

## Topic 24. Introduction to the Seed Plants: The Gymnosperms

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### Domain Eukarya

#### Kingdom Plantae

#### The Conifers

#### Genus *Pinus*

#### The Cycads

#### The Ginkgoes

#### Gnetophytes (The Vessel Bearing Gymnosperms)

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### Seed Plants: An Overview of Terms

The remaining five phyla of plants, are all seed plants. Seeds are borne on sporophytes and contain young sporophytes (embryos). Superficially it appears as if these plants skip the gametophytic generation. In all cases, the gametophytic generation is still there, but is either hidden by sporophytic tissues or dramatically reduced. Our knowledge of the life cycles of non-seed plants provides us with a perspective about the evolution and life cycles of the seed plants.

All seed plants are **heterosporous**. All the terms we introduced in regards to the *Selaginella* life cycle apply to seed plant life cycles. Below is a list of old terms and new ones necessary to understand seed plant life cycles. You need to know and understand then all.

**Micro:** Suffix that originally denoted small but has, in a botanical sense, taken on the meaning “male”.

**Microspore Mother Cell = Microsporocyte:** Diploid cell destined to undergo meiosis to produce microspores in the seed plants.

**Microsporangium:** Sporangium that bears microspores. In seed plants synonymous to a pollen sac.

**Microspore:** Spore that develops into a microgametophyte.

**Microgametophyte:** In seed plants this is the **pollen grain**.

**Microsporophyll:** Modified leaf that bears microsporangia. Examples from the seed plants include the stamens of flowers and the subunits of the pollen cones of conifers.

**Microsporangiate cone = male cone:** terminal clusters of microsporophylls such as the pollen cones of conifers.

**Mega:** Suffix that originally denoted large, but has, in a botanical sense, taken on the meaning “female”

**Megaspore mother cell = Megasporocyte:** Diploid cell destined to undergo meiosis to produce megaspores. In seed plants this cell is buried in the tissue of the megasporangium.

**Megasporangium = nucellus** in the seed plants: It is surrounded by sterile tissues called **integuments**. The integuments retain both the nucellus and the megagametophyte keeping this generation bound to the sporophyte.

**Integuments:** Sterile tissues surrounding the nucellus. These tissues mature into a seed coat.

**Megaspore:** Haploid cells resulting from the meiosis of a megasporocyte. It develops into the megagametophyte. In seed plants the megaspore is not released but is retained in the nucellus.

**Ovule:** The integuments together with the nucellus form the ovule. Later stages include the **megagametophyte** and embryo.

**Megagametophyte = Female gametophyte:** In the seed plants is retained on the sporophyte in the nucellus. In the gymnosperms, the megagametophyte is present in the mature ovule (seed) where it functions as the food storage tissue for the embryo. In the angiosperms this generation is destroyed by **double fertilization**.

**Megasporophyll:** Modified leaf bearing the megasporangia (hence the ovules). Not all seed plants have them. Cycads are one group with megasporophylls. In flowering plants megasporophylls are termed **carpels**.

**Megasporangiate cone:** Structure composed of subunits bearing **ovules**. These subunits are not megasporophylls but seed-scales in the conifers.

**Seed:** Mature ovule bearing a young sporophyte (an embryo) complete with food storage tissue covered by a seed coat derived from integuments.

# The Gymnosperms

Gymnosperms are simply seed plants that are not angiosperms. This means that they are grouped by what they don't have. Gymnosperms do not bear fruits and their seeds are not enclosed. 'Gymnosperm' literally means naked-seeded as their seeds are not enclosed in fruits. The nutritive tissue in the seeds of all gymnosperms is the megagametophyte, and they do not have endosperm storage tissue. There are four phyla of gymnosperms. One group, **Gnetophyta**, was once thought to be closely related to the flowering plants. Today, the relationship of these four groups to each other and to the flowering plants is still unclear.

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## I. Conifers.

Conifers are seed plants all of which have woody stems. Their life cycle does not include motile sperm. The sperm nuclei are carried all the way to the egg by the pollen tube. While absent in the yews, the most distinctive feature of the group is the **compound ovulate cone**, consisting of a central stem bearing **seed-scale complexes**. Each seed scale complex consists of a modified leaf called a **sterile bract**. In the axil of the sterile bract a modified stem called a **seed scale** develops. This in turn bears the **ovules**.

### Ia. Demonstration of Conifer Diversity

Conifers include many commercially and ecologically important species. These include the pines, spruces, hemlocks, douglas fir, junipers, cedars and all three genera of the redwoods. Conifers are among the world's largest, tallest and oldest trees. Observe the examples of conifers on display. All the fresh cuttings were collected on campus. Note the diversity of form. You should be able to recognize all these as examples of conifers. Pay special attention to *Pseudotsuga*. Its mature cones clearly show the sterile bracts associated with the seed scales of the ovulate cone. **Do not damage the large pine cones (Coulter and Sugar pines) or the redwood cones!** These are western species and these cones cannot be easily replaced.

### Ib. Life Cycle of the Genus Pinus

*Pinus resinosa* (red pine) is a commonly planted species of pine in Wisconsin. We will study it in detail as our primary example of the conifers.

**Identifying the Genus Pinus:** The genus *Pinus* is unique in that all the leaves of mature plants are born in fascicles. The fascicle of pine is a dwarf shoot that bears the leaves and dies when the leaves die. Observe the red pine boughs in the lab room.

How many leaves are borne on a fascicle in *Pinus resinosa*? \_\_\_\_\_

**Microsporangiate Stages:** In conifers microsporangiate cones are borne for only a matter of days or weeks and are then shed. In *Pinus* the microsporangiate cones are borne in clusters and emerge with the new spring growth of the lower branches. Here in Dane county the microsporangiate cones emerge in May.

### Clustered Microsporangiate Cones

- Observe the clusters of microsporangiate cones on the boughs at the front of your bench.

Explain the alternating bare areas interspaced by leafy areas behind the clustered cones:

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### Studying the Details of the Microsporangiate Cone

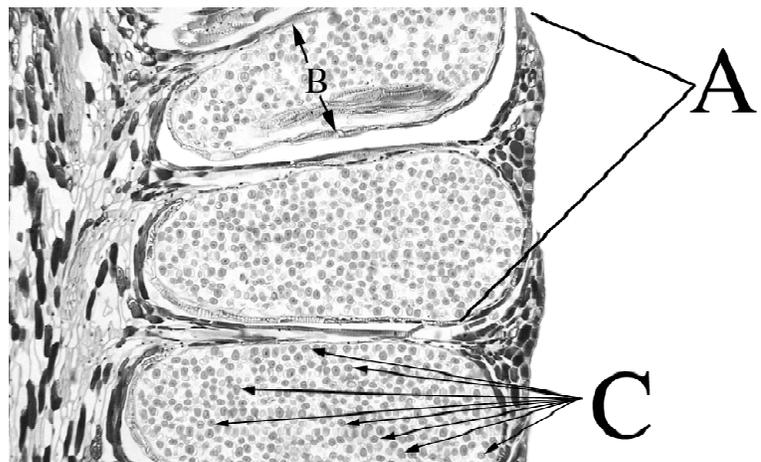
- Take a microsporangiate cone from the bowl next to the bough bearing the clustered cones. Take the prepared slide labelled, "*Pinus* Male Strobilus". Study the whole cone and then compare with the section using your unaided eye. You should be able to correlate that the slide is indeed a longitudinal section through a male cone.
- Study this prepared slide. Identify the **microsporophylls**, **microsporangia** (pollen sacs) and the **immature microgametophytes** (pollen grains).

Label the figure.

A = \_\_\_\_\_

B = \_\_\_\_\_

C = \_\_\_\_\_



After viewing the prepared slide, dissect a whole cone. This is best done by initially pulling the cone apart using your fingernails then using teasing needles to dissect out individual microsporophylls.

Make two drawings of the same microsporophyll. Label one, "upper surface", and the other, "lower surface." Also label the pollen sacs and the microsporophyll itself.

**Upper surface**

**Lower surface**

### **The Microgametophyte (Pollen Grain)**

In all seed plants the microgametophyte is greatly reduced. For fertilization to occur the microgametophyte must be physically carried to the ovule. This event is **pollination** and in pine is accomplished by the wind. Sample the water at the bottom of the dish with the microsporangiate cones with a pipette and make a wet mount.

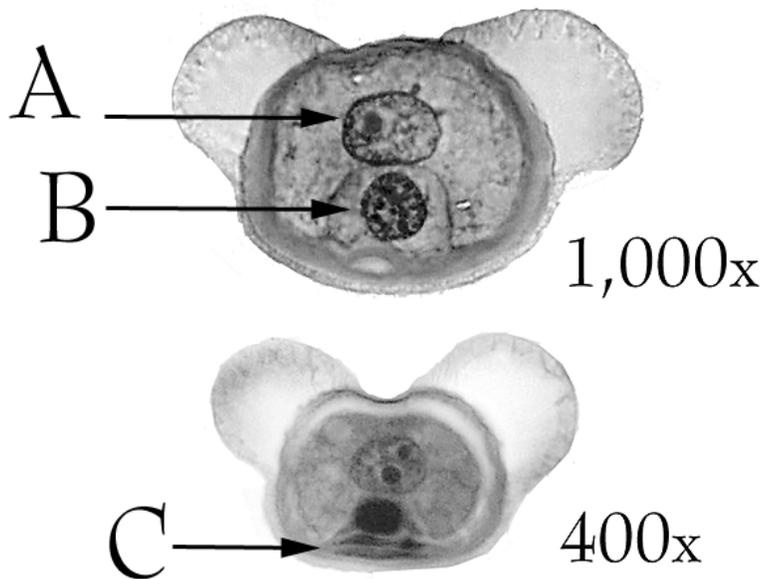
Draw a pollen grain.

What possible survival advantage could be provided by the "Mickey Mouse" ears?

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Again view the prepared slide under your microscope. Look carefully at the pollen grains in the pollen sacs at 400x. Identify the nuclei of the tube (A) and generative (B) cells. You should just be able to see the boundary between these two cells. Also, by looking at a number of different pollen grains you should be able to discern the prothallial cells (C) though they may not appear as two distinct cells. These are all that is left of the vegetative body of the microgametophyte. The tube cell will germinate into the pollen tube which will grow through the nucellus and eventually up through the neck of the archegonium to an egg. After pollination the generative cell will divide to form a stalk cell and a spermatogenous cell. The spermatogenous cell, in turn will undergo mitosis to form two sperm nuclei. Both of these nuclei will be delivered to the egg nucleus via the pollen tube.



## Megasporangiate Stages

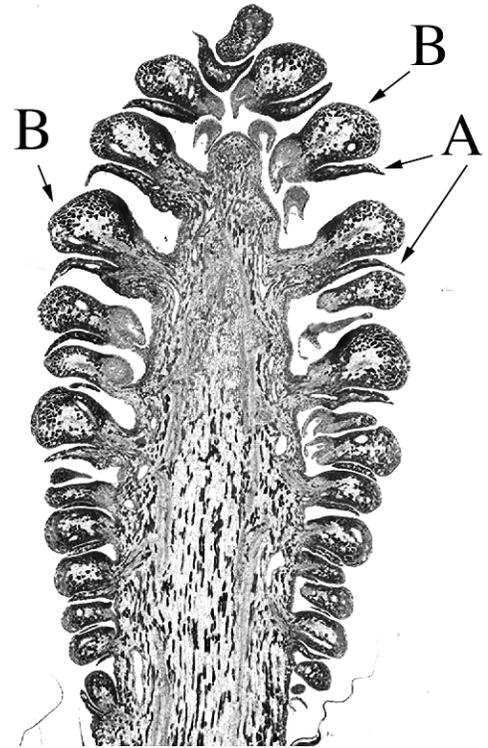
In conifers megasporangiate cones persist through the year and their presence give rise to the common name of the group. In *Pinus* the megasporangiate cone emerges with the new spring growth of the upper branches. Here in Dane county the megasporangiate cones emerge in May and do not reach maturity where they disperse seed until the fall of the following year.

## Bough with Megasporangiate (ovulate) Cones

Study the pine bough at the front bench with the various stages of ovulate cones. The smaller cones emerged this year in May and are six months old. The older cones emerged the preceding May and are 18 months old. Note, there may be even older cones still attached to the bough. If so these are three-years old and have been dead for a year. In pine the ovulate cones are not actively abscised, but eventually fall off due to the growth of the bark and the wood.

## Studying the Details of the Megasporangiate Cone

Take a whole six month old cone to your seat and compare it with the prepared slide labeled “Pine: female strobilus”. Verify that the section is indeed a section. Observe the prepared slide through your microscope. Identify the sterile bracts labelled “A”, and the seed scales labelled “B” on the next page. A sterile bract with its associated seed scale is a seed scale complex. All conifers except the yews have ovulate cones made up of seed scale complexes though they are reduced in *Podocarpus*.



**Dissection of a Megasporangiate Cone:** Work with the people at your bench. Return all the six-month cones to the stock bowl except for one. Take this cone and pull it apart using your fingers. Share the pieces with those at your table. Everyone should then dissect out one seed-scale complex. Use a dissecting microscope! Lay it flat and observe the ovules.

How many ovules are there on each seed-scale?

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Flip over the seed-scale and observe the sterile bract.

**Draw** each view of one seed-scale complex. Label **seed-scale**, **ovules**, and **sterile bract**.

Top view (showing ovules)

bottom view (showing sterile bract)

Observe a mature cone. Note that the sterile bracts have not grown in step with the seed-scales. Observe the douglas fir cone at the conifer display to see an example where the sterile bracts are visible in a mature cone.

## Studying the Details of the Ovule

Take the prepared slide labeled “Pine female strobilus” and use 400x to study details of the ovule. To observe all the structures listed you will need to view a number of different ovules as it is rare to find one section with all these structures. Identify the **integument**, and the **micropyle** of the ovule where the integument comes together but fails to meet. Look for an ovule with a huge cell in the center. This cell is the **megaspore mother cell**. It will undergo meiosis to produce four **megaspores**. In *Pinus*, only one megaspore will go on to produce a **megagametophyte**. The tissue in which this cell is embedded is the **nucellus (megasporangium)**. It is surrounded by the integument, but note that the two tissues are not joined near the micropyle. The space between these two tissues is the **pollen chamber**. Carefully search the pollen chambers of several ovules for pollen.

Has pollination occurred? \_\_\_\_\_

How does pollen get to the ovule and then into the pollen chamber?

Label the figure of the ovule below. Note the micropyle is not in the plane of section.

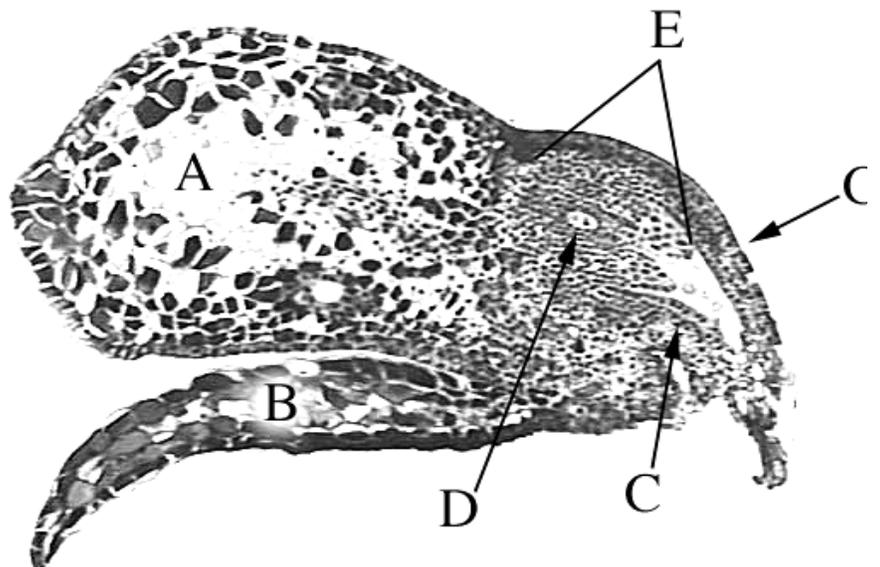
A= \_\_\_\_\_

B= \_\_\_\_\_

C= \_\_\_\_\_

D= \_\_\_\_\_

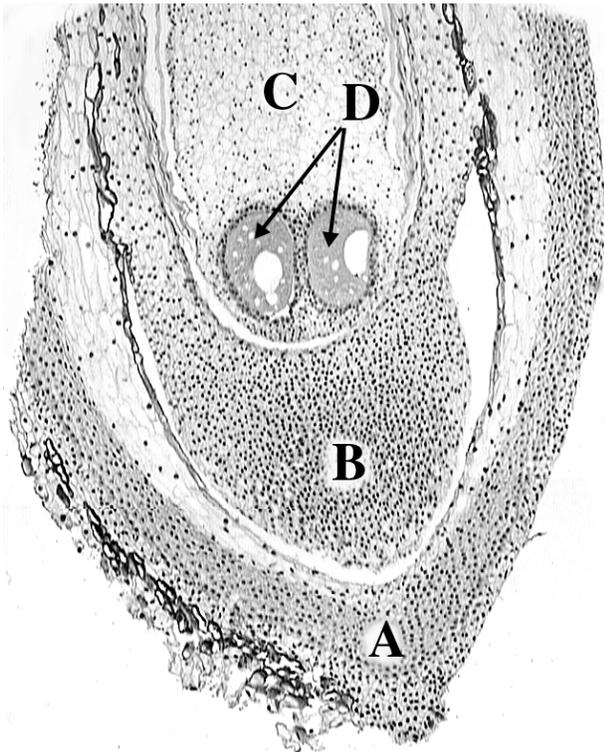
E= \_\_\_\_\_



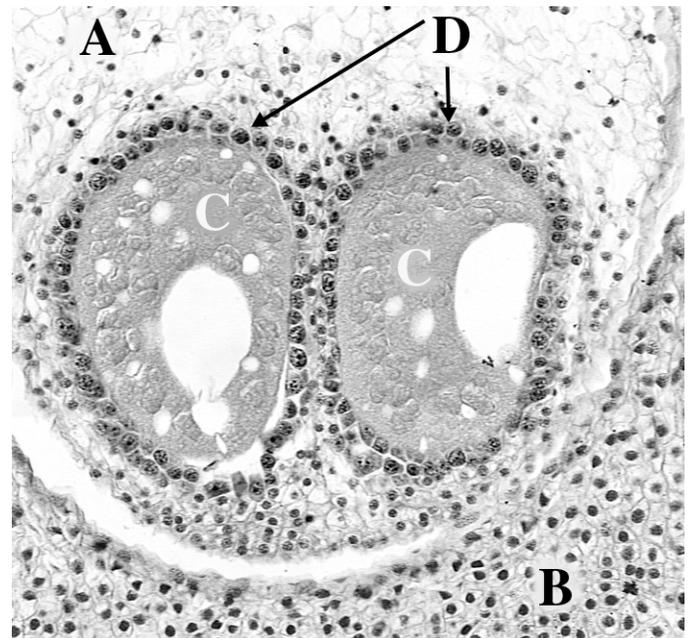
## Studying the Megagametophyte

Take the prepared slide labelled “Pinus Archegone” and observe the slide with your unaided eye. Note that this is a longitudinal section through an ovule. The megagametophyte occupies the central region of the ovule and one or two eggs will be visible without magnification. Observe the slide with your microscope. Note that the eggs are associated with an **archegonium**. It is improbable that you will have a section that perfectly sections the neck, however the cells of the venter should be easy to identify at 400x. Identify the following: **megagametophyte**, **venter** of the archegonium, **egg**, **nucellus**, **integument**. **Label the Figures.**

**40x**



**400x**



**A =** \_\_\_\_\_

**B =** \_\_\_\_\_

**C =** \_\_\_\_\_

**D =** \_\_\_\_\_

**A =** \_\_\_\_\_

**B =** \_\_\_\_\_

**C =** \_\_\_\_\_

**D =** \_\_\_\_\_

## Studying The Seed and Seedling Stages of Pine

Go to the front bench and take a Piñon pine seed. These seeds are called pine “nuts” and are used in pesto. They are a western species and these seeds are many times larger than the seeds of red pine. Make a small cut in the seed coat with a razor blade, then using your finger nails peel off the seed coat.

**What tissue gave rise to the seed coat?** \_\_\_\_\_

Immediately below the seed coat is a papery brown layer. Peel this layer off also.

**Based on your understanding of the pine ovule, from which tissue was this brown layer derived?**  
\_\_\_\_\_

The white tissue exposed is female gametophyte. To expose the embryo, dig your thumb nails into the tissue and rip the structure in two. This should clearly reveal the embryo inside. Identify the cotyledons and the central axis of the stem and root.

Take the slide “Pinus: embryo”, hold it to the light and study the section with your unaided eye. Note this is a longitudinal section through a pine seed that has had the seed coat removed. Observe this slide with your microscope. Identify the **cotyledons** (seed leaves), the **apical meristem of the shoot**, and the **apical meristem of the root**. Label the figure below:

**Figure of Dissected Pine Seed (left) and longitudinal section (right).**



**Seedling Stages:** Study the demonstration of the various seedling stages at the front.

What is the function of the cotyledons immediately after germination?

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What is the function of the cotyledons after the seed coat is released?

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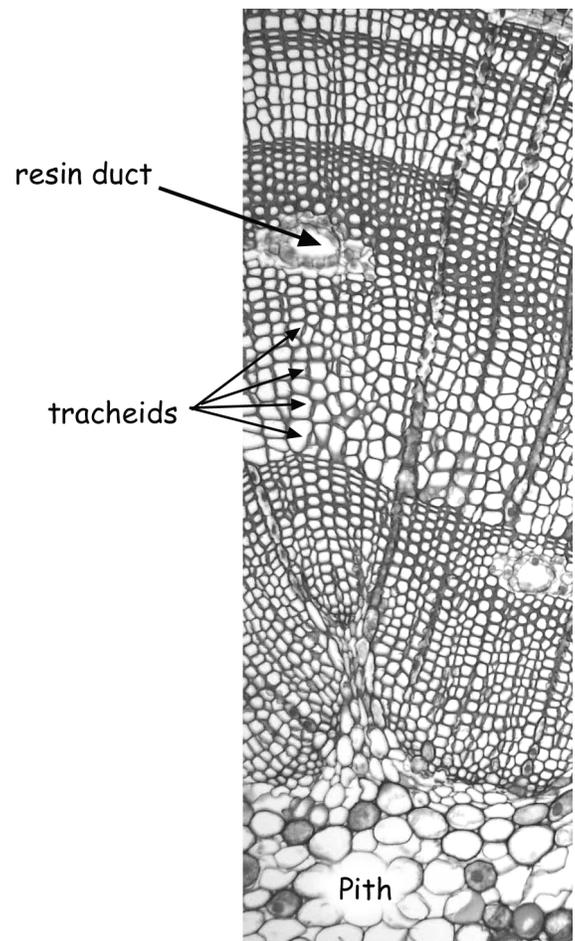
**Draw germinating pine seedlings below: Label cotyledons, seed coat, first foliage leaves.**

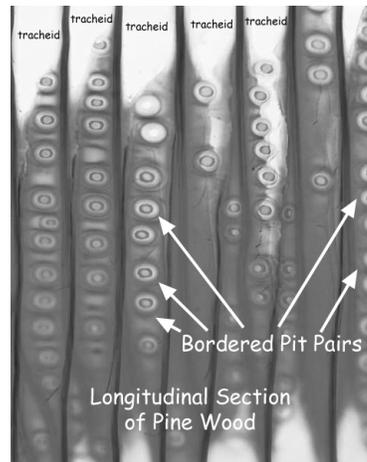
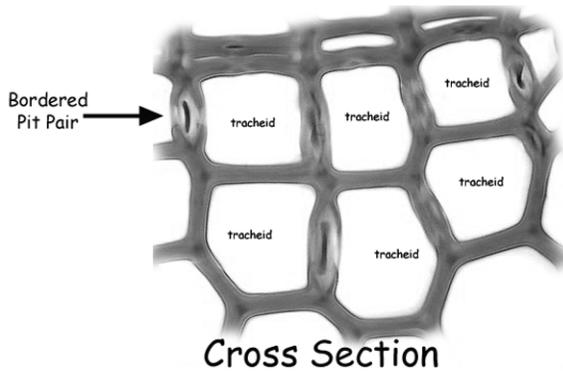
## Ic. Softwoods vs. Hardwoods

By convention conifer woods are classed by lumbermen as “softwoods” and angiosperm woods as “hardwoods”. This is so, because, in general, conifer wood is softer. Keep in mind though that, by this system, balsa wood is a “hardwood” and yellow pine is considered as a “softwood”, even though balsa wood is considerably lighter and weaker than yellow pine. The central difference between the two is that conifer wood has only one type of tracheary element, tracheids, and angiosperm wood has both tracheids and vessel elements.

### Sections of Pine Wood

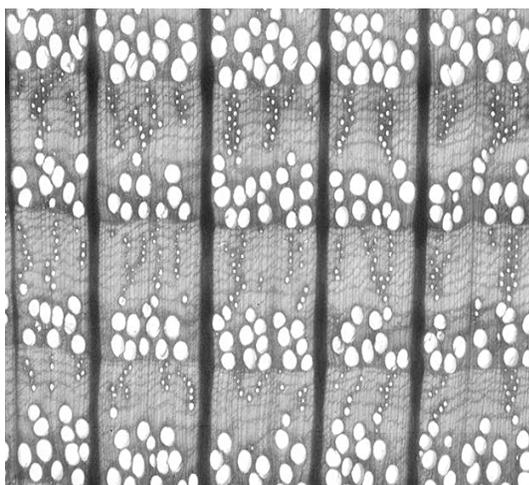
Take the slide of pine stem in your box and note that there are three sections on one slide. One section is a **cross section** where you see the growth rings as concentric rings. The other two sections are **longitudinal sections**. Pine wood has only two types of cells, **tracheids** and **parenchyma cells**. Pores that appear to be vessels are **resin ducts**. Close inspection will reveal that these pores are lined with parenchyma. Adjacent tracheids are connected by **bordered pit pairs**. Use the figures on the next page to identify these various structures on your slide.



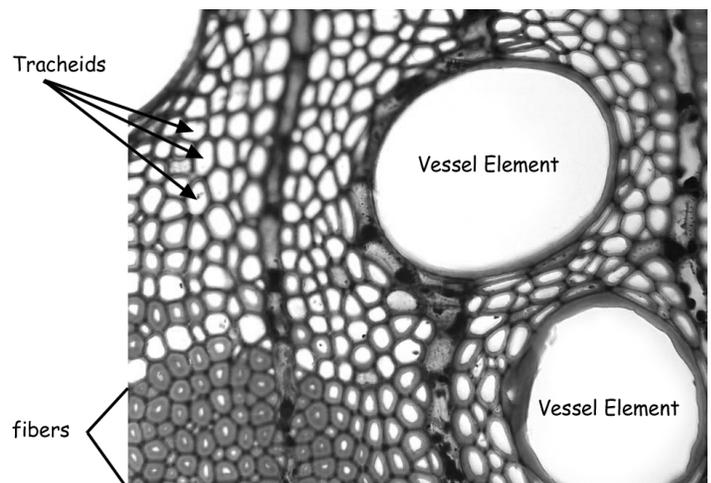


## Sections of Oak (*Quercus*) Wood

Take the slide of oak (*Quercus*) stem in your box and note that there are three sections on one slide. One section is a **cross section** where you see the growth rings as concentric rings. The other two sections are **longitudinal sections**. Oak wood has **tracheids** and **parenchyma cells**, but also has **vessel elements**, **fibers** and cells that intergrade between tracheids and fibers. Vessel elements are lighter and weaker than tracheids. The fibers of oak wood, however, are so dense and strong that, overall, oak wood is stronger and heavier than pine. Note that the largest vessels are concentrated in the spring wood. With the naked eye one can see these in the cross section, and woods with this characteristic are termed **ring porous woods**. Use the figures below to identify these various structures on your slide.



Ring porous wood of oak



## II. Cycads.

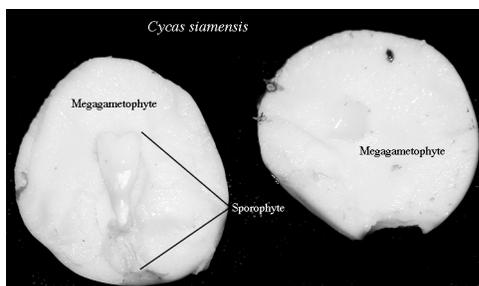
Cycads are a clade of seed plants with non-woody secondary growth. Plants are **dioecious** either bearing **megasporophylls** or **microsporophylls**. **Foliage is palm-like** with pinnately compound leaves. Cycads have **flagellated sperm** carried to the archegonium by means of the pollen tube. This group was more important ecologically in the past than in the present. Today the group consists of only three families of plants. Cycads are extensively planted in tropical and subtropical areas as ornamentals.

Observe the examples of cycads on the side bench. Note the demonstration of Microsporangiate and megasporangiate stages for both *Cycas* and *Zamia*.

*Zamia* has both **megasporangiate strobili** consisting of **megasporophylls** bearing **ovules**, and **microsporangiate strobili** consisting of **microsporophylls**.

All sporophylls are organized into determinate strobili (strobili consisting of a shoot where the apical meristem does not persist, hence the strobilus terminates growth at that point).

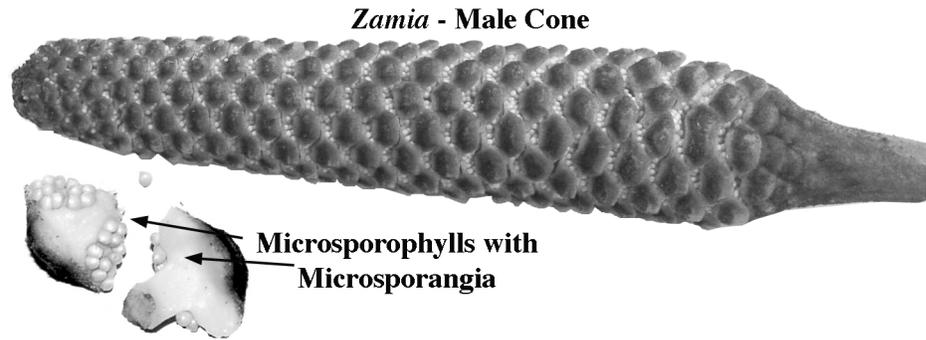
*Cycas* has its microsporophylls arranged as above. However, the megasporophylls are not organized in determinate strobili. They form at the apex of the shoot and are followed by new growth consisting of vegetative leaves.



Dissected Seed of Cycas



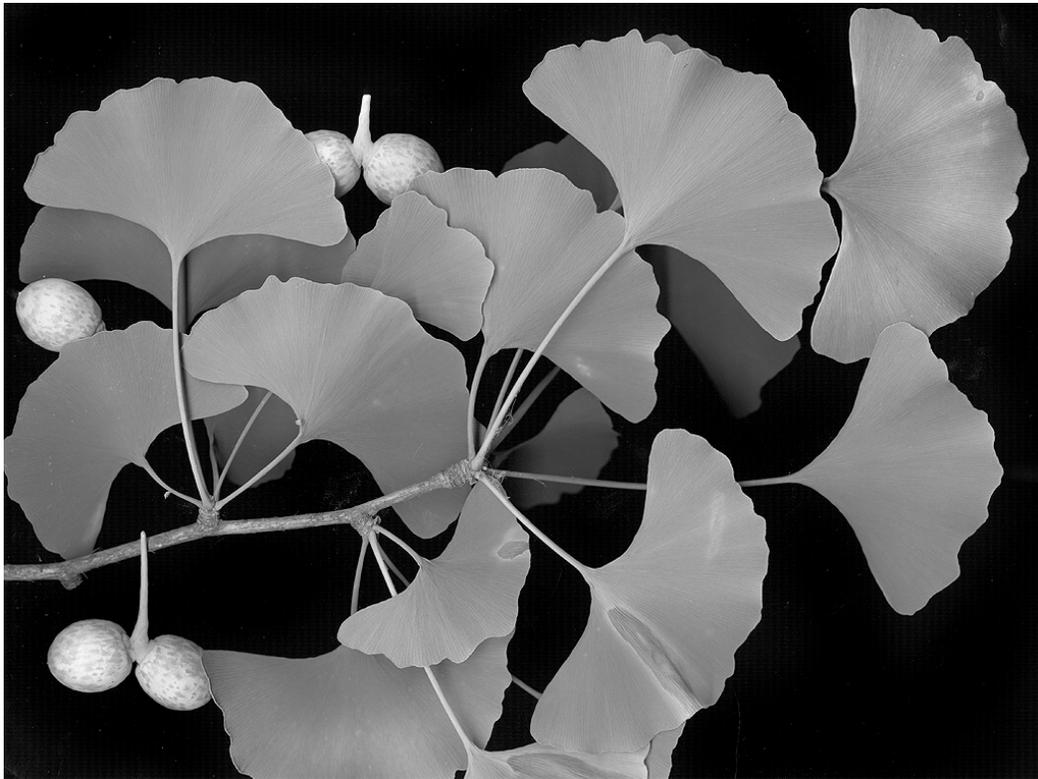
Ovulate Cones of *Zamia*



### III. Ginkgoes.

Ginkgoes have woody secondary growth and distinctive fan shaped leaves. Male bear microsporangiate strobili. Females bear ovules on peculiar stalk-like structure each with two ovules. The ovules mature into a stinking fruit-like seed. *Ginkgo* has flagellated sperm carried to the archegonium by means of the pollen tube.

The group was more important ecologically in the past than in the present. Today the phylum includes one species, *Ginkgo biloba*, which is extensively planted as a street tree.



Observe the demonstration materials of *Ginkgo biloba* on the side bench.



### Mature Seeds of *Ginkgo*

From what tissue is the fleshy covering of the *Ginkgo* seeds derived?

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## IV. Gnetophytes (Vessel-Bearing Gymnosperms).

This group, like the flowering plants, and unlike the other three groups of gymnosperms, has vessels in their xylem. This is a peculiar group consisting of only three genera that are radically different in shape and form from each other. These plants are dioecious. Even though these three genera are morphologically dissimilar, they are thought to be a true clade of plants.

**Learning Objectives:** Recognize each of the three genera as vessel-bearing gymnosperms.

Label each figure with the appropriate genus name (*Ephedra*, *Gnetum*, *Welwitschia*):

Genus: \_\_\_\_\_



Genus: \_\_\_\_\_



Genus: \_\_\_\_\_

