

References (Textbook -pages 424 - 427, Lab manual - page 145 - 150)

- The term *gymnosperm* means "*naked seed*" (*Greek - gymnos - naked*) (*Greek - sperma - seed*)

Major Characteristics

1. *Gymnosperms* are *vascular plants*
2. *Gymnosperms* produce *seeds*
 - A. A *seed* is composed of *three parts*. These are
 - *Sporophyte embryo*
 - *Stored food*
 - *Protective seed coat*
 - B. *Stored food* and *protective seed coat* allow embryo to *survive* harsh conditions during long *periods* of *dormancy*, maybe even for *hundreds* of *years*.
 - C. When a *seed germinates* the *stored food* is a *source* of *nutrients* for the growing *seedling*
 - D. The *survival value* of seeds are the *reason* that *plants* that *produce seeds* are the *most plentiful* plants *on earth*.
 - E. In gymnosperms the *seed* is *naked* in that it is *totally exposed* or *borne* on the *scales* of *cones* and is *not enclosed* in an *ovary*.
3. The *sporophyte* is the *dominant life stage* of a *life cycle* that exhibits *alternation of generations*.
4. *Gymnosperms* are *heterosporous*. There are *two types* of *spores* that produce *male* and *female gametophytes*. Two types of spores are:
 - A. *Microspores*
 - *Microspores* are *small* and produce multicellular *pollen grains* which are the *male gametophyte*
 - *Pollen grains* are *drought resistant*

- *no external water is required for fertilization (note difference with Bryophyta and seedless Tracheophytes where external water is required for fertilization.)*
- also note that in *gymnosperms* the *entire male gametophyte moves* to the *female gametophyte*, rather than *just the sperm* as in *seedless plants*

B. Megaspores

- *Megaspores develop within an ovule*
- *Megaspores grow into the female gametophyte* which may *develop several archegonia*
- *After fertilization, the female gametophyte develops* within the *ovule* to eventually form a *seed*.
- As already mentioned - in *Gymnosperms* the *ovules* are *not completely enclosed* by *sporophyte tissue* (ovary in angiosperms) at the time of pollination and are thus called *naked*.

5. *Gymnosperms* include about *750 species* of *perennial trees* and *shrubs*

- *Perennial plants are those that have vegetative structures that live more than one growing season*

6. *Most* are *evergreen* and *shed* their *leaves gradually* and *replace* their *leaves gradually*

- *Evergreen means they retain their leaves year round - deciduous trees lose their leaves in the fall*

7. *Gymnosperms* are *usually woody* and they are often called the *softwoods* because their *wood* is *soft* as *compared* to the *hardwood* of species like *oaks*.

8. The *gymnosperms* were very *prominent* during the *Mesozoic Age* of geologic time. The *Mesozoic* has been called the *Age of Gymnosperms*.

4 Major Groups of Gymnosperms

1. Conifers

A. The term *conifer* means *cone-bearing*

B. Includes approximately *575 species* that are especially *common* in *Canada*, *Northern Europe*, and *Siberia*.

- C. Includes *pin*es, *spruces*, *firs*, *cedars*, *hemlocks*, *redwoods*, *cypresses*, *larches*, and others
- D. Most conifers are *monoecious* and have *separate male* and *female* reproductive organs on the *same plant*. There are commonly called *pollen cones* and *seed cones*.
- E. *Leaves* are *tough*, *needle like* and *resistant* to *water loss* because of a *thick cuticle* and *recessed stomata*
- F. Conifers are mostly *softwoods* and have *evergreen foliage*.
- G. *Uses* of conifers.
- *Wood* of pines used in *construction*.
(the wood of pines is made mostly of xylem and lacks some of the more rigid cell types found in flowering-trees (angiosperms) like oaks. Therefore, pine is considered a softwood rather than a hardwood like oak.)
 - *Resin* made by pines to repel insects and fungus is *harvested* and used to make *turpentine*.
 - Several species of *conifers* are sold and used extensively as *Christmas trees*.
- H. *Two* interesting *conifers*
- The *tallest living vascular plants* are the *coastal redwoods* in northwestern *California* and southwestern *Oregon*. Some of these trees may attain up to *330 feet* in *height*.
 - The *oldest living tree* has been identified as a *bristlecone pine* in *California* that is estimated to be *4,900 years old* (based on tree ring analysis).
- I. We will study the *life cycle* of *pine* in *detail - later*.

2. Cycads

- A. There are about *100 species* of *cycads* that grow *mostly* in *subtropical* and *tropical forests*.
- B. They are widely *used* for *home* and *garden landscaping*.

- C. Most have *leaves clumped* near the *top* of a *stem* and appear *palm-like* in *appearance*
- D. *Cycads* are *dioecious* and *pollen* (male) and *seed* (female) *cones* are on *separate plants*. (*remember they are on the same plant in most conifers - monoecious*)
- E. *Cycads* have a *life cycle similar* to *pinus* except they are *pollinated* by *insects* rather than by the *wind*
- F. Also, the *sperm* in *cycads* are *similar* to the *sperm* of *seedless Tracheophytes* in that it is *flagellated* and still *swims* to reach an egg.

3. Ginkgoes

- A. *Ginkgos* are *common* in the *fossil record*
- B. Only *one tree species*, *Ginkgo biloba*, is *living today*.
- C. The tree *resistant* to *pollution* and is used as a *landscaping plant* along *city streets* and in *city parks*.
- D. Ginkgo trees are *dioecious*.
- E. When *fleshy seeds ripen* in the *fall*, the *female tree* gives off a *foul odor* and *male trees* are usually *preferred* for landscape *plantings*.
- F. Like *cycads*, *sperm* is *flagellated* and *swims* to the *female gametophyte*.

4. Gnetophytes

- A. There are *3 living genera* of *gnetophytes* that include approximately *70 species*.
- B. The *3 living genera* are:

(1) *Gnetum*

- Occurs in the *tropics*
- Are *trees* or *climbing vines*

(2) *Ephedra*

- Occurs only in *southwestern North America* and *southeast Asia*
- A shrub with small scale-like leaves
- *Source* of the drug *ephedrine*

(3) *Welwitschia*

- Lives in the *deserts* of *southwestern Africa*
- Has only *two* large *strap-like leaves*

C. All *gnetophytes* lack an *archegonia*.

(Note that all plants we have studied so far possess an archegonia and this is the first group to lack an archegonium. The lack of an archegonia is also a characteristics of the angiosperms, a group we will study later.)

D. *Insects* are responsible for *pollination* of *gnetophytes*

Life Cycle of Pine (*see handout of Figure 24.18 from page 425 of textbook*)
(*see handout of Figure 13.5 from page 150 of lab manual*)

- Life stage descriptions below - follow the numbering system from figure 24.18 on page 425 in the textbook
1. *Sporophyte* is *dominant life stage*.
 - A. *Sporophyte* is *monoecious*
 - B. *Sporangia* are borne in *pollen* (male) *cones* and *seed* (female) *cones*
 - C. *Pollen cones* are also called *microstrobili* or *staminate cones*
 - D. *Seed cones* are also called *megastrobili* or *ovulate cones*

Development of Male Gametophyte (*see handout of Male Reproductive Structures - Pine*)

2. *Pollen cones* are *small* and develop near *tips* of *lower branches*
 - A. each *pollen cone* is made up of a number of *pollen cone scales* called *microsporophylls*
 - B. *microsporophylls* bear the *microsporangia* (male sporangia)
3. Within *each microsporangium* are *microsporocytes* (or *microspore mother cells*)
 - A. *microsporocytes* (microspore mother cells) undergo *meiosis* to produce *4 microspores*.

4. Each *microspore* develops into a *pollen grain*
 - A. *Pollen grain* is the *male gametophyte* in the *pine life cycle*.
 - B. Each *pollen grain* has *two wings* and is carried by the *wind* to the *seed cone* where *pollination occurs*.

Development of Female Gametophyte

2. *Seed cones* are *larger* than *pollen cones* and located near *tips* of *branches* of higher *branches*
 - A. Each *seed cone* is made up of many *seed cone scales* called *megasporophylls*
 - B. On the *upper surface* of the each *megasporophyll* lie *two ovules*
 - C. Each *ovule* is *surrounded* by a thick, layered *integument* with an *opening* at one *end*
3. *Within each ovule* is a *megasporangium*
4. Inside the *megasporangium*, a *megasporocyte (megaspore mother cell)* undergoes *meiosis* to form *4 megaspores*
5. *Only 1* of these *megaspores* develops into the *female gametophyte*
 - A. *Female gametophyte* will have *2 to 6 archegonia*
 - B. *Each archegonia* will contain a *single large egg* lying *near* the *ovule opening*.

Development of Seed

6. *Pollination* and *fertilization*
 - A. *Pollination* occurs when *pollen* becomes *enclosed* in *seed cone*, and *enters* the *ovule* through the *opening in the integument*.
 - B. Once enclosed, *pollen* grain *develops* a *pollen tube* that *digests* its way toward a *female gametophyte*.
 - This *process* takes a *full year* before the *pollen tube reaches* a mature *egg* in the *archegonium*.

C. **Fertilization** occurs when the **pollen tube releases 2 non-flagellated sperm** into the **archegonium**

(note - water is not needed for successful fertilization as with Bryophytes and seedless Tracheophytes)

- **One sperm fertilizes an egg** and the **other sperm degenerates**

D. **Fertilization** is an entirely **separate event** from **pollination** and **occurs one year after pollination**.

7. **After fertilization, ovule matures into seed**

A. **Seed** is composed of **3 parts**

- **Embryo**
- **Reserve food**
- **Seed coat**

B. In **fall of second season** (after pollination)

- **seed cone** becomes **hard** and **woody**
- seed cone **opens** and **releases winged seeds**
- because **gymnosperm** (pine) **seeds** are **not enclosed** by **fruit**, like **angiosperms**, they are called **naked seeds**

C. seeds fall on fertile soil and germinate into a new pine tree

Draw the following illustration on the blackboard and encourage students to be able to assign the life stages discussed above to their appropriate places on the illustration. ***Note how this is similar to the exercise of constructing sentence diagrams in English grammar classes***