X. The Conifers and *Ginkgo*

Now we turn our attention to the Coniferales, another great assemblage of seed plants.

First let's compare the conifers with the cycads:

Cycads	Conifers
few apical meristems per plant	many apical meristems per plant
leaves pinnately divided	leaves undivided
wood manoxylic	wood pycnoxylic
seeds borne on megaphylls	seeds borne on stems

We should also remember that these two groups have a lot in common. To begin with, they are both groups of woody seed plants. They are united by a small set of derived features:

1. the basic structure of the stele (a *eustele* or a *sympodium*, two words for the same thing) and no leaf gaps

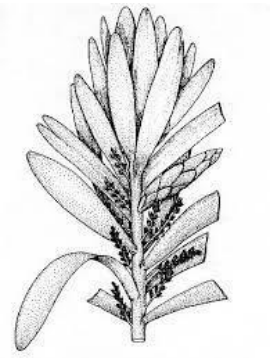
2. the design of the apical meristem (many initials, subtended by a slowly dividing group of cells called the central mother zone)

3. the design of the tracheids (*circular-bordered pits with a torus*)

We have three new seed plant orders to examine this week:

A. Cordaitales

This is yet another plant group from the coal forest of the Carboniferous. The best-known genus, *Cordaites*, is a tree with pycnoxylic wood bearing leaves up to about a foot and a half long and four inches wide. (Find it on the Peabody mural hanging in the lab!) In addition, these trees bore sporangia (micro- and mega-) in strobili in the axils of these big leaves. The megasporangia were enclosed in integuments, that is, they were ovules! Look at fossils of leaves and pollen-bearing shoots of *Cordaites*. The large, many-veined megaphylls are ancestral to modern pine needles; the shoots are ancestral to pollen-bearing strobili of modern conifers.



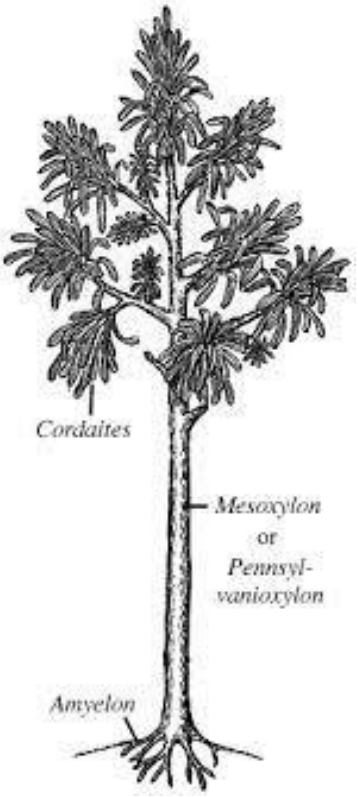
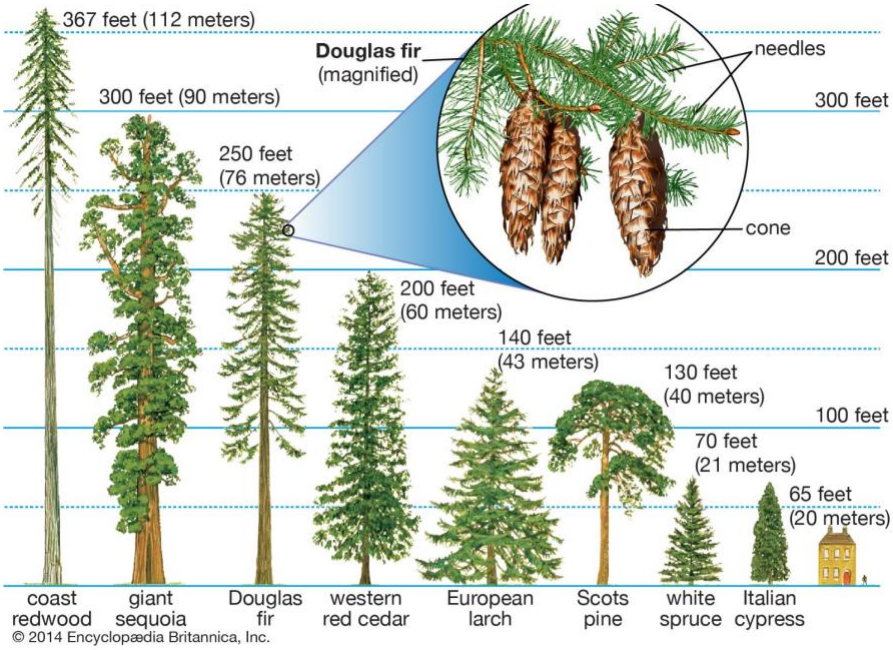


Figure 1. *Cordaites* life form and other form genera. With detail of the mico- and megasporangia in different strobili.

B. Coniferales

Here at last are some plants that we all know well already. Conifers are prominent in Vermont, as they are in a large part of the world. And yet, they are not that rich in species. The Coniferales are an old group: a number are known from the Triassic, and a few are even known from the Permian. All are wind-pollinated trees with seed- bearing cones and a unique new derived trait - sperm without flagellae.



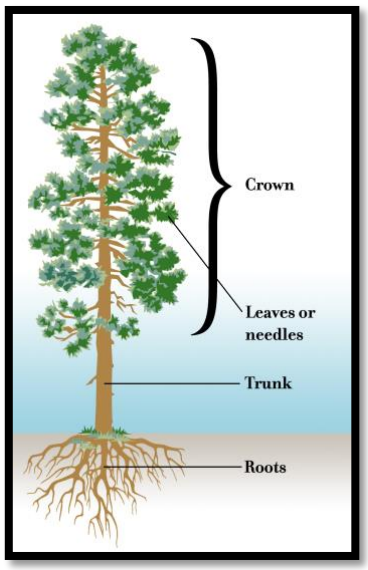


Figure 2. Conifer diversity and height. Detail of the whole organism to the right.

1. Life Form and Leaf Design

Look at plants or foliage of a diversity of conifers, in the lab and around campus. The leaves are single-veined, but they are inferred to be reduced megaphylls since early conifers and *Cordaites* had leaves with repeatedly branched veins.

Around Campus:

i. *Pinus* (pine) - stems with leaves in fascicles
ii. *Thuja* (arbor vitae) - four-ranked, scale-like leaves
iii.*_Picea_ (spruce)
iv.*_Pseudotsuga_ (Douglas fir)
v. *Metasequoia* (dawn redwood) - conifer with deciduous branches
vi. *Taxus* (yew) - coniferous shrub with red fleshy arils
vii. *Xanthocyparis nootkaensis* (Nootka cypress) - 4-ranked, scale-like leaves

*Collect a pollen cone and a seed cone of each of these two conifers and bring them back to the lab for further study

S1. Sketch one of the whole plants of one of the conifers, provide a detailed sketch of a branch tip focusing on leaf arrangement. Label parts in the diagram in Figure 2.

2. Wood and secondary growth

Look at a prepared slide of pine wood. There are three kinds of sections on the slide: the one that looks like fishnet is a transverse (cross) section and the two square ones are the radial (longitudinal through the middle of the twig) and tangential (longitudinal anywhere else).

a. The **circular-bordered pits**, located on the radial walls of the tracheids. These are more visible in the radial section, but more understandable in the transverse section. Look for them under high power.

b. The uniseriate (one cell in width) **parenchyma rays**. These are best seen end-on in the tangential section, but are also visible in the radial section, in which they look like microscopic brick walls, and in the transverse section, in which they look like narrow, pink lines.

c. The ray parenchyma cells are unusual in that they may have **secondary walls** (just when you thought you had this stuff figured out!). If they do, the secondary walls will have pits in them. You should be able to pick these out under high power.

d. You will also see circular **resin ducts**, large canals for the transport of resin.

S2. Make a sketch of all three sections. In each section, label the type of section it is and all the features underlined above.

3. Microsporangiate Strobili

Examine a prepared slide of a microsporangiate strobilus under the microscope. Note that the strobilus is a simple set of sporophylls with abaxial microsporangia. With luck, you should be able to see a pollen grain. Note that the pollen grains have small wing-like projections.

S3. Sketch a detailed strobilus, a microsporangium, and a pollen grain from this slide. Label the terms highlighted the images provided.

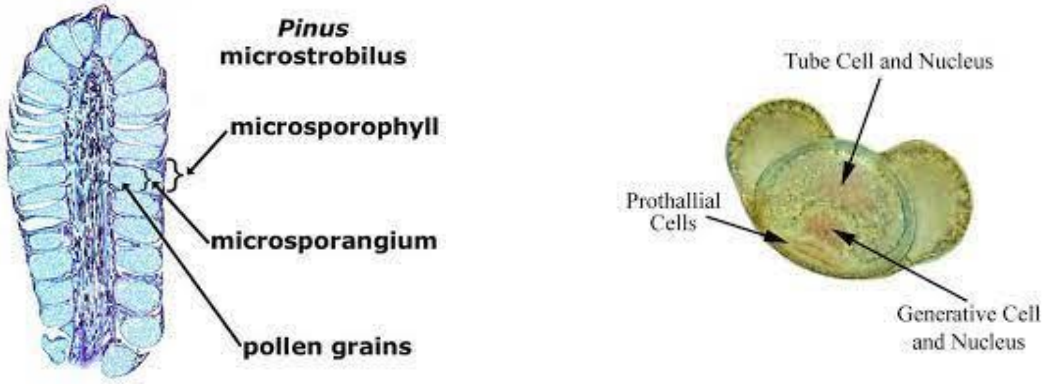


Figure 3. Microsporangiate strobilus and single pollen grain.

4. Ovules and Ovule-bearing Structures (Cones)
Begin by looking at whole cones of *Pseudotsuga menziesii*, Douglas fir.

a. The important point is that the flat segments in a conifer cone are not taken to be leaves, but rather compound structures called **bract-scale complexes**. The bract-scale complex comprises an axillary branch (called an **ovuliferous scale**) with an **ovule** or two attached to it; the scale is adnate to a reduced leaf (called a **bract**). The bracts and scales are easy to tell apart in *Pseudotsuga*.

Figure 4. Young *Pseudotsuga* ovulate cone with conspicuous green ovuliferous scales.

b. Now look at a *Pinus* cone slide briefly to see the same features. In these slides, the ovules are in their places on the adaxial surface of the bract-scale complex. The bract is visible as a dark structure underneath the ovuliferous scale. Some of these ovules are cut so that the micropyle is visible and it is open proximally (towards the center of the cone axis), which seems like a poor place to put something that is supposed to be getting pollen near it.

c. Look at other cones, especially those of *Juniperus*, to see the variety in cone types. The unusual thing about the juniper cone is that the bract scale complexes are fleshy.

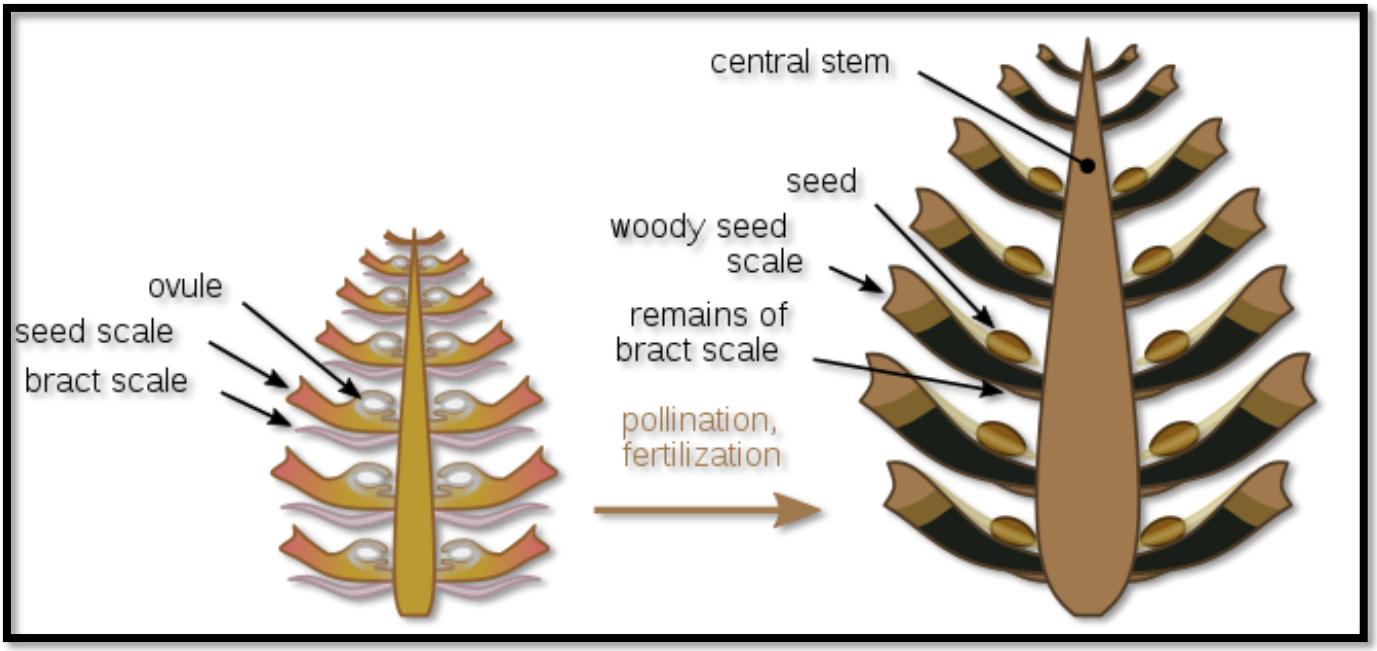


Figure 5. Typical female ovulate strobilus anatomy before fertilization and after.

d. Now look at a prepared slide of *Pinus* ovules. These slides have in them just a single bract scale complex. On the complex is an ovule that is mature enough to have a female gametophyte with a functional archegonium.

   Look closely - identify:

   i. outermost, the **integument** with a narrow entry to the interior, the **micropyle** (the micropyle is not visible in most slides)

   ii. the **nucellus** (megasporangium wall), which is not fused to the integument toward the micropylar end of the ovule - notice that there is a **beak** of the nucellus that projects right up into the region of the micropyle. In the beak are a few odd, large cells - these are cells of male gametophytes that are growing toward the female gametophyte below.

   iii. innermost, the **female gametophyt**e. Look for the huge **egg cells**, and if you have a median section of an archegonium, the neck cells as well.

e. Look at winged seeds of Norway spruce and other conifers. Wind dispersal is typical for the pines.

f. Finally, look at a pignola nut, which is actually the seed of a pine tree from the edge of the desert. The hard, brown seed coat (derived from the stony layer of the integument) has already been removed. What you have before you is a soft, tan, female gametophyte with an embryonic sporophyte within. Visible in the embryo are a radicle (near the micropylar end) and several cotyledons.

S4. Sketch a single cone in longitudinal section. Also the features the young ovule of a pine from the prepared section. Label the terms highlighted above and use the diagrams for reference.

If you like, eat the embryo and female gametophyte.

They're choice!

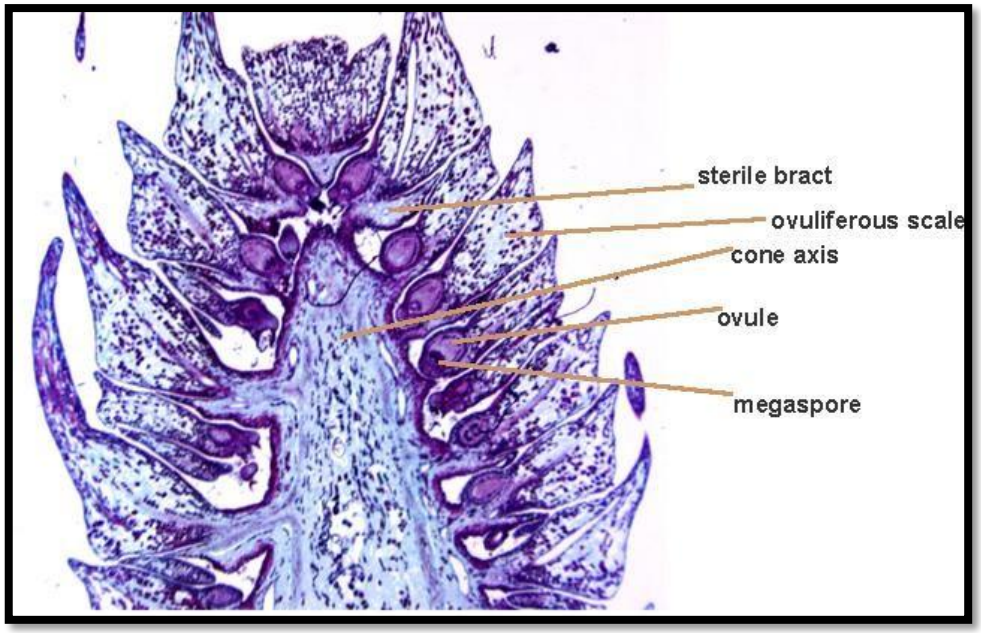


Figure 6. Ovulate strobilus after fertilization in longitudinal section.

C. Ginkgoales

The ginkgos are beautiful and mystical trees that are thought to remain alive because Chinese priestly gardeners kept the tree in cultivation – only recently have wild populations been found in nature.

1. To the Ginkgos!

a. Go on a walk with your lab section to take a look at the *Ginkgo* trees by Morrill Hall. At this time of year, it's easy to see the distinctive life form of these trees: a well-developed central axis with spreading branches to the sides. These branches show what is called a long-shoot/short-shoot organization.

b. Look closely at a **branch** (i.e. **long shoot**): every six inches to a foot there is a small, squat branch (i.e. **short shoot**) covered with leaf scars.

c. Within the next few weeks these buds will open to expose a cluster of leaves and reproductive structures.

2. Leaves and seeds

Underneath the trees you can see two more *Ginkgo* features - leaves and seeds.

a. The **leaves** are unique and beautiful - delicate, fan-shaped megaphylls with numerous **forked veins**. If you can, find one to take back to the lab and include in your notebook.

b. Also look for the smooth, straw-colored seeds. Some may still have the shriveled remains of the fleshy layer of the seed coat; others may just have the stony layer. (They'll look a bit like pistachios in their shells.) Take one or two back to lab if you can find them.

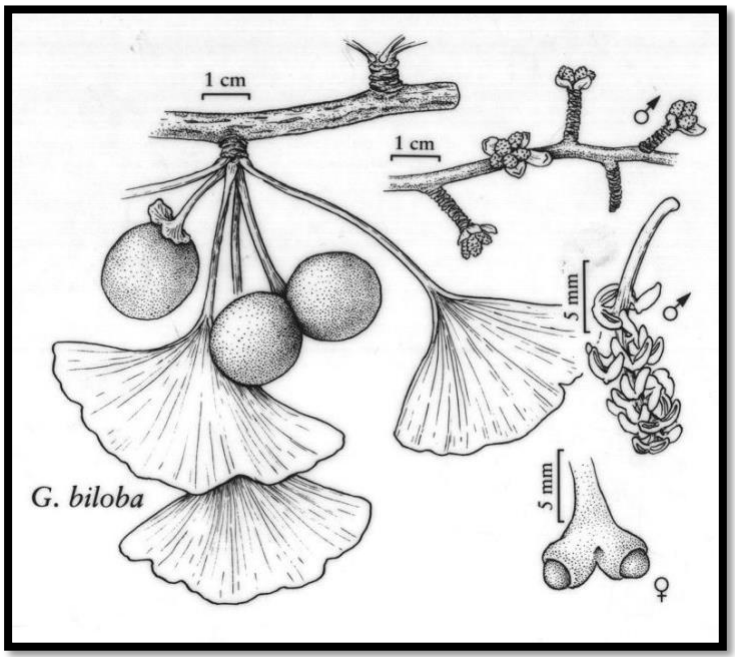


Figure 7. *Gingko biloba* morphology.

S5. Sketch a whole *Ginkgo* tree with a detailed view of the short shoots. Included a separate detailed sketch of the leaves. Label the terms highlighted above.

3. Microsporangia

Take a microsporangiate strobilus from the supply of pickled material and dissect it under the dissecting 'scope.

a. These loose, limp strobili (designed to shake their pollen into the wind) are called **catkins**. First, look at the location of the catkin on the short shoot to get oriented. Under the dissecting 'scope you should be able to see the layout of the strobilus.

b. The **microsporangia** are attached directly to the branchlets of the **strobilus axis** (there are no leaves in the strobilus). Notice that each little branchlet bears two sporangia. These are typical eusporangia, but remember that unlike the sporangia of spore-dispersed plants, these keep their spores through the first stages of male-gametophyte development.

c. Crush open some of the sporangia on a microscope slide and cover with a coverslip. Look for the **pollen** under the microscope. Remember that pollen grains are partially developed male gametophytes.

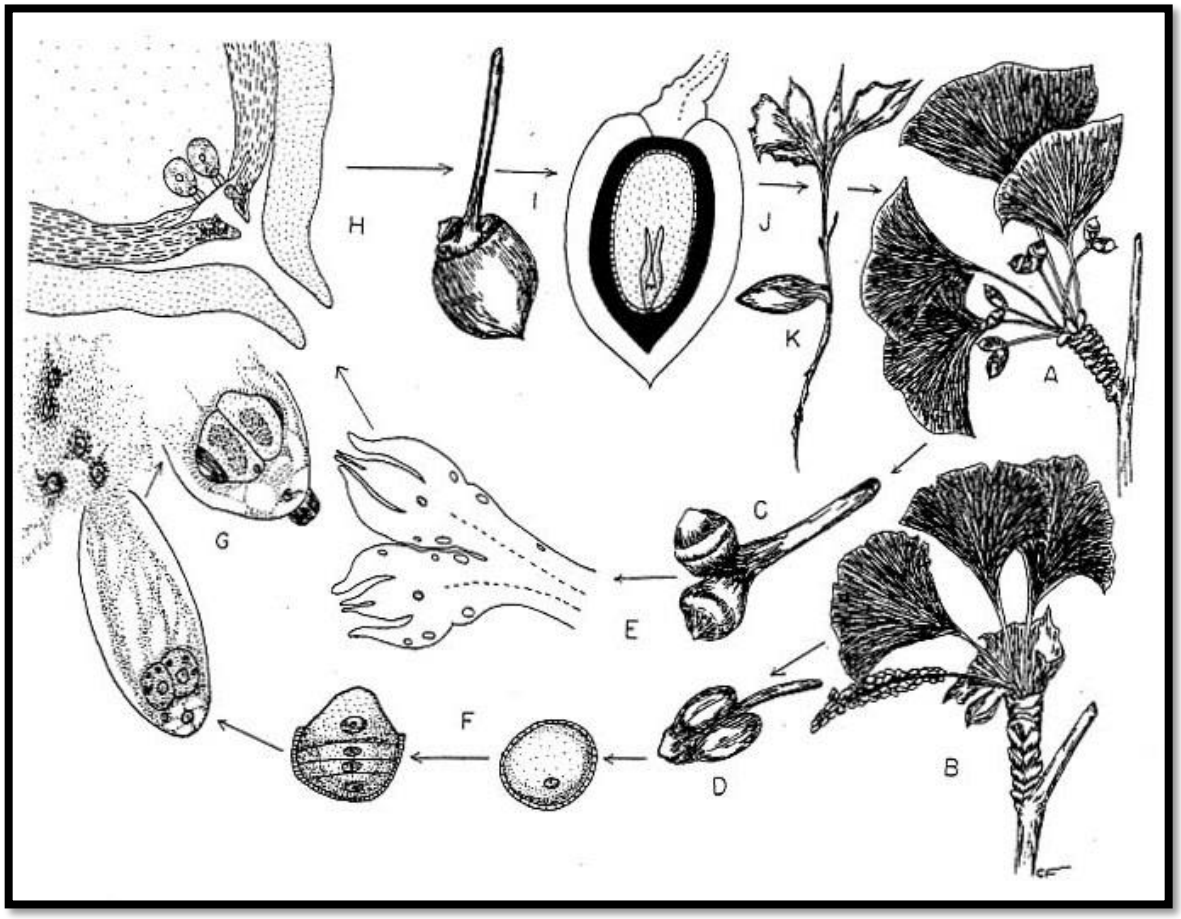


Figure 8. *Gingko biloba* life cycle.

4. Integumented megasporangia (Ovules)

Dissect the seed you collected (or get one from the supply in lab). Begin by making a longitudinal section down through the fleshy and the stony layers. Use a knife, scalpel, or a sharp razor blade and BE CAREFUL. Look for the following features in longitudinal section. You will find it useful to compare your seed to the prepared slide set out in the lab.

a. The **fleshy layer**, full of foul-smelling compounds that only a lizard could appreciate. Some of these are on display in the lab, in case you missed the fleshy layer on your visit to the tree.

b. the **stony layer**, the hardest of the integument layers

c. the **papery layer**: innermost of the integument layers. This layer adheres to the stony layer, but toward the end of the ovule with the interior space you can separate it from the stony layer.

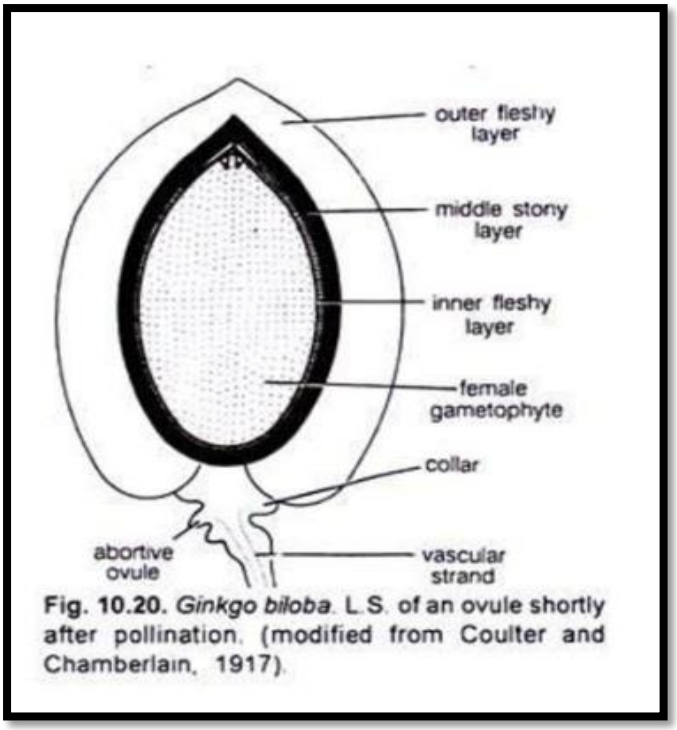


Fig. 10.20. *Ginkgo biloba*. L.S. of an ovule shortly after pollination. (modified from Coulter and Chamberlain, 1917).

Figure 9. *Gingko biloba* longitudinal section of an ovule after pollination

d. the **nucellus**: thought to be homologous with the megasporangium wall. The nucellus is fused to the papery layer for most of its length, but it is a separate layer that lies over the female gametophyte (innermost, greenish part of the seed) at the end with the interior space. A small projection of the female gametophyte called the **tent pole** holds the nucellus away from its summit, providing a chamber in which the flagellate sperm can swim.

e. You may find an embryonic **sporophyte** in the tissue of the female gametophyte. If so, look for cotyledons surrounding an embryonic stem apex (called an epicotyl) and at the other end an embryonic root apex (called a radicle).

S6. Sketch a mega- and microsporangium of *Ginkgo* in detail. Label the terms highlighted above.