Mechanisms

- Asexual reproduction involves only one parent.
  - There are no special reproductive organs or cells involved.
  - Genetically identical offspring are produced.
  - Production of offspring is simple, direct and rapid.

Asexual Reproduction: Reproduction Without Gametes

- Neither eggs nor sperm are involved
- Unless mutations occur, all offspring have the same genotype and are clonal.
- Asexual reproduction is widespread in bacteria, unicellular eukaryotes and many invertebrate phyla.
- Asexual reproduction ensures rapid increase in numbers

Types of Asexual Reproduction

- **Binary fission** is common among bacteria and protozoa.
  - The parent divides by mitosis into two parts; each grows into an individual similar to the parent.
  - Binary fission can be lengthwise or transverse.
  - In **multiple fission**, the nucleus divides repeatedly; cytoplasmic division produces many daughter cells.
  - **Sporogony** is spore formation, a form of multiple fission in parasitic protozoa.

- **Budding** is unequal division of an organism.
  - The bud is an outgrowth of the parent; it develops organs and then detaches.
  - Budding occurs in cnidarians and some other animal phyla.
Other types of Asexual Reproduction

- **Gemmulation** is formation of a new individual from an aggregation of cells from the parent individual surrounded by a resistant capsule (gemmule).
  - Freshwater sponges survive winter in the dried or frozen body of the parent.
  - In good conditions, the enclosed cells become active, emerge and grow a new sponge.
- **Fragmentation** involves a multicellular animal breaking into many fragments that become a new animal.

Sexual Reproduction: Reproduction With Gametes

- **Bisexual Reproduction**
  - Also called biparental, bisexual reproduction produces offspring from union of gametes from two genetically different parents.
  - Offspring therefore have a genotype different from either parent.
  - Generally individuals are male or female and produce spermatozoa or ova, respectively.
    - The female produces the ovum; it is large with stored yolk and is nonmotile.
    - The spermatozoon is produced by the male; it is small, motile and much more numerous.

Bisexual Reproduction

- Most vertebrates and many invertebrates have separate sexes; they are dioecious.
- **Meiosis** (duplication and two divisions) produces four haploid cells.
- In **fertilization**, two haploid cells combine to restore the diploid chromosome number in the zygote.
- A **zygote** divides by mitosis for all somatic (body) cells.

Not all species produce distinct sexes

- Many unicellular organisms can reproduce both sexually and asexually.
- When sexual parents merely join together to exchange nuclear material (conjugation), distinct sexes do not occur.
- Organs that produce germ cells are gonads; testes produce sperm and ovaries produce eggs.
- **Gonads** are primary sex organs; some animals lack any other “accessory” sex organs.

Hermaphroditism

- Some animals have both male and female organs; they are monoecious or hermaphrodites.
  - Many sessile, burrowing and/or endoparasitic invertebrate animals and a few fish are hermaphroditic.
  - Most avoid self-fertilization and exchange germ cells with another member of the same species.
  - Each individual is reproductive, in contrast to dioecious species where about half is male.
  - In sequential hermaphroditism, a fish starts life as one sex and is genetically programmed to change to the other sex later.

Parthenogenesis

- **Parthenogenesis** is the development of an embryo from an unfertilized egg.
  - The male and female nuclei may fail to unite after fertilization.
  - In **ameiotic parthenogenesis**, no meiosis occurs and the egg forms by mitotic division.
  - In **meiotic parthenogenesis**, the haploid ovum is formed by meiosis and develops without fusion with the male nuclei.
    - 1) Sperm may be absent or they may only activate development.
    - 2) In some species, the haploid egg returns to a diploid condition by chromosomal duplication.
Parthenogenesis
- Some desert lizards have modified meiosis so offspring are clones of the female parent.
- Parthenogenesis avoids the energy and dangers of bringing two sexes together; but it narrows the diversity available for adaptation to new conditions.

Haplodiploidy
- Occurs in bees, wasps and ants.
  1) The queen controls whether the eggs are laid fertilized or unfertilized.
  2) Fertilized eggs become female workers or queens; the unfertilized eggs become drones.

Why do so many animals reproduce sexually rather than asexually?
- The costs of sexual reproduction are greater.
  1) It is more complicated, requires more time and uses more energy than asexual.
  2) The cost of meiosis to the female is passage of only half of her genes to offspring.
  3) Production of males reduces resources for females that could produce eggs.
- Asexual organisms can have more offspring in a short time to colonize new environments.

Benefits to Sexual Reproduction
- Sexual organisms produce more novel genotypes to survive in times of environmental change.
- In crowded habitats, selection is intense and diversity prevents extinction.
- On a geological time scale, asexual lineages with less variation are prone to extinction.
- Many invertebrates with both sexual and asexual modes enjoy the advantages of both.

Origin and Maturation of Germ Cells
- Somatic cells are non-reproductive body cells; they differentiate, function and die before or with the animal.
- Germ cells form gametes; the germ cell line provides a continuous line between generations.
- Somatic cells support, protect and nourish the germ cell line.
- The germ cell lineage may be traceable; in some invertebrates, the germ cells develop from somatic cells.

Migration of Germ Cells
- Vertebrate gonads arise from a pair of genital ridges that grows into the coelom from the dorsal coelomic lining on each side of the hindgut near the anterior end of the kidney.
- Primordial germ cells themselves arise from yolk-sac endoderm, not the developing gonad.
- Germ plasm from the vegetal pole of the uncleaved egg mass moves to gut endoderm and migrates by ameboid movement to genital ridges.
- Germ cells divide first by mitosis, increasing from a few dozen to several thousand.
Sex Determination

- Originally gonads are sexually indifferent.
- In human males, SRY (sex determining region Y) on the Y chromosome organizes the gonad into a testis.
- Formed as a testis, it secretes testosterone which, with dihydrotestosterone (DHT), masculinizes the fetus; causing development of a penis, scrotum and male glands.
- In the brain, testosterone is enzymatically converted to estrogen, which determines brain organization for male-typical behavior.
- A region of the X chromosome named DDS (disease sensitive sex reversal) or SRVX (sex reversing X) can promote ovary formation.
- However, absence of testosterone in a genetic female embryo promotes development of female sexual organs: vagina, clitoris and uterus.
- Despite levels of estrogen, the female brain does not become masculinized perhaps due to low estrogen receptors.

Genetics of sex determination vary

- XX-XY
- XX-XO
- Haploidy
- Temperature
- Others

Reproductive Patterns

Live-birth Versus Egg-bearing

- Ovoviviparous animals retain eggs in their body.
  - Essentially all nourishment is derived from the yolk.
  - This is common in some invertebrate groups and certain fishes and reptiles.
  - Fertilization is internal.
- Viviparous animals give birth.
  - Eggs develop in an oviduct or uterus.
  - Embryos continuously derive nourishment from the mother.
  - Fertilization is internal.
  - This occurs in mammals and some fishes; it provides more protection to offspring.