



Animal Reproduction

Other Placental Hormones

Sex steroids — replace role of corpus luteum

1. Progesterone
2. Estrogens — from fetal-placental unit
 - Placenta uses androgens from fetal adrenal cortex as precursors for estriol.

Other Placental Hormones

Sex steroids — replace role of corpus luteum

- Progesterone + Estrogens
- Enlargement of mother's uterus and endometrial growth, but inhibit contractions.
- Growth of mammary glands & ducts, but inhibit prolactin secretion (milk production).
- Suppresses LH and FSH (stop ovulating).

Parturition

- Estrogen in late pregnancy:
 - Stimulates production of oxytocin & prostaglandin receptors in myometrium.
 - Produces gap junctions between myometrium cells in uterus.
- Factors responsible for initiation of labor are incompletely understood.

Chromosomal Sex and Development of Embryonic Gonads

Development of Accessory Sex Organs and Genitalia

- Presence or absence of testes determines the accessory sex organs and external genitalia.
- Male accessory organs derived from wolffian ducts.
 - Sertoli cells secrete MIF (mullerian inhibition factor).
- Female accessory organs derived from mullerian ducts.

Development of Genitalia