I. **Seed plants**
   A. all are heterosporous vascular plants
   B. three major reproductive adaptations
      1. gametophyte reduced to dependence on sporophyte; retained in moist reproductive tissue
      2. seed – “baby plant in a lockbox with its lunch”; highly resistant structures that allow for a **dormant phase** in the life cycle to wait out poor environmental conditions
      3. evolution of **pollen** as male gametophyte – many seed plants are no longer tied to external water for fertilization
   C. common ancestor with seeds gave rise to all seed plants (gymnosperms and angiosperms); together, gymnosperms and angiosperms are a monophyletic group
   D. fossil evidence indicates origins in progymnosperm group about 360 MYA
   E. **gametophytes** are completely dependent on parent sporophytes for nutrition and are composed of only a few cells
      1. male gametophytes develop from **microspores**
         - become **pollen grains**
         - entire male gametophyte moved to the female as pollen grains
         - cannot perform photosynthesis, depends on nutrients that came from the parent sporophyte
      2. female gametophytes develop from **megaspores** within **ovules**
         - **ovule** contains female gametophyte surrounded by **nucellus** (megasporangium)
         - nucellus is surrounded by 1-2 integuments (cell layers that serve as protective covers)
         - **micropyle** – opening in integuments (allows sperm to get in)
         - cannot perform photosynthesis, depends on nutrients from the parent sporophyte
      3. means of transporting sperm to egg varies, but typically uses a growing **pollen tube** that does not require outside water
      4. moving pollen to vicinity of ovule called **pollination**; agents include wind, animals
   F. seed develops from ovule
      1. seeds are highly resistant structures that allow for a **dormant phase** in the life cycle to wait out poor environmental conditions
      2. embryo protected by a **seed coat**, an extra layer of hardened tissue derived from sporophyte tissue in the ovule (sporophyte tissue from parent, not from embryo)
         - enhanced protection from drought, cold, heat
         - some protection from pathogens and predators
         - external water only needed at **germination**
         - initial food supply for germinating plant is enclosed
      3. seeds replace spores as means of dispersal; can enhance means of dispersal
   G. seeds plants together are a monophyletic group
   H. divided into two “groups” based on whether or not ovule is completely enclosed by sporophyte tissue at time of pollination
BIOL 1030 – TOPIC 6 LECTURE NOTES

1. gymnosperms – “naked seed”
2. angiosperms – “covered seed” – covered in Topic 7

Label the diagram to understand how the different groups of plants vary with gametophyte and sporophyte generations:

II. Gymnosperms
   A. paraphyletic group (a grade) composed of 4 phyla with living members
      1. essentially, all seed plants that are not angiosperms

2 of 6
2. all lack flowers and fruits that are found in angiosperms
3. ovule not completely enclosed by sporophyte tissue at time of pollination
4. instead, ovule sits exposed on a scale (a modified leaf)

B. 4 phyla
1. Phylum Coniferophyta (the conifers)
2. Phylum Cycadophyta (the cycads)
3. Phylum Ginkgophyta (Ginkgo)
4. Phylum Gnetophyta (the gnetophytes)

III. Phylum Coniferophyta (the conifers)
A. monophyletic group
B. ~600 living species; worldwide distribution, more common in cold or dry regions
C. pines, spruces, firs, cedars, junipers, hemlocks, yews, larches, cypresses, redwoods
D. nearly all are evergreen
E. many have needle-shaped leaves adapted to dry conditions (resistant to water loss)
    1. thick cuticle
    2. stomata in pits
F. tallest plant: more than 110 m (Coastal Redwood, *Sequoia sempervirens*)
G. oldest tree: Methuselah, estimated more than 4600 years old (Bristlecone Pine, *Pinus longaeva*)
H. sources of timber, paper, resin, cancer drug taxol, etc.
I. “soft” wood (unlike angiosperm trees, no vessels or fibers in xylem)
J. pines as a representative group
    1. over 100 species
    2. native to Northern hemisphere
    3. typically thick bark (survive fires, drought)
    4. secrete resin from leaves and bark
       • response to wounding
       • deters fungal and insect attacks
       • source of turpentine (volatile liquid, organic solvent) and solid rosin
K. pine life cycle
    1. pine tree is sporophyte, with sporangia located on cones
    2. gametophyte generations reduced; retained within sporangia
       • male gametophyte is pollen grain (no antheridium)
       • female gametophyte produces archegonia within ovule
3. heterosporous: separate male and female cones

4. male cones (pollen cones)
   - clusters of 30-70
   - usually at tips of lower branches
   - 1-4 cm long; papery scales in spirals or whorls
   - pair of microsporangia sacs within each scale
   - microspore mother cells in microsporangia form haploid microspores
   - each microspore becomes 4-celled pollen grain
   - pollen grain carried by wind (pair of air sacs provides buoyancy)
   - mature pollen grains have a “Mickey Mouse” appearance
BIOL 1030 – TOPIC 6 LECTURE NOTES

5. female cones (ovulate cones)
   - typically on upper branches of same tree with pollen cones
   - larger than pollen cones
   - scales become woody (highly lignified)
   - pair of ovules develop at base of each scale
     - megasporangium called nucellus embedded in each ovule
     - nucellus is nutritive tissue surrounded by thick integument (covering) with hole (micropyle) near one end
     - one layer of integument later becomes seed coat
   - single megaspore mother cell in each megasporangium
     - produces 4 haploid megaspores; 3 break down
     - surviving megaspore develops over about one year into female gametophyte with sometimes thousands of cells
   - female gametophyte has 2-6 archegonia, at micropylar end
   - each archegonium has one large egg (visible without a microscope)
   - female cones take two or more seasons to mature

6. reproduction
   - scales of ovulate cone open
   - pollen lands near micropyle, caught by sticky fluid
   - evaporating fluid pulls pollen through micropyle into ovule
   - scales close (female gametophyte not mature)
   - pollen grain germinates, forming pollen tube that digests through nucellus (takes about 15 months to reach archegonium)
   - one of the four pollen grain cells (the generative cell) undergoes mitosis; one of products divides again, making two sperm cells
     - mature male gametophyte is germinated pollen grain with pollen tube and sperm
     - when archegonium is reached, one sperm fertilizes egg
     - zygote develops into embryo within seed; usually only one successful zygote per ovule
     - embryo (new sporophyte, 2N) has rudimentary root, several embryonic leaves (cotyledons)
     - food source in seed derives from rest of female gametophyte (1N)
     - scales of cone open and separate; winged seeds disperse

7. from initial ovulate cone formation to final seed production 3 years or more

IV. Phylum Cycadophyta (the cycads)
   A. monophyletic group
   B. ~200 living species, tropical and subtropical; many in danger of extinction
   C. along with conifers, dominated Mesozoic era (245 MYA – 65 MYA)
   D. slow-growing; some grow >15 m tall
E. most resemble palm trees, but produce cones (female cones up to 45 kg, or 100 lbs!)
F. have life cycle similar to pines
G. unusual sperm
   1. have thousands of flagella arranged in spirals
   2. swim within ovule to archegonium
   3. largest sperm known

V. Phylum Ginkgophyta (Ginkgo)
A. monophyletic group
B. 1 living species, Ginkgo biloba (also known as the maidenhair tree)
C. exists only in cultivation (no natural native populations); first cultivated in Japan and China
D. deciduous – lose leaves
E. flagellated sperm (similar to cycads)
F. dioecious
G. stinky seed coverings (produce butyric and isobutyric acid, making the smell of rancid butter)
H. males often planted on city streets (do not stink like females; resistant to air pollution)

VI. Phylum Gnetophyta (the gnetophytes)
A. apparently a monophyletic group, but could be paraphyletic
B. ~70 living species in 3 genera: Welwitschia, Ephedra, Gnetum
C. closest living relatives of angiosperms (likely monophyletic group with them)
   1. vessels in xylem (common in angiosperms, found only in these gymnosperms)
   2. members of Gnetum have broad leaves similar to angiosperm leaves
   3. genetically similar to angiosperms
D. Welwitschia – bizarre plants of southwest African deserts
   1. stem is shallow cup that tapers into a taproot
   2. two leathery leaves (often split) grow continuously from base
   3. conelike reproductive structures at leaf base
   4. dioecious – separate male and female plants
E. Ephedra common in Mexico and southwestern US, but found on most continents
   1. shrubby, stems resemble horsetails (jointed, with tiny scale-like leaves at each node)
   2. some species monoecious (male and female parts on same plant), some dioecious
   3. drug ephedrine historically extracted mainly from a Chinese species of Ephedra