**Gymnosperms**
- Seeds are naked (ovules are not in ovary)
- Pollen are carried by ovary direct to ovules
- Seed plants without fruits
- Ovule protects the female gametophyte
- Possess secondary growth
- Most lack vessels in the xylem

**Produce both male and female gametophyte**
- alternation of generation similar to other plants
- the gametophytes are unisexual
- ovule forms by meiotic division of a single diploid cell
- three of these megaspores disintegrate
- the fourth undergo repeated cell division with no cytokinesis
- each archegonia contains a single egg

Gingko seeds attached to tree
Yew seed attached to tree
Juniper berries
Cycad seed
Seeds and pollen are produced in cones
• complex reproductive structure at the end of stem called cones (strobilus)
• two types of cones: microstrobili produce pollen grains; megastrobili produce ovules
• Fertilization of sperm cell from pollen grain and an egg in female gametophyte produces seeds
• Sexual reproduction requires transfer of gametes from a male cone to female cone

Pollen grain is a reduced female gametophyte
• produce huge amount of pollen (allergies)
• each immature pollen contains two cells generative cell and the tube cell

Pollination by wind

Pollination droplet
Gymnosperm are divided into four groups

- Maidenhair: Ginkgophyta
- Cycads: Cycadophyta
- Conifers: Pinophyta
- Gnetophytes: Gnetophyta

Maidenhair: Ginkgophyta

- *Gingko biloba*, is the only representative
- Is dioecious
- the sperm cells are flagellated and after pollen release swim their rest of the way to egg
- Mature seed looks like plums but no ovary surrounds the ovule
- Gingko trees are deciduous
- CAN IMPROVE MEMORY (NOT PROVEN)
Ginkgo biloba

Fall

Spring

Cycads: Cycadophyta

- 10 genera and 100 species (tropical)
- are dioecious
- contains palm like leaves
- roots of some cycads have nodules (N-fix)
- have large cones with simple modified leaves
- contains flagellated sperms like Gingko

Medullosa

Extinct: Cycadeoidea: a broad pith, a small xylem and an outer protective layer
Conifers: Pinophyta

• conifers (plants that bear cones)
• Mirkus pine (*Pinus merkusii*) native to S. hemisphere
• Bristlecone pine (one of the oldest living plants)
• usually have pine needle leaves in fascicles
• most are evergreen with few exceptions
• extended reproductive cycle > 1 year

Limber pine, *Pinus flexilis* (Family Pinaceae), has five short leaves (needles) per fascicle. The unit of foliage leaves and leaves around the base is a short shoot.

Coastal redwood leaves

*Bald Cypress*
Conifers: Pinophyta (contd.)

- seed cones are small at the time of pollination
- ovule bearing scales are slightly separated
- after pollen entry, micropyle closes and seals up
- pollen tube transfers sperms to female gametophyte
- the seed increases in size and becomes woodier
- time between pollination and maturation is 18 months
- the mature dried cones release the winged seeds
- cones of some pines are resistance to opening

Gnetophytes: Gnetophyta

Unique sexual reproduction: Double fertilization?

- Three genera: *Ephedra* (40), *Gnetum* (30), *Welwitschia* (1)
- *Ephedra*: monoeccious or dioecious
- Common drug ephedrine isolated from *Ephedra* stem
- most photosynthesis in *Ephedra* occurs in green stem
- *Gnetum*: found in tropical forests, dioecious: (dicots)
- *Welwitschia mirabilis*, sole living species
- Plants have two strap shaped large leaves, dioecious

Ephedra

*Ephedra sinica*
Gymnosperms are adapted to temperate environment

- the ecology is similar to flower bearing plants
- gymnosperm habitat is narrower than angiosperm
- morphology more adapted to temperate environment
- possess narrow leaves, sunken stomata, waxy cuticle
- Only few cycads and Gnetum are found in the tropics

Economic Importance of Gymnosperms

- Picea glauca: main source of pulpwood in N America
- Douglas fir: Pseudotsuga menziesii
- Amber from Agathis robusta
Angiosperms

• 250,000 species compared to 720 Gymnosperm
• Terrestrial and fresh water habitat
• Evolved 65M years ago/disappearance of cycadoids
• Advantage of pollination by insects and shorter generation time

Affects of Dinosaurs on Gymnosperm Diversity

• The era of the cycadoids/dinosaurs
• Cretaceous period: dinosaurs shrink in size
• Cretaceous period: evolution of angiosperm decline of gymnosperm
• Tertiary period: Dinosaurs became extinct Angiosperms became more diverse
The Life Cycle of Flowering Plants

- Double fertilization
- Absence of antheridia and archegonia
- Gametophyte consists of few cells
- Sporophyte dominates the life cycle
- The female gametophyte lives in the large sporophyte

Evolutionary advantage of small gametophytes

Preserved 135M years old DNA in fossil weevil.

Are the reports skewed due to contamination?
Wheat, Rice and Corn: Members of the Grass Family Poaceae

Evolution of Domesticated Wheat
Hybrid Vigor and Corn

- Maize inbred lines were week
- Hybrid corn are more robust
- Hybrid corn are produced by crossing two inbred lines
- Largest seed business in the world
Food and the World Population

Norman Borlaug:
Father of the green revolution

The other side of green revolution

Social and Environmental Impacts

Future Prospects

- Only 30 of >250,000 species provide 90% of the world food

Plant Germplasms

- International Rice Research Institute
- The National Germplasm System (USDA)
- Potato Center; Wisconsin