Introduction

Vascular seed-bearing plants, such as **gymnosperms** (cone-bearing plants) and **angiosperms** (flowering plants) exhibit the most advanced adaptations for living in the terrestrial environment (see Table I in Plant Life Cycles and Adaptations I lab). They not only possess true vascular tissues (**xylem** which conveys water and minerals up from the roots, and **phloem** which distributes sugars throughout the plant), but also they complete their life cycles without the need for external water.

Instead of producing swimming sperm which must swim from the antheridium to the archegonium, seed-bearing plants produce **pollen grains** and **seeds**. Pollen grains are actually tiny male gametophyte plants that fertilize an egg through an extension of a **pollen tube**. The pollen tube fuses with the egg of the female gametophyte allowing a haploid male nucleus to join the haploid female nucleus in the egg. Pollen grains may be carried to the female gametophyte by the wind or by pollinating insects.

The female gametophyte develops and spends its entire life completely enveloped by sporophyte tissues, never living an independent life of its own. In the most common form of gymnosperms (**conifers**), the female gametophytes are found within female cones produced by the sporophyte. In the angiosperms, the female gametophyte may be found inside the **ovary** of the sporophyte-produced flowers.

After fertilization, the zygote develops only part-way to yield an embryo encased with essential nutrients as a seed. The seed may survive for a long time in a kind of "suspended animation" until encountering the minimal conditions for germination.

In this laboratory exercise you will learn about these seed-bearing plants and their life cycles. You should identify the features that distinguish gymnosperms and angiosperms. In addition, you should pay special attention to the adaptations exhibited by these plants for living successfully in the terrestrial environment. You will be provided with diagrams and other materials to assist you in making your observations.

Procedures and Assignments

**Bring several different kinds of fresh flowers to lab on the day of the lab activity.**

Read the appropriate information in your textbook, Campbell and Reece (2005), pages 591-606 (Ch. 30) and 771-780 (Ch. 38), before coming to the laboratory session. Bring this textbook, along with your Photoatlas for Biology, to lab to use as references.

I. **GYMNOSPERM**

Gymnosperms (Gr. *gymnos*, "naked," and *sperma*, "seed") include the cycads, ginkgos, and the conifers. In all of these groups, the seed does not develop inside an ovary. Gymnosperms do not produce flowers.

A. **Pine Life Cycle Display**

Examine the pine life cycle display. Relate the display materials to the diagram of the pine life cycle provided. Also attempt to relate these observations to other observations described below.

B. **Staminate (male) cone**

1. Examine the prepared slide of a longitudinal section through a mature male cone. Note the microsporangia in which diploid microspore mother cells (microsporocyte) produce haploid microspores through meiosis. Draw and label a diagram that illustrates 2 or 3 microsporangia.

2. The microspores develop into pollen grains, each of which bears a pair of external wings. Observe some mature pollen grains.

3. By what mechanism do pollen grains reach the ovule?

C. **Female Cone**

1. Examine the prepared slide of a longitudinal section through an ovulate female cone exhibiting megasporangia.
in which diploid megaspore mother cells (megasporeocyte) are still present. The megaspore mother cells produce haploid megaspores through meiosis. When meiosis occurs four haploid nuclei are produced from each megaspore mother cell, but three of these degenerate and only one will undergo mitosis to produce a haploid female gametophyte. It is at this stage that pollen grains may become trapped in the female cone. You may even see some pollen grains near the entrance into the ovule. Draw and label a typical ovule identifying the ovule, micropyle, megasporangium, integument, and megaspore mother cell.

2. Examine the prepared slide of a longitudinal section through a female in which the mature gametophytes have developed from the megaspore. Draw and label a diagram of this stage illustrating the gametophyte, its archegonia, and the eggs.

D. Pine Seeds

Examine the pine seeds on display. Note that each seed bears a leaf-like wing.

1. Draw and label a diagram of a typical pine seed.

2. How are pine seeds dispersed from the parent plant?

II. ANGIOSPERMS

Angiosperms (Gr. angion, "container") are all flowering plants whose seeds develop within an ovary. The wall of the ovary becomes the fruit. All angiosperms belong to a single plant division, Division Anthophyta (Gr. antho, "flower"). The fruit may function to protect the seeds and/or aid in the dispersal of the seeds from the parent plant.

A. Basic Plant Anatomy

Observe the plant models and specimens on display. Note the following structures: roots, stems and leaves. Do these structures possess vascular tissues? What are their respective functions?

B. Flower Anatomy

Examine the flower model on display. Identify the petals, sepals, stamens and carpel.

After becoming familiar with the parts of a typical flower, examine several different kinds of living flowers. Using both dissecting and compound microscopes, examine the parts of these flowers and relate them to the flower model.

1. Most petals are brightly colored. From what typical vascular plant structures do you think the petals are derived from? What function do the petals serve?

2. The stamen is the male part of the flower. Note that the stamen is composed of two parts, the anther and the filament. What is produced by the anther?

3. Examine some pollen grains and the prepared slide illustrating pollen tube formation. How are these pollen grains different from conifer pollen grains? By what mechanism are angiosperm pollen grains transferred to a different flower?

4. The carpel, the female part of the flower, is composed of three regions: the stigma (the sticky top of the pistil), the style (the neck), and the ovary. There may be one or more carpels in the flower. Together all of the carpels comprise the pistil. What is produced in the ovary?

5. Does the construction of the typical flower (e.g., the arrangement of the stamens relative to the pistil) permit easy transfer pollen to the stigma within a flower (i.e., self-pollination)?

6. There are many variations in flower structure. A flower with all its floral parts, i.e., sepals, petals stamens, carpels, is called complete. If any flower part is missing, the flower is said to be incomplete. If a flower has both male (stamens) and female parts (carpels), the flower is regarded as perfect. On the other hand, it either (or both) the stamens or carpels are missing, the flower is called imperfect. Describe the completeness (complete
vs. incomplete) and the perfectness (perfect vs. imperfect) of your flower specimens.

7. Draw and label a typical flower that identifies the following structures: sepal, stamen, anther, filament, carpel, ovary, style, stigma, ovule.

C. Pollen Tube Formation

When a pollen grain lands on the stigma of a flower, it begins to grow a pollen tube that extends through the style towards the ovary.

1. What is the function of the pollen tube?

2. Prepare a wet mount of pollen grains from an Impatiens flower in 1-2 drops of a 10% sucrose solution for microscopic examination. Initiation of pollen tube growth takes approximately 10 to 15 minutes. After pollen tube development has progressed somewhat, draw a labeled diagram illustrating what you observed.

D. Fruits

A fruit is a mature ovary containing seeds. Fruits protect dormant seeds and aid in their dispersal.

1. In the bean pod, the entire pod is the fruit. The wall of the pod is derived from the wall of the ovary of the flower. Open up a fresh bean pod and note the arrangement of the seeds. What function does the fruit serve in the bean pod?

2. Some fruits are fleshy, that is they possess layers of thick organic matter, often sweet, that appears to encourage animals to eat them, seeds and all. Slice open a fresh apple and note the arrangement of the seeds. From what original structure of the ovary is the fleshy part of the apple derived? What is the function of a fruit in an apple?

3. A variety of fruits may be placed on display. After examining each type, determine the likely function of each (e.g., protection, dispersal through animal ingestion, dispersal by attachment to animals, dispersal by the wind, or some other possible function).

E. Seeds: Monocots Versus Eudicots

Phylum Anthophyta is divided into two major groups: monocots, named for their single cotyledon (seed leaf) in each seed, and eudicots, which have two cotyledons in each seed. Monocots and dicots also differ from each other in leaf venation (parallel vs. network), arrangement of vascular tissues in stems (bundles vs. rings), root morphology (fibrous vs. taproots), and flower parts (multiples of three vs. multiples of four or five).

1. Examine a fresh corn seed. Cut in half longitudinally. Compare this seed to the corn seed model on display. The embryo consists of the single cotyledon, the plumule (becomes the shoot) and the radicle (becomes the root). The rest of the seed consists of the triploid endosperm composed primarily of starch. The entire seed is covered by a seed coat. During germination, the cotyledon releases an enzyme that breaks down the starch into simpler sugars which are then absorbed into the embryo. These sugars supplies the germinating seedling with materials and energy for growth until it is able to support itself through its own photosynthesis. Draw a diagram that illustrates a longitudinal section of corn seed and label the following structures: seed coat, endosperm, cotyledon, plumule, and the radicle.

2. Examine a pre-soaked lima bean. Remove the seed coat and split apart the two cotyledons revealing the plumule and radicle. Note that no endosperm can be seen. During the development of the bean seed the endosperm was completely absorbed by the cotyledons. Draw a diagram that illustrates a split-open lima bean and label the following structures: seed coat, cotyledon, plumule, hypocotyl, and the radicle.

3. Prepare a short summary table (call this Table I) that compares the corn seed with the lima bean in regards to the number of cotyledons, size of the embryo, and presence of endosperm.

4. Obtain four bean seeds, four corn kernels, some vermiculite, and two clear plastic cup planters from your instructor.
Take these home and plant the four bean seeds in one planter and the four corn kernels in the other. The seeds should be placed about two cm below the surface of the vermiculite near the sides of the planters so that they may be seen from the outside. Water the planters until the soil is uniformly moist and placed in a warm, well-lit location at home. Each day observe the seeds (water if necessary) and record (in table form) the day when each of the following developmental events occurs.

**For the bean seed:** (1) breaking of the seed coat; (2) emergence of the radicle; (3) first development of secondary roots; (4) emergence of the hypocotyl; (5) emergence of the hypocotyl above the vermiculite surface; (6) straightening of the hook; (7) appearance of the epicotyl; and (8) the emergence and unfolding of the true foliage leaves.

**For the corn kernel:** (1) emergence of the radicle; (2) first development of secondary roots; (3) emergence of the coleoptile from the kernel; (4) emergence of the coleoptile above the vermiculite surface; and (5) the emergence of the true foliage leaves.

5. In a short paragraph or two, contrast germination in monocots and dicots as exhibited by corn kernels and lima beans.

### III. SUMMARY FOR SEED PLANTS

#### A. Adaptations to the Terrestrial Environment

Answer the following questions regarding the adaptations of seed plants for their survival in the terrestrial environment.

1. How do seed plants obtain water and minerals from the environment?
2. How do seed plants transport water?
3. How do seed plants oppose the force of gravity?
4. How do seed plants complete their reproductive cycles without the dependence on external water?

#### B. Summary Table

Fill in the table below with the appropriate information.

<table>
<thead>
<tr>
<th></th>
<th>Dominant Generation</th>
<th>Vascular Tissue</th>
<th>Fertilization</th>
<th>Dispersal of Species</th>
<th>Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiosperm</td>
<td>sporophyte or gametophyte</td>
<td>present or absent</td>
<td>swimming sperm or pollen tubes</td>
<td>explain the mechanism</td>
<td>present or absent</td>
</tr>
<tr>
<td>Gymnosperm</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

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**TABLE II**

COMPARING GYMNOSPERMS AND ANGIOSPERMS
VOCABULARY

seed
gymnosperm
angiosperm
xylem
phloem
pollen grain
pollen tube
conifer
staminate cone
microsporangium
microspore mother cell
microsporocyte
microspore
ovulate cone
megasporangium
megasporocyte
megaspore
flower
fruit
petal
sepal
stamen
carpel
pistil
anther
filament
stigma
style
ovary
ovule
fleshy fruit
cotyledon
monocot
dicot
plumule
radicle
hypocotyl
epicotyl
coleoptile
triploid
endosperm
seed coat

Lab Summary

Your lab summary should consist of the following:

1. Descriptive title
2. Short introduction identifying main objectives of the lab activity.
4. Results and Discussion section including labeled diagrams and tables as described in the Procedures and Assignment section above and following the appropriate protocols for presenting figures and tables in a laboratory report. Be sure to follow all of the rules from producing figures for lab reports (one figure per page). Corresponding to each figure, there should be a short paragraph that describe the significant features of the figure.
5. In addition, be sure to answer all questions asked.
6. Please organize your report with numbered sections corresponding to the numbered sections in the Procedures and Assignment section of this lab description.
7. Short conclusion summarizing what was learned.
1. Branch with staminate cones
2. Portion of staminate cone in longitudinal section
3. Microspore
4. Microsporangium
5. Microsporophyll
6. Prothallial cells
7. Generative cell
8. Tube cell
9. Male gametophyte (pollen grain)
10. Wing
11. Branch with ovulate cone
12. Portion of ovulate cone in longitudinal section
13. Ovuliferous scale (nucellus)
14. Megaspore mother cell
15. Micropyle
16. Integument
17. Growing megaspore (three degenerate)
18. Female gametophyte, free-nuclear stage
19. Female gametophyte, develops one of the four embryos, only one seed develops
20. Megaspore coat
21. Pollen tubes
22. Archegonia
23. Female gametophyte
24. Male nucleus
25. Egg
26. Zygote
27. Two free nuclei, from division of zygote
28. Four free pro-embryonic nuclei
29. Apical cells of embryos
30. Suspensor cells of embryos. Of these four embryos, only one develops into a seed
31. Seed
32. Cotyledons
33. Seed coats
34. Hypocotyl
35. Seedling

Figure 1. Pine life cycle.
Figure 2. Lily life cycle.

A. Habit of plant
B. Longitudinal section of flower
C. Cross section of anther
D. Germinating pollen grain
E. Cross section of ovary
F. Section of ovule, 8 - nucleate stage
G. Section of ovule, double - fertilization stage
H. Section showing embryo
I. Seedling (habit)

1. Anther
2. Ovary
3. Pollen grain
4. Generative nucleus
5. Tube nucleus
6. Sperm nuclei
7. Pollen tube
8. Ovule
9. Embryo sac
10. Antipodal cells
11. Polar nuclei
12. Egg nucleus
13. Synergide
14. Remains of pollen tube
15. Embryo
16. Endosperm
17. Seed
18. Root
19. Leaf
Figure 3. Seed germination
Figure 4. Comparison of Monocots and Dicots

A1. Flower parts usually in threes or sixes
A2. Flower parts usually in fours or fives
B1. Leaves usually parallel veined
B2. Leaves usually net veined
C1. Stems endogenous, bundles separate and irregular in arrangement
C2. Stems exogenous, with central pith and outer cortex separated by bundles which form a hollow tube; annual rings in woody stems
D1. Roots have several to many xylem elements
D2. Roots usually have three, four or five xylem elements
E1. One cotyledon, or seed leaf
E2. Two cotyledons, or seed leaves