Many plants and other organisms depend on sexual reproduction.

Flowers are the sexual reproductive organ systems of angiosperms.

**Sexual reproduction**

**gametes**

All plants produce naked (wall-less) sperm and egg cells like animals.

**zygote**

If conditions are favorable, the zygote may develop into an adult organism.

The life cycle is then completed.

Sexual reproductive cycles of eukaryotes require **meiosis**.

**Meiosis**

Animals, including humans, have a life cycle in which gametes (sperm and egg) fuse to form zygotes.

Zygotes combine the chromosomes of egg (N) and sperm (N), and thus have 2N chromosomes.

Gametes are produced as the results of meiosis.

The chromosome number is reduced by one-half.
Sexual reproduction in eukaryote is characterized by gametes, a zygote, and meiosis.

**Meiosis, the Basis of Sexual Reproduction**

Sexual reproduction does not produce genetically identical replicas of the parents.

In sexual reproduction, each offspring inherits a unique combination of genes from its two parents.

As a result, sexual reproduction can produce great variation among offspring.

**The Process of Meiosis**

**Meiosis I**
- **Interphase**
  - Chromosomes duplicate
  - Homologous chromosomes pair and exchange genetic material
- **Prophase I**
  - Pairing of homologous chromosomes
- **Metaphase I**
  - Tetrads line up
- **Anaphase I**
  - Pairs of homologous chromosomes split up
  - Chromosomes are still double (sister chromatids are still not separated)
- **Telophase I**
  - Two haploid cells form; chromosomes are still double (sister chromatids are still not separated).

**Meiosis II**
- **Prophase II**
  - Chromosomes are not duplicated
- **Metaphase II**
  - Chromosomes line up in the center of the cells
- **Anaphase II**
  - Sister chromatids are pulled to the poles of the cells
- **Telophase II**
  - Four haploid daughter cells result with single chromosomes.

End result:
- **4 haploid cells**
The Process of Meiosis

The number of chromosomes are halved, so each of the four daughter cells resulting from meiosis have only half as many chromosomes as the starting cell. Diploid → haploid

Exchange of genetic material between homologous chromosomes.

Meiosis produces gametes with half the number of chromosomes (haploid number, \(N\)) as the parent cell.

The zygote that results from fertilization is then diploid (2N) again.
Asexual reproduction

Offspring produced by asexual reproduction inherit all of their chromosomes from a single parent.

Mitosis

Mitosis (Cell division)

Mitosis and cytokinesis are the basis for population growth of single-celled eukaryotes and body development in multicellular organisms.
Location of mitosis versus meiosis in plants

Mitosis
- produces daughter cells genetically identical to the parent cell.
- involves 1 division of the nucleus
- produces 2 diploid cells

Meiosis
- yields genetically unique haploid daughter cells (cells with only one member of each homologous chromosome pair).
- involves 2 nuclear and cytoplasmic divisions
- produces 4 haploid cells
Sexual reproduction is common among eukaryotes and widely present in:

**Sexual reproduction - disadvantages**

It requires organisms to invest scarce resources and expend considerable energy to produce gametes.

**Sexual reproduction - advantages**

Genetic diversity - sexual reproduction combines the DNA of 2 different organisms (usually of the same species) and produces new combinations of valuable genetic traits.

**Why do so many organisms reproduce asexually?**

*Phytophthora* (plant destroyer), reproduces both sexually and asexually. This protist causes the disease that resulted in the Irish Potato Famine.

*Kalanchoë* reproduces both sexually and asexually, from plantlets on the edge of the leaves.
- all the progeny are genetically alike (well, mostly), so the chances are good that many will survive if the environment is stable and homogeneous.

These advantages explain why asexual reproduction has commonly evolved in nature.

Aspen trees (*Populus tremuloides*)

Dandelions (*Taraxacum officinale*) and related species of hawkweeds (*Hieracium* spp.) are examples of hundreds of plants that reproduce exclusively by seeds formed asexually.
Life cycles link one generation to the next

Asexual organisms

Sexual organisms

Three basic types of sexual life cycles:
- gametic
- zygotic
- sporic

Asexual reproduction - disadvantages
- less genetic diversity than sexual reproduction
Gametic life cycle

The reproductive cycle of humans and other animals is the life-cycle that is probably most familiar to you.

All sexually reproducing modern animal groups have a gametic life cycle
- It arose very early in evolutionary history

Diatom Life Cycle
Zygotic life cycles

-These organisms are haploid during most of their life cycle

Advantages of zygotic life cycles
- Gametes can be produced quickly by mitosis.

When environment conditions improves, zygotes undergo meiosis and produce genetically diverse progeny.

Sporic life cycles

All plants, from bryophytes to flowering plants, as well as some algae, have sporic life cycles known as alteration of generations.

Sporic life cycles involve 2 types of multicellular bodies:

- The plant spores are the products of meiosis.
- Plant gametes are produced as a result of mitosis, rather than meiosis.
Plant groups differ in the relative sizes of the sporophyte and gametophyte.

As land plants evolved, the size of the haploid gametophyte became reduced, while the diploid sporophyte increased in size and became more important.
- Understand sexual reproduction
  Know terms—sexual reproduction, gametes, zygote, meiosis, [haploid (N), diploid (2N)]—Fig. 13.3
  Know general characteristics of sexual reproduction
  - meiosis is the cell division that is associated with sexual reproduction
  - sexual reproduction does not produce genetically identical replicas of parents
  - in sexual reproduction, each offspring inherits a unique combination of genes from its two parents
  - sexual reproduction can produce great variation among offspring

- Understand the process of meiosis
  Know different stages of meiosis as described in Fig. 13.12 IIa-j and overview in lecture.
  Understand that meiosis is essential to sexual reproduction
  - meiosis produces gametes with half the number of chromosomes (haploid, N) as the parent cell
  - diploid \( \rightarrow \) haploid
  - the zygote that results from the fertilization of the two haploid (N) gametes is diploid (2N)
  - meiosis prevents the chromosomes from doubling in every generation

- Understand the process of mitosis
  Know the different stages of mitosis as described in Fig. 13.12 la-f and overview in lecture. If you need further review of mitosis, read Chapter 7—Cell Division—pg. 124-129.

- Understand meiosis versus mitosis
  - Where does mitosis occur in the plant?
  - Where does meiosis occur in the plant?

<table>
<thead>
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<th>Mitosis</th>
<th>Meiosis</th>
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<td>- produces daughter cells genetically identical to the parent cell.</td>
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<td>- produces 2 diploid cells</td>
<td>- produces 4 haploid cells</td>
</tr>
</tbody>
</table>

- Compare sexual and asexual reproduction
  - Sexual reproduction is common in which groups of eukaryotes?
  - What are the disadvantages of sexual reproduction?
  - What are the advantages of sexual reproduction?
  - What are the disadvantages of asexual reproduction?
  - What are the advantages of asexual reproduction?
  - Name some organisms that reproduce asexually.

- Understand the importance of life cycles
  - Know term—life cycle, gametic, zygotic, sporic, sporophyte, and gametophyte
  - What are the general differences between the life cycles of asexual organisms and sexual organisms?
  - Know the three basic types of sexual life cycles—gametic, zygotic, and sporic
  - Be able to recognize and briefly summarize a gametic life cycle—(Fig. 13.14b)
  - In general what types of organisms exhibit a gametic life cycle?

  - Be able to recognize and briefly summarize a zygotic life cycle—(Fig. 13.14c)
  - In general what types of organisms exhibit a zygotic life cycle?

  - Be able to recognize and briefly summarize a sporic life cycle—(Fig. 13.14d)
  - In general what types of organisms exhibit a sporic life cycle?
  - What are the main differences between gametic and sporic life cycles?
  - As land plants evolved, how did the relationship between haploid (gametophyte) and diploid (sporophyte) change?
Study outline for Chapter 13- Reproduction, Meiosis, and Life Cycles

Define sexual reproduction. Give an example.

Define gametes. Give an example.

Define haploid.

Define zygote.

Define diploid.

Define meiosis.

Label the image below with the following terms:
- haploid
- diploid
- meiosis
- gametes (sperm & egg)
- mitosis
- zygote
- fertilization

Define asexual reproduction. Give an example.

Define mitosis.

Where does mitosis occur in the plant?

Where does meiosis occur in the plant?

Use the figures below to briefly describe the different phases of Mitosis.
Study outline for Chapter 13: Reproduction, Meiosis, and Life Cycles

Use the figures below to briefly describe the different phases of Meiosis I and Meiosis II.

Explain the main differences between meiosis and mitosis.

<table>
<thead>
<tr>
<th><strong>Mitosis</strong></th>
<th><strong>Meiosis</strong></th>
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List the advantages and disadvantages of sexual reproduction vs. asexual reproduction.
Define life cycle.

What are the main differences between sexual life cycles and asexual life cycles?

What are the 3 basic types of sexual life cycles?

Identify the following life cycles as gametic, sporic, or zygotic.

Gametic life cycle—

Zygotic life cycle—

Sporic life cycle—

Briefly summarize in general terms gametic, zygotic and sporic life cycles.

As land plants evolved, how did the relationship between haploid (gametophyte) and diploid (sporophyte) parts of the life cycle change?