Reproduction:

Methods of reproduction:

- asexual. This only involves a single animal, and the genes of the offspring all come from the parent (without going through sperm/egg fusion).

- sexual. Involves fusion of egg and sperm to develop a zygote. A zygote is the cell that results from fusion of egg and sperm.

Asexual:

- fission - the parent splits into two more or less equal halves. Each half then goes on to grow and mature.

- budding - generally similar, but here the parent may bud off new individuals that are smaller than parent. This new individual may remain attached, or separate.
  - corals (cnidarians) - young stay attached.
  - hydra (also cnidarians) - young detach.

- fragmentation - the body breaks into several pieces, each of which can form a new individual. [This does not include merely re-growing limbs (or tail)]. Starfish example.

Some animals may reproduce both sexually and asexually. Corals again are a good example.

In general, sexual reproduction is used during more stressful times, and asexual reproduction when times are good (why?).

Parthenogenesis:

- Egg develops without being fertilized. Resulting individual may be haploid or diploid, depending on whether or not haploid egg doubles before developing.

- occurs in many animals, e.g. Rotifers, Daphnia, and whiptail lizards.

Sexual reproduction - obviously, fertilization is required. Sperm must meet up with and fertilize egg.

- problem for sessile organisms. How to transport sperm?? E.g., tapeworm.

- one solution -> hermaphroditism. A hermaphrodite has both female and male reproductive structures. This makes it easier to find a mate. Also, since two individuals can exchange sperm, potentially twice as many offspring can be produced (though this is really a bit more complicated than that!!).
- sequential hermaphroditism. Some fish can change sex during lifetime. This depends on whether large size may be an advantage - e.g. in some fish males defend territory, so they need to be larger. Just be aware that this exists.

- methods of fertilization:

  - external - union of sperm and egg occurs outside the body. Typically, eggs are released by the female, then the male covers the eggs with sperm. Many animals will do this (frogs, many fish, etc.)

  - internal - sperm are deposited in or near the female reproductive tract, and fertilization occurs within the female reproductive tract.

  - note: many mechanisms are in place to insure that mating takes place only within the same species - behavior, pheromones, environmental cues

- for vertebrates (and some others), we can consider the following breakdown as well:

  - oviparous - animal lays egg, embryo develops within egg, egg hatches.

  - viviparous - animal develops inside body of mother, AND gets nutrients from mother. Typically, mammals, and just possibly a few reptiles.

  - ovoviviparous - animal develops inside egg (or similar structure), but the egg is retained in female body until young has developed. Many reptiles and some fish (e.g., sharks) do this.

Reproductive systems, some general comments:

- gonads - organs that produce gametes.

- complexity of reproductive system can vary much over the animal kingdom.

Human reproductive system:

Male system:

- externally, consists of scrotum and penis.

- internally [2 OVERHEADS, fig. 27.4 A & B, p. 538]:

  - sperm forms in the testes. But, body temperature is too high for normal formation of sperm, so the testes must be kept outside body (in the scrotum, which is about 2 degrees colder than the body).

  - in many animals, testes don't descend except during the
breeding season. In a few, body temperature seems to be low enough.

- epididymis - from the testes, sperm move into the epididymis. This is basically a coiled tube. Sperm are matured and stored here. It takes about 20 days for sperm to move through the epididymis.

- vas deferens - during ejaculation, sperm are moved from the epididymis into the vas deferens. The vas deferens joins a short duct coming from:

- seminal vesicles - these contribute volume, but also fructose (energy) and other items (mucus, enzymes, ascorbic acid, and prostaglandins).

- the duct from the seminal vesicles joins that from the vas deferens, forming a short ejaculatory duct, which then runs into the urethra (urethra is coming from bladder).

- prostate gland - a large gland at the base of the bladder. The ejaculatory duct and urethra join up within gland. This contributes more anticoagulant enzymes, and some more nutrients.

- This causes the most common medical problem in men over age 40, and enlarges in about half these cases - almost all men over 70 have enlarged prostates - usually this is noncancerous, but obviously needs to be checked.

- bulbourethral glands - secrete a clear mucus before ejaculation. This also helps neutralize any leftover acidity from urine. Bulbourethral fluid often also contains some sperm, which contributes to the failure of the "withdrawal method".

- Overall, semen that is finally ejaculated has the following properties:

- it is slightly basic, which helps neutralize the acidity in the female reproductive tract.

- contains anticoagulants which help keep the sperm liquid in later stages.

- prostaglandins thin the mucus at the opening to the uterus, and then help stimulate contractions of the uterus to move sperm further into the female reproductive tract.

Female reproductive system [2 OVERHEADS, fig. 27.3A & C, p. 536 - 537].

- externally consists of the clitoris, and two sets of labia around the clitoris
and the opening to the vagina (& urethral opening).

- internally (working from inside out):

  - ovaries - female gonads. These lie in the abdominal cavity. Each ovary contains follicles.

  - follicles - consist of an egg and numerous “supporting cells”. All follicles will have developed before birth.

  - after puberty, one follicle matures and releases it's egg during each menstrual cycle. The cells of the follicle are also responsible for producing estrogen (which means that the levels of estrogen vary throughout the menstrual cycle).

  - ovulation - this is the process of releasing eggs into the fallopian tubes (or oviducts).

  - the follicle then develops into a "corpus luteum". This maintains the hormones necessary for the maintenance of the uterine lining. If the egg is not fertilized, then this disintegrates, and obviously hormone levels then drop.

  - cilia lining the oviduct help move the egg into the oviduct, and also transport the egg from the oviduct into the uterus.

  - Uterus - a thick, muscular organ that can expand and hold the fetus as it develops. The inside lining (endometrium) is highly vascularized. The uterus opens into the:

    - Cervix - a constricted area at base of uterus that connects to the vagina.

Development of secondary sexual characteristics at puberty:

- males - androgens, primarily testosterone:

  - development of facial, pubic hair, muscle growth, deepening voice, etc. [Note that the primary sexual characteristics are also controlled by these hormones (e.g, the vas deferens, structures, etc.).]

- females - estrogen:

  - development of breasts, change in distribution of body fat, broadening of the pelvis.

- Note: this process is not yet well understood.
Female reproductive cycle (males don't really have one (or at least, it's not well understood (but see p. 539 - essentially FSH & LH work to stimulate sperm production))).

- most mammals: have an estrous cycle. This differs from menstrual cycle in that a most of the uterine lining is reabsorbed if there is no pregnancy (but there’s always a trade-off: hormonal changes are generally more pronounced).

- humans - menstrual cycle [Fig. 27.6, p. 543]:
  
  - usually, first day of menstruation is considered "day 1".
  
  - when flow ends, 3-4 days later (varies), uterine lining is very thin, and no ripe follicles are in the ovaries.
  
  - FSH (Follicle stimulating hormone) is produced by the pituitary - this simulates follicle production.
  
  - Together with LH (Lutenizing hormone), this causes the follicles to release estrogen.
  
  - Eventually, one follicle becomes "dominant"; this causes the others to stop growing. Estrogen stimulates the thickening of the uterine lining.

  [ This phase usually lasts 9-10 days]

  - The high level of estrogen then causes a surge in LH production from the pituitary. This LH surge triggers ovulation (at this point, the follicle is “mature”).
  
  - The Follicle then stops growing. LH then induces the follicle to change into a Corpus luteum.
  
  - The corpus luteum continues to release estrogen, though at slightly reduced levels.
  
  - This also secretes progesterone. Progesterone changes the surface of the uterus to allow for implantation.
  
  - Progesterone also seems to limit FSH and LH production (thus inhibiting the next ovulation cycle (this is the mechanism behind some birth control pills)).
- If no fertilization occurs, the corpus luteum begins to disintegrate (after about 11 days).

- Progesterone levels fall, the uterine lining can't be maintained, and LH and FSH production is restored. Some of the lining is reabsorbed, the rest is sloughed off and the cycle is over (or better, “starts over”).

Summary (use a non-proportional font if it doesn’t look right):

FSH & LH --> follicle production ---
       |-------- estrogen production <-
       |----- growth of uterine lining,
       |       eventually LH surge

LH surge --> ovulation --> release of egg.
       |----> follicle develops into Corpus luteum.

Corpus luteum --> progesterone --> prepares &
       |        maintains
       |        uterus
       |        lining.
       |----> suppresses LH &
       |        FSH production.

Corpus luteum disintegrates, so above pathway stops. Uterine lining is lost, FSH and LH production start up again.

(If fertilization occurs, Corpus luteum is maintained).

(A few details, for example, exactly how LH surge is caused seem to be different depending on which book you read).

Pregnancy -

- causes the growth of the placenta (corpus luteum does not disintegrate), ovulation stops, breasts enlarge.

- placenta is the place of exchange for nutrients and gases between fetus and mother. Note that there is no direct exchange of fluid between the mother and young [Fig., not in book, but see 27.15F,
- high levels of estrogen will also cause the formation of oxytocin receptors in the uterus. Oxytocin is produced by both the mother and the fetus. This eventually will cause the placenta to secrete prostaglandins, which together with oxytocin then stimulates contractions of the uterus [Fig. 27.17A, p. 558].

- a couple of comments about the immune system:

  - mechanisms are in place that prevent the mother's immune system from attacking the fetus (remember that half of the fetus’ genes are from the father - this could potentially cause an immune response).

  - Much of the immunity for infants is provided through breast milk.

  - one of the reasons breast feeding has become the norm again (after decades of “formula” and bottle feeding).

Inflammations, various infectious diseases and stomach problems are much less common in infants that are breast fed - immunity is transferred through the milk.