# Table of Contents

PLSC 211 Syllabus .................................................................................................................... 3
Lab 1: Plant Identification ...................................................................................................... 7
Lab 2: Sexual Propagation ................................................................................................. 22
Lab 3: Asexual Propagation ............................................................................................. 29
Lab 4: Plant Growth Regulation ...................................................................................... 35
Lab 5: Plant Nutrition ....................................................................................................... 36
Lab 6: Designing of a Flower Garden ................................................................................. 49
Lab 7: Greenhouse Production .......................................................................................... 50
Lab 8: Landscape Design .................................................................................................. 57
Lab 9: Pruning and Training ............................................................................................. 60
Lab 10: Lawn Care ............................................................................................................ 68
Lab 11: Plants for Interiors ............................................................................................... 74
Lab 12: Exercise on Fruits ............................................................................................... 100

# Acknowledgments

Special thanks to Vickie Azcuenaga, Rick Abrahamson, Barbara Laschkewitsch, and Louise Heinz for their contributions and technical assistance in the preparation of this lab manual.
PLSC 211-HORTICULTURE SCIENCE LAB (1 Credit)
Fall Semester, 2010
Department of Plant Sciences

1. GENERAL INFORMATION
   a. Instructors: Dr. Chiwon William Lee, Professor
      Office: Room 266-F, Loftsgard Hall
      Phone: 701-231-8062, fax 701-231-8474, cell 701-361-9411
      E-mail: <chiwon.lee@ndsu.edu>

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      E-mail <naa.ardayfio@ndsu.edu>

      Stephanie Olson, Teaching Assistant
      Phone 701-306-3279
      E-mail <stephanie.olson@ndsu.edu>

   b. Class Hours: Section 1: 1:00-2:50 p.m. Mon
      Section 2: 3:00-4:50 p.m. Mon
      Section 3: 1:00-2:50 p.m. Wed
      Section 4: 3:00-4:50 p.m. Wed

   c. Place: Horticulture Greenhouse Classroom

   d. Web Site: http://www.ndsu.nodak.edu/pubweb/chiwonlee/plsc211/

   e. Related Course: PLSC 210-Horticulture Science (3 Credits)
      General education class
      10 a.m. Mon, Wed, Fri (Loftsgard Hall 114)
      (http://www.ndsu.nodak.edu/pubweb/chiwonlee/chlee/plsc210/)

2. OBJECTIVES
   a. Rationale

      Horticulture enriches our lives by providing such basic requirements as nutritious food, esthetic
      environment, and emotional well-being. Gardening and other horticultural practices have long
      been considered as the most favorite leisure activities in American life. This class is designed to
      provide first-hand experiences in basic horticulture to students interested in the subject.

   b. Goals

      Upon completion of this class, students will have the basic knowledge and skills in horticulture.
      With practical experience, students will be familiar with a wide range of subject matter
      including plant identification, propagation, controlled environment production, horticulture
      information retrieval system, pruning, and lawn care, plants for interior uses, and fruits and
      vegetables.
3. WHO SHOULD TAKE THIS COURSE

a. Horticulture Majors

This course is required for all incoming horticulture majors. Students majoring in horticulture must complete this class before taking other horticulture courses in the Department of Plant Sciences. Transfer students who completed a similar course from a two-year technical college or other institution must consult the instructor to determine whether this course can be waived.

b. Non-Majors

This class is available to all students interested in the subject matter for the general education requirement in science and technology. This course is designed to provide a broad range of training in practical horticulture to any student who likes to work with plants.

4. TEXTBOOK


5. COURSE CONTENT

a. Introduction - General introduction to the field of horticulture and horticulture greenhouse facility
b. Local greenhouse tour - Two-hour field trip to a local greenhouse
c. Plant identification - Nomenclature, classification, identification of selected horticultural plants
d. Sexual propagation - Plant propagation by seed, germination test, scarification, stratification
e. Asexual propagation - Plant propagation by cuttings, layering, grafting, tissue culture, division, underground storage organs such as bulbs and corms
f. Horticulture internet - Horticulture websites, writing internet articles using web-authoring programs
g. Plant nutrition - Macro- and micronutrients, fertilizer calculation, nutrient deficiency symptoms
h. Flower garden design - Garden design for annual and perennial flowering plants
i. Greenhouse production - Environmental control, facility, culture, light measurements, hobby greenhouses
j. Landscape design - Landscape design principles, landscape installation and maintenance
k. Pruning and training - Basic and practices of tree training and pruning
l. Lawn care - Identification of warm-season and cool-season turfgrasses, care lawns for homes, golf courses, and other recreational facility
m. Interior plants - Identification of foliage plants, cultural requirement, interior landscaping
n. Exercise on fruits - Classification and identification, cultural requirements, tasting of various fruits and nuts
o. Plant growing – Practical experience in propagating and growing selected greenhouse crops

6. LAB REPORTS

Seven lab reports are submitted throughout the semester. Each is worth 20 points.
7. EXAMINATIONS

There will be one mid-term exam and a final exam (lab practical). One-third of the final exam is comprehensive covering old materials. Each exam is worth 65 points.

8. GRADING

<table>
<thead>
<tr>
<th>Points</th>
<th>Grading Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seven weekly lab reports 140</td>
<td>A 90-100%</td>
</tr>
<tr>
<td>Horticulture article 30</td>
<td>B 80-89%</td>
</tr>
<tr>
<td>Mid-term lab examination 65</td>
<td>C 70-79%</td>
</tr>
<tr>
<td>Final lab examination 65</td>
<td>D 60-69%</td>
</tr>
<tr>
<td>Total 300</td>
<td>F &lt;60%</td>
</tr>
</tbody>
</table>

9. STUDENT OUTCOMES ASSESSMENT

You are required to take a pre-test for the course material during the first week of class and complete the post-test during the last week of semester. These tests are administered via an internet website (http://www.ndsu.nodak.edu/pubweb/chiwonlee/plsc211/). Those who participate in both the pre- and post-tests will receive 10 extra points toward their final grades.

10. ADDITIONAL INFORMATION

a. Class Attendance

Regular attendance of classes is required. In case of sickness or other emergencies, students should contact the instructor so that make-up lab exercise can be arranged.

b. Students with Special Needs

Any student with disabilities or other special needs, who needs special accommodations in this course, is invited to share these concerns or requests with the instructor as soon as possible.

c. Office Hours

Office hours for the instructor: 8:30 a.m.-12:00, Tues and Thurs. Please put your name on the appointment calendar on the door (Room 266F, Loftsgard Hall) for office visits. You may also arrange for an appointment by e-mail (chiwon.lee@ndsu.edu) or telephone (office 701-231-8062, mobile 701-361-9411).
<table>
<thead>
<tr>
<th>Week</th>
<th>Lab No.</th>
<th>Sections I, II (Mon)</th>
<th>Sections III, IV (Wed)</th>
<th>Lab Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wk 1</td>
<td>Lab 1</td>
<td>Aug 30</td>
<td>Sep 1</td>
<td>Plant Identification</td>
</tr>
<tr>
<td>Wk 2</td>
<td>-</td>
<td>(Sep 6)*</td>
<td>Sept 8</td>
<td>Local Greenhouse Tour</td>
</tr>
<tr>
<td>Wk 3</td>
<td>Lab 2</td>
<td>Sep 13</td>
<td>Sep 15</td>
<td>Sexual Propagation</td>
</tr>
<tr>
<td>Wk 4</td>
<td>Lab 3</td>
<td>Sep 20</td>
<td>Sep 22</td>
<td>Asexual Propagation</td>
</tr>
<tr>
<td>Wk 5</td>
<td>Lab 4</td>
<td>Sep 27</td>
<td>Sep 29</td>
<td>Horticultural Website Design (IACC 114)</td>
</tr>
<tr>
<td>Wk 6</td>
<td>Lab 5</td>
<td>Oct 4</td>
<td>Oct 6</td>
<td>Plant Breeding Exercise</td>
</tr>
<tr>
<td>Wk 7</td>
<td>Lab 6</td>
<td>Oct 11</td>
<td>Oct 13</td>
<td>Plant Nutrients and Fertilizers</td>
</tr>
<tr>
<td>Wk 8</td>
<td>Lab 7</td>
<td>Oct 18</td>
<td>Oct 20</td>
<td>Flower Garden Design (Midterm Exam)</td>
</tr>
<tr>
<td>Wk 9</td>
<td>Lab 8</td>
<td>Oct 25</td>
<td>Oct 27</td>
<td>Controlled Environment Production</td>
</tr>
<tr>
<td>Wk 10</td>
<td>Lab 9</td>
<td>Nov 1</td>
<td>Nov 3</td>
<td>Pruning Principles and Practices</td>
</tr>
<tr>
<td>Wk 11</td>
<td>Lab 10</td>
<td>Nov 8</td>
<td>Nov 10</td>
<td>Landscape Design</td>
</tr>
<tr>
<td>Wk 12</td>
<td>Lab 11</td>
<td>Nov 15</td>
<td>Nov 17</td>
<td>Plant Hormones and Growth Regulators</td>
</tr>
<tr>
<td>Wk 13</td>
<td>Lab 12</td>
<td>Nov 22</td>
<td>Nov 24</td>
<td>Plants for Interiors</td>
</tr>
<tr>
<td>Wk 14</td>
<td>Lab 13</td>
<td>Nov 29</td>
<td>Dec 1</td>
<td>Fruits, Vegetables, and Health</td>
</tr>
<tr>
<td>Wk 15</td>
<td>Lab 14</td>
<td>Dec 6</td>
<td>Dec 8</td>
<td>Free labs and Reviews</td>
</tr>
<tr>
<td>Wk 16</td>
<td>Lab 15</td>
<td>Dec 13</td>
<td>Dec 15</td>
<td>Final Exam</td>
</tr>
</tbody>
</table>

Dates for lab exercises are subject to change. *No classes (holidays)
Lab Exercise 1
PLANT IDENTIFICATION

Objectives:

1. To introduce plant nomenclature and classification.
2. To become familiar with basic plant morphology.
3. To begin to identify plants using morphological characteristics.

Introduction

Plants can be identified by observing certain distinguishing morphological characteristics. Some plants are closely related, which is shown by the similarity of their flower structures. These plants are placed into a specific plant family. A herbaceous example of a family that is based on similarity of flower parts would be Asteraceae, the aster family, of which marigolds and zinnias are members. An example of a woody plant family would be Aceraceae to which maples belong.

Within each family there are members that are more closely related than others. This relationship is demonstrated by the similarity of basic morphological traits like leaf shape or arrangement. These plants are placed in a group called a genus. Maples belong to the genus Acer, while marigolds are placed in the genus Tagetes.

Members of a plant genus are again subdivided, according to their similar morphological characteristics, into a grouping called a species. For example, each different type of maple belongs to a different species (see list below).

The Binomial Plant Classification System, which we have just described, gives each plant a scientific name using the genus and species.

Examples of scientific names:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer saccharinum</td>
<td>Silver maple</td>
</tr>
<tr>
<td>Acer platanoides</td>
<td>Norway maple</td>
</tr>
<tr>
<td>Tagetes erecta</td>
<td>African marigold</td>
</tr>
<tr>
<td>Tagetes patula</td>
<td>French marigold</td>
</tr>
</tbody>
</table>

When botanists group plants, they use flower parts as their primary guide because the flower is the least affected by growing conditions. In this lab we will be looking at leaf characteristics to help us identify plants because they are more likely to be available to you.
Plant Classification Lecture Outline

A. Plant Nomenclature

1. Binomial classification system
   a. Two Latin names:
      genus - the first letter is capitalized
      species - all lower case
   b. Varieties and cultivars:
      Variety -
      Cultivar -
   c. Importance:

B. Morphological Characteristics

1. Plant types
   a. Woody
      1) deciduous
      2) evergreen
   b. Herbaceous
      1) annual
      2) perennial
      3) biennial

2. Leaf types (we will study this in detail in lab)
3. Fruit types

   a. pod  
   b. silleque  
   c. capsule

   d. samara  
   e. schizocarp  
   g. achene

   h. nut (acorn)  
   i. berry  
   j. pome

   k. pepo  
   l. cone  
   m. hesperidium

   n. aggregate fruit  
   o. multiple fruit

4. Inflorescence

   Flowers are borne on structures called inflorescence, which is a collection of individual flowers arranged in a specific order or form.

   a. spike  
   b. catkin

   c. raceme  
   d. corymb

   e. umbel  
   f. compound umbel

   g. cyme  
   h. panicle

   i. head  
   j. solitary flower

5. Other characteristics
PLANT MORPHOLOGY

In order to successfully identify woody plants it is necessary for an individual to have a keen awareness (working knowledge) of taxonomic terminology and concise mental pictures of leaf, bud, stem, flower, and fruit morphology.

LEAF MORPHOLOGY

ANGIOSPERM LEAF TYPES

Simple Leaf vs. Compound Leaf

The position of the bud determines whether the leaf is simple or compound. In the case of the single leaf the bud is found in the axil of the leaf and stem. If the bud is located in the axil of a structure containing more than one leaf it is termed compound. Compound leaves may have from three to 1500 leaflets. Ex: Acer with three or Albizia julibrissin with 400 to 1500 leaflets.

Variation in Compound Leaves

- **Palmate**
  - Ex: Acanthopanax, Parthenocissus

- **Odd Pinnate**
  - Ex: Acer negundo, Fraxinus

- **Even Pennate**
  - Ex: Gleditsia
**Bipinnately Compound Leaves**

Bipinnately compound leaves are twice divided. What was considered the leaflet of the pinnately compound leaf is now another leaf-bearing axis to which additional leaflets are attached. The new leaf bearing axes are referred to as pinnae. Each pinna has a certain number of leaflets. Ex: *Gymnocalcndus, Albizia, Gleditsia* (in certain instances).

**ANGIOSPERM LEAF TYPES**

Cone-bearing or naked seeded plants often display different leaf types than those associated with angiosperm plants. Not all conifers (or cone-bearers) have evergreen foliage (exceptions include *Taxodium, Metasequoia, Larix, and Pseudolarix*).

<table>
<thead>
<tr>
<th>Leaf Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awl-like</td>
<td>The needles (leaves) are shaped like an awl. They are usually very sharp to the touch. Many <em>Juniperus</em> (Junipers) exhibit awl-shaped foliage. This character is manifested in juvenile forms of juniper, however, there are many species and cultivars (<em>Juniperus communis, J. Procumbens, J chinensis</em> ‘Pyramidalis’ to name a few) which possess the awl-like of needle foliage in youth and old age.</td>
</tr>
<tr>
<td>Scale-like</td>
<td>Scale-like foliage overlaps like the shingles on a roof or the scales on a fish. This type of foliage is relatively soft to the touch. <em>Thuja, Chamaecyparis, Cupressus, Calocedrus</em> and many <em>Juniperus</em> species exhibit this type of foliage.</td>
</tr>
<tr>
<td>Needle-like</td>
<td>Needle-like foliage is typical of several evergreen genera and species. The drawing depicts the foliage of a 5-needled pine. In the genus <em>Pinus</em> the leaves (needles) are usually contained in fascicles of 2, 3, 2 and 3, or 5. Other species such as <em>Abies, Picea, Cedrus, Pseudotsuga</em>, and <em>Taxus</em> have the needles borne singly or in clusters along the stem. The needles may be relatively flat (2-sided) or angular (often quadrangular) in cross-section.</td>
</tr>
</tbody>
</table>
ARRANGEMENT OF LEAVES

Many vegetative keys employ the arrangement of leaves and buds as a basis for separation. The use of the four categories by the student allows him/her to categorize plants into groups and assists in eliminating many plants from consideration in the process of positive identification.

Opposite
Leaves and buds directly across from each other on the stem. Ex: Acer, Lonicera, Deutzia, Viburnum.

Alternate
Leaves and buds are spaced in alternating fashion along the axis of the stem and seldom, if ever, are seated directly across from each other. Ex: Betula, Fagus, Quercus, Celtis, Ulmus, Carya, Juglans.

Subopposite
Subopposite refers to a condition where the leaves and buds are not spaced sufficiently far apart to be considered alternate nor are they perfectly opposite, hence, the term subopposite. Ex: Rhamnus cathartica, Cercidiphyllum japonicum, Chionanthus virginicus.

Whorled
Whorled refers to a condition when three buds and leaves (or more) are present at a node. Ex: Catalpa, Hydrangea paniculata 'Grandiflora', Cephalanthus occidentalis.
LEAF VENATION

Pinnate
The leaf has a prominent central vein (often termed the midrib) which extends from the base, where the petiole attaches to the blade, to the apex of the leaf. If the interveinal areas were removed the overall effect would be that of a fishbone. Pinnate venation occurs in the leaves of many plant types. The elm (*Ulmus*) and oak (*Quercus*) are classic examples.

Palmate
There are several main veins all of approximately equal size which extend from the base of the leaf to the apex of the lobe or margin of leaf. Ex: *Acer, Platanus, Cercis*.

Dichotomous
A very limited type of venation, the most familiar representative of which is *Ginkgo biloba*. The basal veins extend for a distance and then branch forming a “Y” type pattern.

Parallel
Typical of many monocotyledonous plants. The veins run essentially parallel to each other along the long axis of the leaf. Ex: *Zea* (corn), *Ruscus, Danae*. 
LEAF SHAPES

The tremendous quantity of terminology related to leaf shapes can be confusing. Association of the following pictures with the terms will help to alleviate the burden of strict terminology. This also applies to leaf bases, margins, and apices.

- Ovate
- Lanceolate
- Cordate
- Elliptical
- Spatulate
- Obovate
- Oblanceolate
- Obcordate
- Oblong
- Linear
- Peltate
- Cuneate
- Reniform
- Hastate
### LEAF BASIS

<table>
<thead>
<tr>
<th>Basis</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuneate</td>
<td><img src="image1" alt="Cuneate" /></td>
</tr>
<tr>
<td>Acute</td>
<td><img src="image2" alt="Acute" /></td>
</tr>
<tr>
<td>Rounded</td>
<td><img src="image3" alt="Rounded" /></td>
</tr>
<tr>
<td>Cordate</td>
<td><img src="image4" alt="Cordate" /></td>
</tr>
<tr>
<td>Oblique</td>
<td><img src="image5" alt="Oblique" /></td>
</tr>
<tr>
<td>Sagitate</td>
<td><img src="image6" alt="Sagitate" /></td>
</tr>
<tr>
<td>Hastate</td>
<td><img src="image7" alt="Hastate" /></td>
</tr>
<tr>
<td>Truncate</td>
<td><img src="image8" alt="Truncate" /></td>
</tr>
<tr>
<td>Auriculate</td>
<td><img src="image9" alt="Auriculate" /></td>
</tr>
</tbody>
</table>

### LEAF MARGINS

<table>
<thead>
<tr>
<th>Margin</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire</td>
<td><img src="image10" alt="Entire" /></td>
</tr>
<tr>
<td>Serrate</td>
<td><img src="image11" alt="Serrate" /></td>
</tr>
<tr>
<td>Serrulate</td>
<td><img src="image12" alt="Serrulate" /></td>
</tr>
<tr>
<td>Doubly-Serrate</td>
<td><img src="image13" alt="Doubly-Serrate" /></td>
</tr>
<tr>
<td>Dentate</td>
<td><img src="image14" alt="Dentate" /></td>
</tr>
<tr>
<td>Crenate</td>
<td><img src="image15" alt="Crenate" /></td>
</tr>
<tr>
<td>Incised</td>
<td><img src="image16" alt="Incised" /></td>
</tr>
<tr>
<td>Sinuate</td>
<td><img src="image17" alt="Sinuate" /></td>
</tr>
<tr>
<td>Undulate</td>
<td><img src="image18" alt="Undulate" /></td>
</tr>
<tr>
<td>Lobed</td>
<td><img src="image19" alt="Lobed" /></td>
</tr>
</tbody>
</table>
### LEAF APICES

<table>
<thead>
<tr>
<th>Mucronate</th>
<th>Cuspidate</th>
<th>Acuminate</th>
<th>Acute</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Mucronate" /></td>
<td><img src="image2" alt="Cuspidate" /></td>
<td><img src="image3" alt="Acuminate" /></td>
<td><img src="image4" alt="Acute" /></td>
</tr>
<tr>
<td>Obtuse</td>
<td>Truncate</td>
<td>Emarginate</td>
<td>Obcordate</td>
</tr>
<tr>
<td><img src="image5" alt="Obtuse" /></td>
<td><img src="image6" alt="Truncate" /></td>
<td><img src="image7" alt="Emarginate" /></td>
<td><img src="image8" alt="Obcordate" /></td>
</tr>
</tbody>
</table>
Lab 1. List of Plants for Identification

This list is representative of the plants commonly found in landscapes. You will be responsible for identifying some or all of them on the exam.

**Woody Plants:**

1. American Elm *Ulmus americana*
2. Green Ash *Fraxinus pennsylvanica*
3. Flowering Crabapple *Malus sp.*
4. Bur Oak *Quercus macrocarpa*
5. Colorado Spruce *Picea pungens*
6. Ponderosa Pine *Pinus ponderosa*
7. American Linden *Tilia americana*
8. Creeping Juniper *Juniperus horizontalis*
9. Silver Maple *Acer saccharinum*

**Herbaceous Plants:**

1. Petunia *Petunia hybridra*
2. Zinnia *Zinnia elegans*
3. Geranium *Pelargonium hortorum*
4. African Marigold *Tagetes erecta*
5. French Marigold *Tagetes patula*
**Plant Identification Key**

### A. Woody Plants

<table>
<thead>
<tr>
<th>#1 Name</th>
<th>Plant type</th>
<th>Leaf arrangement</th>
<th>Leaf type</th>
<th>Leaf margin</th>
<th>tip</th>
<th>shape</th>
<th>Fruit type</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2 Name</td>
<td>Plant type</td>
<td>Leaf arrangement</td>
<td>Leaf type</td>
<td>Leaf margin</td>
<td>tip</td>
<td>shape</td>
<td>Fruit type</td>
</tr>
<tr>
<td>#3 Name</td>
<td>Plant type</td>
<td>Leaf arrangement</td>
<td>Leaf type</td>
<td>Leaf margin</td>
<td>tip</td>
<td>shape</td>
<td>Fruit type</td>
</tr>
<tr>
<td>#4 Name</td>
<td>Plant type</td>
<td>Leaf arrangement</td>
<td>Leaf type</td>
<td>Leaf margin</td>
<td>tip</td>
<td>shape</td>
<td>Fruit type</td>
</tr>
</tbody>
</table>

Other characteristics:
#5 Name

Plant type_________ Leaf arrangement___________ Leaf type__________

Leaf margin________ tip__________ shape_________ Fruit type__________

Other characteristics:

#6 Name

Plant type_________ Leaf arrangement___________ Leaf type__________

Leaf margin________ tip__________ shape___________ Fruit type__________

Other characteristics:

#7 Name

Plant type_________ Leaf arrangement___________ Leaf type__________

Leaf margin________ tip__________ shape___________ Fruit type__________

Other characteristics:

#8 Name

Plant type_________ Leaf arrangement___________ Leaf type__________

Leaf margin________ tip__________ shape___________ Fruit type__________

Other characteristics:

#9 Name

Plant type_________ Leaf arrangement___________ Leaf type__________

Leaf margin________ tip__________ shape___________ Fruit type__________

Other characteristics:
B. **Herbaceous Plants**

#1 Name

Plant type __________________ Leaf arrangement ____________________________
Leaf margin __________________ tip __________________ shape ____________
Flower characteristics:
Other characteristics:

#2 Name

Plant type __________________ Leaf arrangement ____________________________
Leaf margin __________________ tip __________________ shape ____________
Flower characteristics:
Other characteristics:

#3 Name

Plant type __________________ Leaf arrangement ____________________________
Leaf margin __________________ tip __________________ shape ____________
Flower characteristics:
Other characteristics:

#4 Name

Plant type __________________ Leaf arrangement ____________________________
Leaf margin __________________ tip __________________ shape ____________
Flower characteristics:
Other characteristics:

#5 Name

Plant type __________________ Leaf arrangement ____________________________
Leaf margin __________________ tip __________________ shape ____________
Flower characteristics:
Other characteristics:
LAB 1 - Plant Identification
Lab Report

Name _______________________________   Lab Section __________________

1. What are three identifying characteristics of a dicot? **Give an example.**

2. What are three identifying characteristics of a monocot? **Give an example.**

3. What are the differences between annual and perennial plants? **Give an example of each.**

4. Why are scientific nomenclature and plant classification important?

5. What are the differences between deciduous and evergreen trees?
Lab Exercise 2
SEXUAL PROPAGATION OF PLANTS

A seed is formed when a pollen grain lands on the stigma of the flower, and sends down a pollen tube which releases a sperm cell into the ovule. This fertilization or joining of the sperm cell and ovule forms a cell called a zygote. The zygote then develops into an embryo. The embryo along with the food storage organs, cotyledons and/or endosperm, and the seed coat or testa make up what is called the seed.

The embryo is a diminutive plant and under the proper conditions it will grow into a plant. This new plant will have characteristics from both of its parents. The embryo has two basic parts: the radicle, which grows into the root or below ground portion of the plant and the plumule, which grows into the above ground portion of the plant. The seed also contains food stored as either starch (wheat), fats (sunflower), protein (beans), or a combination of all three. The food storage gives the growing embryo and developing seedling energy until its leaves can begin photosynthesizing.

The process of seed germination is much more complicated than it would appear. Germination is a biochemical process that involves the activation of many chemical reactions. This happens in three stages.

The first stage of seed germination involves the uptake of water. This is called imbibition. During imbibition the protein synthesizing systems are activated and various enzymes are synthesized. These enzymes catalyze reactions used in the second stage of germination.

The second stage of germination involves the breakdown of the stored energy rich compounds of the cotyledons and endosperm. The second stage is a period of readying the embryo for rapid growth during the third stage.

During the third stage of germination, cell division begins and the embryo grows into a seedling. The first growth occurs in the radicle, and the root system is established. This is followed by the emergence of the plumule. Once the seedling has formed leaves it becomes a self sufficient plant.
Lab 2. Lecture Outline

A. What is sexual propagation?
   1. Definition
   2. Advantages over asexual propagation
   3. Disadvantages

B. Which method should you use?
   1. depends on:
      a.
      b.
      c.

C. Uses
   1.
   2.
   3.

D. Factors affecting germination
   1. Seed viability
   2. Germination is affected by:
      a.
      b.
3. Seed dormancy

4. Treatments to overcome dormancy
   a. Scarification
      1) Mechanical
      2) Hot water
      3) Acid treatment
   b. Stratification
      1) Moist chilling
      2) Warm moist followed by cold moist

5. Environmental conditions needed for germination
   a. Moisture
   b. Aeration
   c. Light
   d. Temperature
Lab 2. Sexual Propagation
Lab Exercises

I. Objective
To learn seed structure, viability test, and treatments to overcome seed dormancy.

II. Materials
Bean seeds (old, new, water-soaked, TTC-treated), razor blades, petri dish, paper towels, sand a paper or file.

III. Procedures

1. Seed Anatomy
Cut through a soaked bean seed and observe the internal structure. Sketch and label the parts of the seed.

2. Seed Viability
Bean seeds have been soaked overnight in TTC (triphenyltetrazolium chloride). This changes living tissue to a red color. Uncolored spots will indicate poor viability. Cut open several seeds and sketch your observations. Based on your observations how would you describe their viability? Why?

3. Seed Germination Tests
Seed has been divided into "old" and "new" lots. Count out 10 seeds from each lot and plant according to instructor's directions. Record the number of seeds that germinated for each group and calculate corresponding germination percentages.

4. Seed Scarification
This exercise will evaluate scarification techniques and their effect on germination percentages. Select 10 seeds for each of the four treatments and plant in the four different containers provided.

   a. Treatment 1- Control (no scarification)

   b. Treatment 2- Seeds soaked in hot water

   c. Treatment 3- Seeds soaked in acid (sulfuric acid)

   d. Treatment 4- Mechanical scarification (use sandpaper, file, or clippers)

IV. Results
Obtain seed germination data for the steps 3 and 4 above for your group and the entire class. Use this information for your lab report.
Bean Seed

Structure of Bean Seed

Germination and seedling development of bean
Epigeous germination of cherry seed (endocarp removed)

Hypogeous germination of peach seed (endocarp removed)
LAB 2 - Sexual Propagation of Plants
Lab Report

Name ___________________________________________    Lab Section __________________

1. Define seed scarification and stratification.

   Scarification:

   Stratification:

2. Summarize results of the seed scarification experiment (Procedure # 4).

   Plant species 1 ____________________  Plant species 2 ____________________

   Treatment      | Total no. seeds | No. seeds germinated | % germination
   ______________ | _______________ | ____________________ | ______________
   Species 1
   a. Control     | _______________ | ____________________ | ______________ |
   b. Hot water   | _______________ | ____________________ | ______________ |
   c. Acid        | _______________ | ____________________ | ______________ |
   d. Mechanical  | _______________ | ____________________ | ______________ |
   Species 2
   a. Control     | _______________ | ____________________ | ______________ |
   b. Hot water   | _______________ | ____________________ | ______________ |
   c. Acid        | _______________ | ____________________ | ______________ |
   d. Mechanical  | _______________ | ____________________ | ______________ |

   Comments:

3. What is the function of the cotyledon?

4. What is the difference between endosperm and embryo?

5. Why is water necessary for seed germination?

6. What are three factors that affect seed viability?
Lab Exercise 3
ASEXUAL PROPAGATION OF PLANTS

Asexual propagation is used to reproduce or multiply many horticultural plants. Plants that are propagated asexually are genetically the same as the mother plant. This is also called cloning. Although cloning is being talked about a lot today, it is not a recent development. Farmers have been cloning crop plants since before recorded history. One of the oldest clones in existence is Thompson seedless grapes. The plant with the largest number of daughter plants is the navel orange. All clones originate from a single plant and all of the plants that are propagated from it, asexually, are genetically the same.

Some asexually propagated crops that are grown extensively are: tree fruits, cane fruits, strawberries, sugar cane, potatoes, sweet potatoes, cassava, cranberries, and most herbaceous and woody ornamental plants. Almost all the flower crops and green plants grown as greenhouse crops are also propagated asexually.

Plants are propagated asexually for the following reasons:

1. to preserve the genetic characteristics of a particular plant;
2. to propagate plants that do not produce viable seeds (bananas, pineapple, seedless grape, etc.);
3. to propagate plants that produce seed that is difficult to germinate or has a very short storage life (cotoneaster, willow);
4. to bypass the juvenile stage of plant growth when the plants will not flower and bear fruit (apple).

By far the most important of these is the first. This is the main reason that many horticulture plants are propagated asexually.

Asexual propagation may be done by making cuttings from the stem, root or leaves of the desired plant. Stem cuttings are made by removing a small branch or twig from the plant. This cutting will usually contain two or more buds, one of which will grow into the top of the plant. With proper treatment, adventitious* roots will be produced on the end of the cutting that was closest to the root of the original plant. Root cuttings are made in a similar fashion, but produce an adventitious stem on the end of the cutting that was nearest to the stem of the original plant. Leaf cuttings produce both roots and stems when the leaf is placed under proper conditions.

*adventitious [not properly belonging to]- Referring to a structure arising from an unusual place, such as buds at other places than leaf axils, or root growing from stems or leaves.

Grafting is another type of asexual propagation. In the process of grafting, a part of the stem of one plant is mechanically joined to the stem or root of another plant. If the graft is to be successful, the stem (scion) and the root (stock) must be closely related taxonomically. Grafting is used primarily for woody plants and most tree fruits are propagated in this manner. The scion may be a single bud (budding), or it may have several buds (grafting).

Some plants can be propagated asexually by dividing clumps of the plants. This is called division and is used for such plants as iris, some lilies, orchids, many house plants and perennials. In division, the clumps are cut or torn apart and the individual plants replanted. These will then make another clump which can be divided to keep the process going.

Plants can also be asexually propagated by layering. The process of layering is as if you rooted a cutting while it was still attached to the plant. There are several different ways to layer a plant, but generally the process involves placing a part of the plant stem under conditions favorable for rooting.
Once roots have formed the new plant is separated from the mother plant and established in a new location.

Over the last several years tissue culture propagation has been perfected as a way to propagate plants asexually. Tissue culture uses very small cuttings that are sterilized and grown in test tubes under aseptic conditions. In some instance the cutting can be as small as a single cell isolated from various plant tissues. Once the cutting (explant) is established in a test tube, the medium on which the explant is to grow can be modified to promote the production of numerous stems or roots. Usually the culture is first manipulated to produce many stems. These stems are then placed under cultural conditions to promote rooting. Plants can be reproduced very rapidly using tissue culture methods. A single bud from a potato plant can be multiplied a million times in a single year.
Notes - Plant Propagation Video

A. Specialized Plant Parts

Bulbs

Corms

Tubers

Tuberous roots

B. Propagation by Division

What

How

C. Micropropagation

Explants

Sterile medium

Controlled environment

Advantages
  1.
  2.
  3.
  4.

Disadvantages
  1.
  2.
  3.
ASEXUAL PROPAGATION BY VEGETATIVE PARTS

A. Propagation by Cuttings

1. Four main groups of stem cuttings:
   a. Hardwood - dormant
   b. Semi-hardwood - late summer
   c. Soft wood - late spring or early summer
   d. Herbaceous - when actively growing

2. Sanitation

3. Environment

4. Transplanting

5. Harden-off

B. Layering

C. Air Layering

D. Grafting and Budding

1. Scion

2. Stock

3. Union

4. Cambium
Lab Exercise 3
ASEXUAL PROPAGATION - CUTTINGS

Objective: a) To acquaint the student with some of the basic techniques used in propagating plants using cuttings, and b) to test a hypothesis that a temperature differential between root zone and ambient air in mist room promotes root initiation and quality.

Materials Needed: Stock plants, knives, pruning shears, cell packs to hold rooting medium, rooting hormone (IBA powder or solution), pot labels, marking pens.

Procedures:

1. Preparation of cuttings: Swedish Ivy (*Plectranthus australis*), Indin Laurel (*Ficus benjamina*).
   
   a. Select growing shoot tips that are 8-10 cm long and contain at least 2 nodes. Cut the tips from the stock plant. Remove leaves from the basal 4-5 cm. Make the cuttings as uniform as possible.

   b. Each group will make 80 cuttings of one species.

   Label plant materials with treatment, date, your name and lab section. Use pencil or water-proof marking pen.

   c. Divide the cuttings into 4 groups of 20 cuttings each.

   Treat each group as follows:

   - **Group 1:** No rooting compound - bottom heat.
   - **Group 2:** Rooting compound - bottom heat.
   - **Group 3:** No rooting compound - no bottom heat.
   - **Group 4:** Rooting compound - no bottom heat.

   To treat cuttings in rooting compound, dip in water, shake off excess water and dip into rooting powder. Then place in rooting media in packs.

2. Take cuttings from any of the additional plants provided.

   - Iron Cross Begonia (*Begonia masoniana*) - leaf cutting
   - Snake Plant (*Sansevieria trifasciata laurentii*) - leaf sections
   - African Violet (*Saintpaulia ionantha*) - leaf cutting
   - Giant Dumbcane (*Dieffenbachia amoana*) – canes (5 cm segments), lay horizontally on media
   - Peperomia (*Peperonia obtusifolia*) - stem, leaf cutting

   Other materials will also be provided.

3. Check progress of plants after 7 and 14 days. Hand in results with your recommendation of the best treatment for propagating the plant you worked with. The additional cuttings are for your information only and may take longer to root.
LAB 3 - Asexual Propagation of Plants
Lab Report

Name ____________________________  Lab Section __________________

1. Obtain data on the rooting of cuttings after 7 and 14 days. Using the data obtained after 14 days, discuss the outcome of your experiment (part 3, lab exercise #3) and draw a conclusion whether higher root-zone temperature in relation to ambient temperature actually promoted root initiation and quality.

a. Experimental results:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total no. of cuttings planted</th>
<th>No. of cuttings rooted</th>
<th>% rooting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Control, no bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Control, bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) IBA, no bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) IBA, bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Species #2 (Woody plant)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total no. of cuttings planted</th>
<th>No. of cuttings rooted</th>
<th>% rooting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control, no bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Control, bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. IBA, no bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. IBA, bottom heat</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Conclusion and discussion:

2. Define asexual propagation. How does it differ from sexual propagation?

3. What are three reasons why plants are propagated asexually?

4. What is the purpose of using IBA (indolebutyric acid) in cutting propagation?

5. List 4 environmental factors that are important in rooting of cuttings.
Lab Exercise 4
HORTICULTURE ARTICLE FOR INTERNET

I. Introduction

During this lab, we will use the internet as a source of information on horticultural topics. This information can be applied to other areas as well. We will study the basic fundamentals of surfing, using search engines, and linking to other sites. You are required to write a horticulture article about a topic of your choice.

Keyword - a word that describes a subject area (i.e., carnation).
Link - a clickable area on a page that will lead to another page.
Page - a document on the internet.
Search engine - a site that lists other sites and can be used to find information.
URL - an Internet address (eg. http://www.ndsu.nodak.edu).

II. Objectives

This lab exercise is designed to acquaint the students with various horticulture web sites. Specific objectives are to: a) obtain information on selected horticultural topics of student’s choice, b) learn how to use the HTML language, and c) write a horticulture article of your interest for placement on a web site.

III. Procedure

A 30-minute lecture will cover how to a) assemble information, b) design a web-page, c) introduce pictures and graphic files, and d) establish links to other articles, using the web-authoring programs (i.e., DreamWeaver). Students may be able to turn in a draft copy of a web-article by the end of the class.

IV. Assignment

a. Select a horticultural topic of your choice,
b. Find information from horticultural web sites by surfing,
c. Write a horticulture article that will be placed on the class home page.
d. Cite references for web sites as source of information and further reference. (These web sites must be listed at the end of your article as links so that readers can visit the specific sites as needed)
e. Turn in: a hard copy of your article and a diskette containing your article. All graphic files must be placed in your folder. The folder name should include the initial of your first name and full last name.

V. Grading of Article

Articles submitted will be graded on the basis of: a) information content, b) originality, c) organization, d) artwork and appearance, and e) appropriateness in citation and references. Sources for the pictures and graphs used in the article must be shown with proper labeling and permission from the original publisher. A total of 30 possible points is given.
Lab Exercise 5
PLANT NUTRITION

I. General Introduction

All living organisms require certain elements for their survival. Plants are known to require carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), calcium (Ca), sulfur (S), potassium (S), and magnesium (Mg), which are called Macronutrients, because they are needed in larger amounts. Plants also need large amounts of carbon (C), hydrogen (H), and oxygen (O) for growth and development. Plants absorb these elements through air and water, they are not usually applied as fertilizers.

Micronutrients which are needed in very minute quantities are: iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), and chlorine (Cl). There is no "most important element" since all are required for life, growth and reproduction. They are therefore called essential elements.

Plant tissues also contain other elements (Na, Se, Co, Si, Rb, Sr, F, I) which are not needed for the normal growth and development.

<table>
<thead>
<tr>
<th>Element</th>
<th>Chemical symbol</th>
<th>Atomic weight</th>
<th>Ionic forms absorbed by plants</th>
<th>Approximate dry tissue concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macronutrients</td>
<td>Nitrogen</td>
<td>N</td>
<td>NO₃⁻, NH₄⁺</td>
<td>4.0 %</td>
</tr>
<tr>
<td></td>
<td>Phosphorus</td>
<td>P</td>
<td>PO₄³⁻, HPO₄²⁻, H₂PO₄⁻</td>
<td>0.5 %</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>K</td>
<td>K⁺</td>
<td>4.0 %</td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
<td>Mg</td>
<td>Mg²⁺</td>
<td>0.5 %</td>
</tr>
<tr>
<td></td>
<td>Sulfur</td>
<td>S</td>
<td>SO₄²⁻</td>
<td>0.5 %</td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
<td>Ca</td>
<td>Ca²⁺</td>
<td>1.0 %</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>Iron</td>
<td>Fe</td>
<td>Fe²⁺, Fe³⁺</td>
<td>200 ppm</td>
</tr>
<tr>
<td></td>
<td>Manganese</td>
<td>Mn</td>
<td>Mn⁷⁺</td>
<td>200 ppm</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>Zn</td>
<td>Zn²⁺</td>
<td>30 ppm</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>Cu</td>
<td>Cu²⁺</td>
<td>10 ppm</td>
</tr>
<tr>
<td></td>
<td>Boron</td>
<td>B</td>
<td>Bo₃²⁻, Bo₄⁷⁻</td>
<td>60 ppm</td>
</tr>
<tr>
<td></td>
<td>Molybdenum</td>
<td>Mo</td>
<td>MoO₄²⁻</td>
<td>2 ppm</td>
</tr>
<tr>
<td></td>
<td>Chlorine</td>
<td>Cl</td>
<td>Cl⁻</td>
<td>3000 ppm</td>
</tr>
<tr>
<td>Essential But Not Applied</td>
<td>Carbon</td>
<td>C</td>
<td>CO₂</td>
<td>40 %</td>
</tr>
<tr>
<td></td>
<td>Hydrogen</td>
<td>H</td>
<td>H₂O</td>
<td>6 %</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
<td>O</td>
<td>O₂, H₂O</td>
<td>40 %</td>
</tr>
</tbody>
</table>

Under most agricultural and horticultural conditions, only nitrogen, phosphorus, and potassium are depleted from the soil to the extent that growth and development are interrupted. These are the fertilizer elements. Modern agriculture depends on the addition of these elements to the soil to ensure optimum yields of food crops. Soil tests are used to determine the levels of the elements available to the crop and the quantities that must be added as fertilizer to get profitable yields. Deficiencies of other elements such as sulfur, zinc and copper may occur in some soils. These deficiencies can be corrected by the addition of small amounts of these elements to the soil or as sprays to the plant. Under some
conditions the soil may contain adequate supplies of the element, but because of soil pH (acidity or alkalinity) the element is unavailable to the plant. This occurs with iron in high pH (alkaline) soils. Many plants growing in these soils will have yellow (chlorotic) leaves. All species of plants do not react the same under these conditions. Some will show the deficiency symptom, while others are apparently able to extract the iron from the soil.

II. Fertilizer Concentration Calculations

A. Units Used

- ppm = parts per million
- mM = milli molar
- meq/l = milliequivalent per liter

B. Conversion Factors (metric vs. British system)

- 1 ounce = 28.35 g
- 1 pound = .45 kg
- 1 gallon = 3.78 liters
- 1 g = .035 ounce
- 1 kg = 2.205 pounds
- 1 acre = 43,560 ft²
- 1 liter = 1 kg

C. Fertilizer Concentrations

a. Parts per million (ppm)

The term, parts per million, is an expression of concentration used often to describe very dilute solutions. The term states how many parts of solute there are in a million parts of the whole solution. Parts per million almost always expresses concentrations on a mass basis. For example, a 10 ppm solution is one in which every million grams of solution contains 10 grams of solute. The ppm designation is most often applied to dilute solutions in water. For example, 1 kilogram (1000 gram) of water contains 1 million milligrams of water; thus

\[
1 \text{ kg} = 1 \text{ kg} \times 1000 \text{ g/kg} \times 1000 \text{ mg/g} = 1,000,000 \text{ mg}
\]

At normal temperatures, 1 liter of a dilute water solution has a mass of approximately 1 kilogram. If we have 10 mg of solute in 1 liter of solution, it will be 10 ppm.

\[
\frac{10 \text{ mg solute}}{1 \text{ liter solution}} = \frac{10 \text{ mg solute}}{1,000,000 \text{ mg solution}} = 10 \text{ ppm}
\]

Thus when we say that the concentration of nitrogen in water is 200 ppm, we mean that 1 liter of the solution contains 200 milligrams of nitrogen. The important thing to remember is:

\[
1 \text{ kg} = 1,000,000 \text{ mg} \\
1 \text{ liter water} = 1 \text{ kg} \\
\text{therefore, } 1 \text{ liter water} = 1,000,000 \text{ mg}
\]
b. **Milli-molar (mM)**

One millimolar (mM) concentration refers to a solution containing one-thousandth of molecular weight (g) of the solute per liter of water. One molar (M) concentration equals 1000 millimolar (mM) concentration.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Molecular or atomic weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>14.01</td>
</tr>
<tr>
<td>K⁺</td>
<td>39.10</td>
</tr>
<tr>
<td>NH₄NO₃</td>
<td>80.05</td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>18.01</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>62.01</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>40.08</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>24.32</td>
</tr>
<tr>
<td>S</td>
<td>32.07</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>96.07</td>
</tr>
<tr>
<td>MgSO₄7H₂O</td>
<td>246.50</td>
</tr>
</tbody>
</table>

1 mM NH₄NO₃ = 80.05 mg per liter (mg/l)
1 mM NO₃⁻ = 62.01 mg/l
1 mM SO₄²⁻ = 96.07 mg/l
1 mM MgSO₄7H₂O = 246.5 mg/l

c. **Milliequivalent per liter (meq/l)**

Milliequivalent per liter (meq/l) concentrations are often used to show the strength of fertilizer ions (anion or cation) in a solution. Since one equivalent weight is the molecular weight divided by valence, one meq/l refers to the ionic concentration of a solution that contains one millimole/valence per liter of water.

\[
\text{NH}_4\text{NO}_3 \rightarrow \text{NH}_4^+ + \text{NO}_3^- \quad \text{(Monovalent ions)}
\]

\[
(80) \quad (18) \quad (62)
\]

\[
\text{MgSO}_4\text{7H}_2\text{O} \rightarrow \text{Mg}^{2+} + \text{SO}_4^{2-} \quad \text{(Divalent ions)}
\]

\[
(246.5) \quad (24.3) \quad (96.1)
\]

1 meq/l NH₄NO₃ = 80 mg/l
1 meq/l NH₄⁺ = 18 mg/l
1 meq/l NO₃⁻ = 62 mg/l

1 meq/l MgSO₄7H₂O = (246.5 mg/2)/l = 123.3 mg/l
1 meq/l Mg²⁺ = (23.3 mg/2)/l = 11.6 mg/l
1 meq/l SO₄²⁻ = (96.1 mg/2)/l = 48.0 mg/l

D. **Fertilizer Analysis**

a. **Commercial Analysis**

Commercial analysis is given by the percentages of nitrogen (N), phosphorus (P₂O₅), and potassium (K₂O) in that order. For example, Peters 20-16-20 fertilizer contains 20% N, 16% P₂O₅, and 20% K₂O by weight.
b. **Elemental Analysis**

Elemental analysis is used for more technical and scientific purposes. It is expressed as percent weights of elemental nitrogen (N), phosphorus (P), and potassium (K) in that order.

c. **Conversion of Commercial Analysis to Elemental Analysis**

By using the ratios of elemental to oxides for phosphorus and potassium, the commercial analysis can be converted to elemental analysis.

\[
\begin{align*}
\text{Nitrogen} & : \text{always expressed as elemental N} \\
\text{Phosphorus} & : \frac{P_2}{P_2O_5} = 0.44, \quad \text{or} \quad \frac{P_2O_5}{P} = 2.99 \\
\text{Potassium} & : \frac{K_2}{K_2O} = 0.83, \quad \text{or} \quad \frac{K_2O}{K} = 1.20
\end{align*}
\]

Thus, Peters 20-16-20 commercial analysis fertilizer can be labeled as a 20-7.04-16.6 elemental analysis fertilizer.

\[
20\% \text{ N} - 16\% \text{ P}_2\text{O}_5 - 20\% \text{ K}_2\text{O} = 20\% \text{ N} - 7.04\% \text{ P} - 16.6\% \text{ K}
\]

For example, if you want to apply 200 ppm nitrogen to your plants and were going to mix up 1 liter of solution you then would have to put 1000 mg or 1 gram of fertilizer into the liter of water.

\[
\frac{200}{0.20} = \frac{x}{1.00}
\]

\[x = 1000 \text{ mg} = 1 \text{ g}.
\]
III. Problems

1) You wish to prepare 5 gallons of a 100 ppm nitrogen (N) fertilizer. How much 15-10-5 commercial analysis fertilizer will you need to add to 5 gallons of water to get the desired concentration?

2) You are mixing 5 gallon of concentrate fertilizer to apply with a hose-on (1:15 proportion), and you want the final concentration to be 200 ppm nitrogen (N). What amount of fertilizer, if you are using 20-20-20 commercial analysis fertilizer, do you need to add to 5 gallon of water?

3) What would be the concentrations of phosphorus and potassium in the fertilizer solution above? (see #2)

\[
\begin{align*}
\text{Nitrogen} & = 200 \text{ ppm N} \\
\text{Phosphorus} & = \underline{\text{___}} \text{ ppm } P_2O_5 = \underline{\text{___}} \text{ ppm P} \\
\text{Potassium} & = \underline{\text{___}} \text{ ppm } K_2O = \underline{\text{___}} \text{ ppm K}
\end{align*}
\]

4) The fertilizer bag says add 5 oz. to 100 gallons of water. What ppm N, P, K will this solution be, assuming the fertilizer has a commercial analysis of 20-20-20?
DEMONSTRATION OF NUTRIENT DEFICIENCIES
Lab Experiment

A. Objective

Plants require large quantities of macronutrients (N, P, K, Ca, Mg, S). Of these macronutrients, deficiency symptoms of nitrogen, phosphorus, and potassium can be visually detected on plants grown under an artificially controlled culture system. The objective of this study is to artificially induce and characterize deficiency symptoms of nitrogen, phosphorus, and potassium on selected plants. During the course of this study, students will observe and characterize abnormal symptoms of plants lacking nitrogen, phosphorus, or potassium.

B. Materials and Method

Plant Materials

Three species of plants (corn, bean, leaf lettuce) will be used. Corn and bean will be grown in perlite, whereas leaf lettuce will be grown hydroponically.

Nutrient Solutions

Five different solutions containing the complete combinations of macronutrients lacking one of the three macronutrients N, P, and K. All solutions will contain the standard concentrations of micronutrients (a modification of Hoagland Solution):

- Treatment 1 --- Complete fertilizer
- Treatment 2 --- Lacking nitrogen (-N)
- Treatment 3 --- Lacking phosphorus (-P)
- Treatment 4 --- Lacking potassium (-K)
- Treatment 5 --- Lacking calcium (Ca)
- Treatment 6 --- Lacking all macronutrients

C. Procedures

Germinate seeds of the three species on an inert medium (rockwool, perlite, sand, etc.) using deionized water. When the seedlings start developing true leaves, plant them in 6-inch plastic pots containing perlite (corn and bean). For lettuce, place the seedlings on a styrofoam board which will float on top of a hydroponic solution contained in a plastic tub. Observe plant growth and development of deficiency symptoms for 8 weeks.

D. Observations

Observe the growth of plants with each of the four treatments. Characterize the growth and development of nutrient deficiency symptoms for nitrogen, phosphorus, and potassium in 8 weeks of observation. Using the findings of the experiment, complete your lab report.
PREPARATION OF HOAGLAND SOLUTION

1. Preparation of Nutrient Solutions: Method A, for Amateurs

Either one of the solutions given in Table 1 may be tried. Solution 2 may often be preferred because the ammonium salt delays the development of undesirable alkalinity. The salts are added to the water, preferably in the order given. To either of the solutions, add the elements iron, boron, manganese, and in some cases, zinc and copper, which are required by plants in minute quantities. There is danger of toxic effects if much greater quantities of these elements are added than those indicated later in the text. Molybdenum and possibly other elements required by plants in minute amounts will be furnished by impurities in the nutrient salts or in the water, and need not be added deliberately.

Table 1. Composition of nutrient solutions (amounts given are for 25 gallon solutions).

<table>
<thead>
<tr>
<th>Salt</th>
<th>Grade of salt</th>
<th>Approximate amount, in ounces</th>
<th>Approximate amount, in level tablespoons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium phosphate (monobasic)</td>
<td>Technical</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>Fertilizer</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Calcium nitrate</td>
<td>Fertilizer</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Magnesium sulfate (Epsom salt)</td>
<td>Technical</td>
<td>1.5</td>
<td>4</td>
</tr>
</tbody>
</table>

| Solution 2*                               |               |                             |                                        |
| Ammonium phosphate (monobasic)            | Technical     | 0.5                         | 2                                      |
| Potassium nitrate                         | Fertilizer    | 2.5                         | 5                                      |
| Calcium nitrate                           | Fertilizer    | 2.5                         | 6                                      |
| Magnesium sulfate (Epsom salt)            | Technical     | 1.5                         | 4                                      |

*To either of these solutions, supplements of elements required in minute quantity must be added; see directions in the text.

a. Boron and Manganese Solution - Dissolve 3 teaspoons of powdered boric acid and 1 teaspoon of chemically pure manganese chloride (MnCl₂·4H₂O) in a gallon of water. (Manganese sulfate could be substituted for the chloride.) Dilute 1 part of this solution with 2 parts of water, by volume. Use a pint of the diluted solution for each 25 gallons of nutrient solution.

The elements in group a are added when the nutrient solution is first prepared and at all subsequent changes of solution. If plants develop symptoms characteristic of lack of manganese or boron, solution a, in the amount indicated in the preceding paragraph, may be added between changes of the nutrient solution or between addition of salts needed in large quantities. But care is needed, for injury may easily be produced by adding too much of these elements.

b. Zinc and Copper Solution - Ordinarily this solution may be omitted, because these elements will almost certainly be supplied as impurities in water or chemicals, or from the containers. When it is needed, additions are made as for solution a. To prepare solution b, dissolve 4 teaspoons of chemically pure zinc sulfate (ZnSO₄·7H₂O) and 1 teaspoon of chemically pure copper sulfate (CuSO₄·5H₂O) in a gallon of water. Dilute 1 part of this solution with 4 parts of water. Use 1 teaspoon of the diluted solution for each 25 gallons of nutrient solution.

c. Additions of Iron to Nutrient Solution - Generally, iron solution will need to be added at frequent and regular intervals, for example, once or twice a week. If the leaves of the plant tend to become yellow, even more frequent additions may be required. However, a yellowing or mottling of leaves can also arise from many other causes.

The iron solution is prepared as follows: Dissolve 1 teaspoon of iron tartrate (iron citrate or iron sulfate can be substituted, but the tartrate or citrate is often more effective than the sulfate) in 1 quart of water. Add 1/2 cup of this solution to 25 gallons of nutrient solution each time iron is needed.
2. Preparation of Nutrient Solutions: Method B, for Schools or Technical Laboratories

For experimental purposes, the use of distilled water and chemically pure salts is recommended. Molar stock solutions (except when otherwise indicated) are prepared for each salt, and the amounts indicated below are used.

<table>
<thead>
<tr>
<th>Solution 1</th>
<th>cc in a liter of nutrient solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M KH₂PO₄, potassium acid phosphate</td>
<td>1</td>
</tr>
<tr>
<td>1M KNO₃, potassium nitrate</td>
<td>5</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂, calcium nitrate</td>
<td>5</td>
</tr>
<tr>
<td>1M MgSO₄, magnesium sulfate</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solution 2</th>
<th>cc in a liter of nutrient solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M NH₄H₂PO₄, ammonium acid phosphate</td>
<td>1</td>
</tr>
<tr>
<td>1M KNO₃, potassium nitrate</td>
<td>6</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂, calcium nitrate</td>
<td>4</td>
</tr>
<tr>
<td>1M MgSO₄, magnesium sulfate</td>
<td>2</td>
</tr>
</tbody>
</table>

To either of these solutions, add solutions a and b below.

a. Prepare a supplementary solution which will supply boron, manganese, zinc, copper, and molybdenum, as follows:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Grams dissolved in 1 liter of H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃BO₃, boric acid</td>
<td>2.86</td>
</tr>
<tr>
<td>MnCl₂.7H₂O, manganese chloride</td>
<td>1.81</td>
</tr>
<tr>
<td>ZnSO₄.5H₂O, zinc sulfate</td>
<td>0.22</td>
</tr>
<tr>
<td>CuSO₄.5H₂O, copper sulfate</td>
<td>0.08</td>
</tr>
<tr>
<td>H₂MoO₄.H₂O, molybdic acid</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Add 1 cc of this solution for each liter of nutrient solution, when solution is first prepared or subsequently changed, or at more frequent intervals if necessary.

This will give the following concentrations:

<table>
<thead>
<tr>
<th>Element</th>
<th>Parts per million of nutrient solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>0.5</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>0.02</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.05</td>
</tr>
</tbody>
</table>

b. Add iron in the form of 0.5 per cent iron tartrate solution or other suitable iron salt, at the rate of 1 cc per liter, about once or twice a week or as indicated by appearance of plants. The reaction of the solution is adjusted to approximately pH 6 by adding 0.1 N H₂SO₄ (or some other suitable dilution).

MOLAR SOLUTIONS

The concentrations of stock solutions of nutrient salts used in preparation of nutrient solutions are conveniently expressed in terms of molarity. A molar solution is one containing 1 gram-molecule (mol) of dissolved substance in 1 liter of solution. A molar solution contains 1.000 gram-mole of dissolved substance in 1 liter of solution. A gram-molecule or mol or a compound is the number of grams corresponding to the molecular weight.

Example 1, how to make a molar solution of magnesium sulfate: The molecular weight of magnesium sulfate, MgSO₄.7H₂O is 246.50. One mol of magnesium sulfate consists of 246.50 grams. Hence to make a molar solution of magnesium sulfate, dissolve 246.50 grams of MgSO₄.7H₂O in water and make to 1 liter volume.
Example 2, how to make a one-twentieth molar (0.05 M) solution of monocalcium phosphate, Ca(H₂PO₄)₂·H₂O (used in deficiency studies, below): The molecular weight of monocalcium phosphate, Ca(H₂PO₄)₂·H₂O is 252.17. Hence 0.05 mol of Ca(H₂PO₄)₂·H₂O is 525.17 grams/20 = 12.61 grams. Therefore, to make a 0.05 M solution of monocalcium phosphate, dissolve 12.61 grams of Ca(H₂PO₄)₂·H₂O in water and make to 1 liter volume.

3. Nutrient Solutions for Use in Demonstrating Mineral Deficiencies in Plants

In any experiment to demonstrate mineral deficiencies in plants, solution 1 or solution 2 should be used as a control to show normal growth in a complete solution. Below are given six solutions, each lacking in one of the essential elements. Distilled water should be used in making these solutions.

<table>
<thead>
<tr>
<th>cc in a liter of nutrient solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Solution lacking nitrogen</td>
</tr>
<tr>
<td>0.5 M K₂SO₄</td>
</tr>
<tr>
<td>1 M MgSO₄</td>
</tr>
<tr>
<td>0.05 M Ca(H₂PO₄)₂</td>
</tr>
<tr>
<td>0.01 M CaSO₄</td>
</tr>
<tr>
<td>b. Solution lacking phosphorus</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂</td>
</tr>
<tr>
<td>1M KNO₃</td>
</tr>
<tr>
<td>1M MgSO₄</td>
</tr>
<tr>
<td>c. Solution lacking potassium</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂</td>
</tr>
<tr>
<td>1M MgSO₄</td>
</tr>
<tr>
<td>0.05M Ca(H₂PO₄)₂</td>
</tr>
<tr>
<td>d. Solution lacking calcium</td>
</tr>
<tr>
<td>1M KNO₃</td>
</tr>
<tr>
<td>1M MgSO₄</td>
</tr>
<tr>
<td>1M KH₂PO₄</td>
</tr>
<tr>
<td>e. Solution lacking magnesium</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂</td>
</tr>
<tr>
<td>1M KNO₃</td>
</tr>
<tr>
<td>1M KH₂PO₄</td>
</tr>
<tr>
<td>0.5M K₂SO₄</td>
</tr>
<tr>
<td>f. Solution lacking sulfur</td>
</tr>
<tr>
<td>1M Ca(NO₃)₂</td>
</tr>
<tr>
<td>1M KNO₃</td>
</tr>
<tr>
<td>1M KH₂PO₄</td>
</tr>
<tr>
<td>1M Mg(NO₃)₂</td>
</tr>
</tbody>
</table>

To any of these solutions, add iron and the supplementary solution supplying boron, manganese, zinc, copper and molybdenum as previously described. For use with solution f, lacking sulfur, a special supplementary solution should be prepared in which chlorides replace the sulfates. Also, sulfuric acid should not be used in adjusting the reaction of the nutrient solution.

In order to produce iron-deficiency symptoms, plants should be grown in glass containers and no iron should be added to the otherwise complete nutrient solution. Similarly, it may be possible to produce boron- or manganese-deficiency symptoms with certain plants (tomatoes, for example) by omitting either one of these elements from the supplementary solution. Zinc-, copper-, and molybdenum-deficiency symptoms can usually be produced only by the use of a special technique, the description of which exceeds the scope of this handout.

(Reference. Hoagland, D.R. and D.I. Arnon. 1938. The water culture method for growing plants without soil, University of California Agricultural Experiment Station Circular 347.)
LAB 5 - PLANT NUTRITION
Lab Report

Name ________________________________  Lab Section _________________________

1. Describe the functions of macronutrients nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca) in plants.

2. Write the chemical forms (ions) of nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca) that are actually absorbed by plants.

3. Why is an inert growing medium used to grow plants for detecting nutrient deficiencies?

4. Describe macronutrient deficiency symptoms that you have observed in each species, and provide comments on your findings.

   **Symptoms:**

   Nitrogen (N) deficiency:

   Phosphorus (P) deficiency:

   Potassium (K) deficiency:

   Calcium (Ca) deficiency:

**Conclusion:**
Lab Exercise 6
DESIGNING A FLOWER GARDEN

Notes from video:

A. Where to put it

View from 3 locations

B. Zone you live in. Fargo is in plant hardiness zone 4.

C. Light

1. light each day - morning, afternoon, evening
2. light each season
3. Four classifications of areas by light
   a. full sunlight - some heat stress
   b. part sunlight - 5-6 hr. of full sun
   c. part shade - dappled sun
   d. full shade - not good for blooming plants

D. Many types - rock gardens, wall gardens, water gardens etc.

1. Decorative Home Garden
   a. mix of flowers and shrubs

   b. advantages -
      1)  
      2)  
      3)  

2. Herbaceous Border Garden
   Made up of a mixture of annuals, perennials, and spring bulbs
E. Planning and Designing

1. Curved shapes

2. Plan from background to foreground
3. Three levels - each 1/3 of bed depth
   a. Avoid step look

4. Plant flowers in groups
   a. Annual and perennials in groups up to 6 plants
      (odd numbers in groups look best)
   b. Spring bulbs - 6 to 12 in a group - 20 is max
   c. Keep in scale

5. Keep texture and shape varied

6. Color - beginners should start with 3-5 colors
   a. Contrast - not touching on the color wheel
   b. Harmonious - next to each other on the wheel

7. **Objective** is to have some color blooming in each level at all times
   a. Two perennials to each annual
      - Perennials usually bloom about 3 weeks
      - Annuals bloom most of the summer
   b. Choose perennials to bloom in late spring, summer, and fall in each of the three areas of the border.
   c. Make 3 lists, one for annuals, one for perennials, and one for bulbs. (See Lab 6 Worksheet)
      Start by listing your favorites in each category, making sure they will grow here.
   d. Background plants should be tall; a rule of thumb: as tall as 2/3 the width of the bed.
   e. Middle plants should be 12 - 36” tall.
   f. Foreground plants should be 12” or under
F. Preparing the flower bed.

1. add organic matter
2. till or dig
   a. mix in organic matter
   b. improve drainage
   c. make more oxygen available for the roots

G. Water systems

1. emitter drip irrigation
2. porous hose type
3. drip irrigation
   a. saves 30 - 40% on water
   b. no evaporation or runoff
   c. reduces water on leaves and therefore reduces disease
   d. reduces compaction

H. Mulch

1. weeds compete for nutrients and water
2. one way to control is with 2-4" of mulch
   a. reduces weeds, evaporation, and compaction
   b. mulch should: allow air through, resist wind, hold moisture, and look good
3. types:
4. winter mulch 4-6" deep helps protect plants from frost heave

I. Compost

1. active or passive

J. Maintenance
**Assignment.** Design a flower garden using the principles you saw in the video. This may be for an existing yard or you may make up an area with a flower garden about 8 ft x 25 ft. Please turn in these lists as well as the design, which should be drawn to scale. Be original but adhere to the basic precepts given in the video.

<table>
<thead>
<tr>
<th>Plant name (Scientific preferable)</th>
<th>Bloom Period</th>
<th>Color</th>
<th>Plant Height</th>
<th>Spread</th>
</tr>
</thead>
</table>

**List 1 - Perennials**

1
2
3
4
5
6
7
8
9
10
11
12

**List 2 - Annuals**

1
2
3
4
5
6
7

**List 3 - Bulbs and Corms**

1
2
3
4
5
6
7
Lab Exercise 7
GREENHOUSE PRODUCTION

In this lab we will look at the basic components of a greenhouse and the specific needs of three different types of greenhouses: hobby, research, and commercial.

No matter what the use of a greenhouse the environment must be maintained for the health of the plant. The components of that environment are: temperature, light, humidity and air movement.

Temperature is provided to the greenhouse by the energy of the sun's rays, or when that isn't sufficient, by supplemental heat. Different plants need different temperature ranges. Most will do well in temperatures from 50 to 70 degrees. Tropical plants need temperatures in the 70 to 80 degree range. The heat in the green house must be maintained at a more or less constant temperature during the day with a 10 degree drop at night. There are four ways to maintain the temperature at the desired level: prevent heat loss, store heat, add heat and vent out excess heat. We will discuss this in more detail later.

Light is measured in two areas, quality and quantity. Quality refers to the brightness of the light. Quantity refers to duration. A plant needs a certain length of light. If quality is low a small amount can be made up by adding quantity. In the greenhouse the glazing is the covering that lets the light in. Examples of glazing are: glass, plastic, acrylic (Exolite) and fiberglass. Each has advantages and disadvantages.

Glass lets 90% of the light through but it loses a lot of heat. Plastic, especially double inflated plastic, is inexpensive and is used extensively in bedding plant production. Its major drawback is that it lasts only 2-3 years before recovering is necessary. Exolite, polycarbonate rigid sheets, is being used widely. It allows excellent light penetration, and it is also fuel efficient. Fiberglass is rarely used anymore, because it is a fire hazard and has a great reduction in light penetration over time. The invention of heat curtains and the ability to line glass with a thin sheet of plastic is making glass gain ground as the most popular covering for large commercial greenhouses. This is because glass is still the best at letting in light.

Humidity is the measure of the amount of water that is carried in the air at a given temperature. The ideal humidity for the greenhouse is 50 - 60%. If the humidity is too high the environment will be just right for diseases to attack the plants. If the humidity is too low the plants suffer from water stress. You can control humidity by watering in the morning and venting out the moist air. Never water in the evening.

Air movement is a necessity in a greenhouse. When a plant is outdoors the air is constantly moving providing the plant with fresh air next to its leaves so is can replenish the oxygen and carbon dioxide it uses. In the greenhouse air movement must be supplied through fans. Air movement also helps keep relative humidity down and keep the temperature even throughout the greenhouse.

Hobby greenhouses have all the needs listed above, but they must be carried out in a small space. Heat can be stored or released into the home to double its usefulness.

Commercial greenhouses also have the needs listed above and many more besides. The basic need is to make a profit, to do this a commercial greenhouse must be efficient at providing environments to the plants. The light and temperature needs must be very strictly controlled, computers are now being widely used to provide these controls. Heat must not be wasted; new systems of curtains, which are pulled out at night and rolled back in the morning, have reduced heat losses up to 50%. Movement of plants is another area seeing great strides in efficiency. Benches that move to allow isles, or move from head house to greenhouse and then out to be loaded onto a truck without human hands ever lifting the plants, are now a reality.
How have all these inventions come to pass? One basic answer is research. The research greenhouse, like those here on campus, meets the basic four needs of light temperature, humidity control and air movement like the other greenhouses do. However they do so in small divided spaces. This is not efficient like the commercial greenhouses but it is efficient for research. Small areas can be kept rigidly controlled and separate from each other. Research is very important to all of us in horticulture.

**Soils Used in Plant Propagation and Greenhouse Production**

Soil Makeup: Solid - Sand, Clay, Humus, Silt  
Liquid - Water (Solution containing minerals)  
Gas - Air (Oxygen, Nitrogen, CO₂)

Soil Texture: Related to solid portion, i.e., sand, clay, organic materials

Most greenhouse soils are mixtures of two or more of the following:

- Field Soil - not used much
- Sand - washed quartz sand
- Peat - decomposed plant materials deposited in bags. Sphagnum peat usually used.
- Sphagnum Moss - dried and ground sphagnum moss
- Vermiculite - micaceous mineral that has been heated to 2000°F
- Perlite - Silica material of volcanic origin heated to 1400°F, very porous
- Compost - composted leaves or other organic materials - usually "well rotted"
- Shredded Bark & Sawdust - wood product wastes used in mixing soils. May or may not be composted, depending on tree species.
Environment and Growing Media

Light

Light is essential for photosynthesis. House plants are classified into 3 general light-requirement categories.


Medium Light: 200-500 foot-candles. Light from a north window, or indirect light from a south, east, or west window. Begonia, peperomia, African violet, piggyback plant.

Bright Light: 500-1000 foot-candles. Direct or filtered sunlight from an east, west, or south window. Cacti, dieffenbachia, sansevieria, geraniums and many others.

A foot-candle is the illumination of a surface one foot from the light of a standard candle. Light meters measure light intensity in foot-candles, luxes, or micro-Einsteins.

pH

The pH of a soil is a measure of its acidity or alkalinity. A pH of 7 is neutral, above 7 is alkaline (basic) and below 7 is acidic. Most House plants prefer slightly acid conditions (pH 6.5-7.0), especially orchids and African violets. A few do better in mildly alkaline soils, such as most succulents and geraniums. The following is a list of the pH of some common substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemon juice</td>
<td>2</td>
</tr>
<tr>
<td>Tomato juice</td>
<td>4.5</td>
</tr>
<tr>
<td>Blood</td>
<td>6.6</td>
</tr>
<tr>
<td>Soap</td>
<td>9</td>
</tr>
<tr>
<td>Household ammonia</td>
<td>12</td>
</tr>
</tbody>
</table>

Soluble Salts

Soluble salts are defined as the total of all dissoluble mineral residues in the soil. This includes sodium, magnesium, potassium and calcium. Monitoring soluble salts is important because if they are too low, it may indicate inadequate fertility. If they are too high, water passes out of the root system instead of into the plant, causing dehydration and starvation.
TROUBLE SYMPTOMS FOR FOLIAGE PLANTS AND POSSIBLE CAUSES

1. Lower leaves turn yellow and drop off easily.
   a. over-watering
   b. insufficient light

2. Burned margins or brown tips on leaves.
   a. accumulated salts in soil
   b. drought or low humidity

3. Pale leaf color, long internodes, loss of vigor, dropping lower leaves.
   a. lack of sufficient light

4. Growing tips chlorotic or growth slow.
   a. accumulated salts in soil
   b. too high a soil pH

5. Brown spots on leaves no pathogen present.
   a. excessive light
   b. water spotting

6. Interveinal chlorosis.
   a. iron (Fe) deficiency
   b. high pH

7. Poor flowering.
   a. insufficient light intensity
   b. vegetative growth encouraged (N fertilizers, too large pot, improper photoperiod)

8. Lower leaf drop, yellowing and/or dieback, roots brown and rotting (lower stems may be soft).
   a. excessive watering
   b. poor drainage
   c. accumulated salts (over fertilization)
   d. root rot caused by pathogens: *Pythium*, *Rhizoctonia*, *Phytophthora*
Lab 7 - Greenhouse Production Lab Exercises
Soil pH and Salinity

1. Measure pH and electrical conductivity (EC) of the following solutions using a portable pH meter and an EC meter. Estimate the concentration of total dissolved salts (TDS) for each solution.

<table>
<thead>
<tr>
<th>Water or soil sample</th>
<th>pH</th>
<th>Electrical conductivity</th>
<th>TDS (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. RO water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Bottled water (Aquafina)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Tap water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Fertilizer water (greenhouse)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. House plant soil extract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Sunshine mix extract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Peat extract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Pointsettia pot soil extract</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Why and how electrical conductivity (EC) is used to estimate salt concentrations in solutions?

3. Establish relationship between NaCl concentration and electrical conductivity.

<table>
<thead>
<tr>
<th>Solution no.</th>
<th>ppm</th>
<th>g L⁻¹</th>
<th>EC (µmho/cm)</th>
<th>EC (mmho/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1,000</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2,000</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4,000</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6,000</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>8,000</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>10,000</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Using the data above, plot the EC readings NaCl concentration on a graph
   \((x = \text{ppm NaCl}, y = \text{mmho/cm})\).

b. Derive regression equations for estimating salinity using EC readings:
   1) \(y = \frac{\text{EC (µmho/cm)}}{x}\).
   2) \(x = \frac{\text{EC (µmho/cm)}}{y}\), where \(y\) = electrical conductivity in mmho/cm
      \(x\) = parts per million (ppm) salt
   3) \(1 \text{ mmho/cm} = \frac{\text{ppm NaCl}}{\text{1 µmho/cm}} = \frac{\text{ppm NaCl}}{\text{1 mmho/cm}}\)
1. **Light Intensity Measurements**

This exercise is designed to familiarize you with one method of determining light intensity. A knowledge of light intensities, which are commonly associated with the direction a window faces, can help you choose an appropriate plant, or place plants you already have in a better environment.

Light measurements will be taken at five different locations in the greenhouse.

<table>
<thead>
<tr>
<th>Location</th>
<th>Foot-candle</th>
<th>Lux</th>
<th>µmol m(^{-2}) s(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% reduction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
LAB 7 - Greenhouse Production
Lab Report

Name ________________________________________    Lab Section___________________

1. List five environmental factors that affect plant growth in the greenhouse and briefly explain how these factors can be regulated.

2. What kinds of plant problems can occur with following greenhouse conditions?
   a. Excessive heat
   b. Lack of ventilation
   c. High humidity
   d. Low water pH
   e. High water pH
   f. High soil salinity

3. Should you water the plants in a greenhouse just before you go home at night or wait until the next morning? Why?

4. What percentage of sunlight is transmitted into the greenhouse according to your measurements? Show calculations.

5. What is the optimum soil pH range for most greenhouse crops?

6. Why is high salinity of growing media detrimental to plant growth?
Lab Exercise 8
LANDSCAPE DESIGN

I. Benefits of a well planned landscape
   A. Personal benefits
   B. Conservation
   C. Economic
   D. Aesthetic

II. Landscape Design
    Profession, Art, Science, Process
    A. Profession
       1. Landscape Architect
       2. Landscape Designer
    B. An Art
       1. Principles of landscape design
          a. Unity
          b. Repetition
          c. Balance
          d. Dominance
          e. Scale
       2. Elements of Landscape Design
          a. Form
          b. Line
          c. Texture
          d. Color
C. A Science

1. Know plants
2. Construction
3. Soils
4. Irrigation systems
5. Drafting and graphic presentation technique

D. A Process

1. Site Analysis
   a.
   b.
   c.
   d.
   e.
   f.
2. Design Program
   a.
   b.
   c.
d.

e.

3. **Schematic Diagram or Bubble Diagram**
   a.
   b.
   c.

4. **Plan Development**
   a. Preliminary Plan
   b. Final Plan

5. **Project Installation**
   a.
   b.
   c.
Lab Exercise 9
PRUNING AND TRAINING

General Recommendation

1. Remove all limbs and branches that obstruct walks and drives.
2. Prune back to clear all doors and windows.
3. Remove all broken, diseased, or dead branches from all trees and shrubs.
4. Go back to prune your plants for form, shape, vigor, and beauty!
5. It is usually is best to prune deciduous trees and shrubs during early spring before full leaf.
6. Evergreens, especially shrubs, should where practical, be encouraged to grow and branch to the ground. This not only gives a more healthy plant, but in most cases a much better looking plant.

Purposes of Pruning

1. To control habit of growth.
2. To remove all dead, broken, or diseased plant parts.
3. To produce desired shape and form.
4. To improve flowering and fruiting.
5. To improve chances of survival (usually at transplanting).

Some Pruning Tools

1. Hand Shears (7-1/2 inches long)
2. Pruning Loppers (26 inches long)
3. Pruning Saw (folding)
4. Pole Tree Saw (10 foot handle)

Botany of Pruning

Trees grow, above the ground, primarily from two areas:

1. Branches elongate from buds.
2. Branches increase in diameter from the cambium.

Water and mineral nutrients travel up from the roots through the wood or xylem into the leaves. Here, in the leaves, food is manufactured and sent back through the phloem out to feed all parts of the plant, twigs, buds, flowers, roots, etc.

If the terminal buds are removed, or twig end cut off side branching is induced, and a more compact habit of growth is obtained. If side branches or laterals are removed, a more upright form results.
**Anatomy of a shoot branch**

**Where to Cut**

**IN RELATION TO BUDS.**
- Good
- Too much
- Stub
- Too Close
- Surface
- Too Long
- To Bud

**IN RELATION TO TWIGS.**
- Right
- Wrong

**BUILD YOUR TREE?**
- Cut to outside buds
- Save inside buds
- For spreading growth
- For erect growth

Grow your plants by choice, not by chance.
General Pruning

On all “heavy cuts,” make removal in three steps:

1. Under Cut
2. Over-cut off
3. Stub removal at shoulder ring

Keep all diseased, dead, and broken branches pruned out of your trees at all times.

Avoid weak crotch branching and remove “cross over” or “interfering” branches.

Prune to side branches, laterals, or main trunks. Never leave stubs, snags, or ragged cuts.

Big Cuts

Tight-weak crotch

Proper cut line. Cut at “shoulder ring,” area of rapid growth and heal over.
Directional Pruning (Trees)

All cuts to side branches
All cuts to clean
Stay as near as possible to natural form

Top work to reduce size, clear lines, etc.

Good  Stub pruning causes “bird nesting”

Prune to Side Branches

Shouler Ring
Cut to leave small surface area

Excessive flush cut
Too much surface
Slow heel over

Prune Limbs to Soulder Rings
Deciduous Shrubs
Prune for Form

NOTE: When shrubs get old and leggy - one of three things may be done.

1. Consider rejuvenation. Remove at least half of the existing old canes at ground level. Dormant pruning is best for this. Next year remove remaining canes. As new growth comes up - keep terminal growth pinched back to induce side branching and compact growth.
2. In a few cases you may wish to cut all growth back. Thus allowing all growth to come up new.
3. Complete removal and replanting may be the most practical and economical solution.
**Prune with a purpose on Junipers**

*Discipline:* “Training which corrects, molds, strengthens, or perfects” (Webster)

Start when plants are young, if possible! Strive for a disciplined form. Avoid neglect and abuse.

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Prune diagram" /></td>
<td>Prune “deep” enough to hide all cuts. Cut “Back In” to a top growing twig! Be careful not to leave unsightly “Holes”</td>
</tr>
<tr>
<td><img src="image2" alt="Neglect, disciplined, abuse diagram" /></td>
<td>The form to achieve on uprights is with a single-center trunk, and a “controlled” natural look.</td>
</tr>
<tr>
<td><img src="image3" alt="Neglect, disciplined, abuse diagram" /></td>
<td>In maintaining spreading junipers, strive for the “disciplined” look. Avoid “butch” cut and “scalp jobs”.</td>
</tr>
<tr>
<td><img src="image4" alt="Avoid Sheared and Ugly Ends!" /></td>
<td>Make a cut deep enough to avoid the look of truncation. Remove a stem at the branching point.</td>
</tr>
<tr>
<td><img src="image5" alt="Pinching diagram" /></td>
<td>Much of your pruning can be done by pinching back the new, young shoot growth as it develops each season! This stops terminal growth and avoids stringy.</td>
</tr>
</tbody>
</table>
Building a Hedge

Stakes and tight guide wires or ropes insure a more even surface. Make sure wire is tight and not misplaced by twig.

Overhanging top edges shade sides, which soon loose their leaves and become leggy.

SOME GOOD HEDGE PLANTS

<table>
<thead>
<tr>
<th>Low hedge (2 to 4 feet)</th>
<th>Large hedge (over 6 feet, continued.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pygmy Peashrub</td>
<td>Medora Juniper</td>
</tr>
<tr>
<td>Alpine Current</td>
<td>Chinese Lilac</td>
</tr>
<tr>
<td>Fritsch Spirea</td>
<td>Fragrant Sumac</td>
</tr>
<tr>
<td>Dakota Sunset Potentilla</td>
<td>Siberian Arborvitae</td>
</tr>
<tr>
<td>Little Giant Arborvitae</td>
<td>Bergeson Compact Dogwood</td>
</tr>
<tr>
<td>Hetz Midget Arborvitae</td>
<td>Wayfaring Tree Viburnum</td>
</tr>
<tr>
<td>Emerald Carousel Barberry</td>
<td></td>
</tr>
<tr>
<td>Dwarf Gooseberry</td>
<td>Screening (over 10 ft tall)</td>
</tr>
<tr>
<td></td>
<td>Eastern Red Cedar</td>
</tr>
<tr>
<td>Medium hedge (4 to 6 feet)</td>
<td>Medora Juniper</td>
</tr>
<tr>
<td>Globe peashrub</td>
<td>Chinese Lilac</td>
</tr>
<tr>
<td>Threelobe Spirea</td>
<td>Fragrant Sumac</td>
</tr>
<tr>
<td>Triumph Potentilla</td>
<td>Siberian Arborvitae</td>
</tr>
<tr>
<td>Globe Arborvitae</td>
<td>Bergeson Compact Dogwood</td>
</tr>
<tr>
<td>Miniglobe Honeysuckle</td>
<td>Wayfaring Tree Viburnum</td>
</tr>
<tr>
<td>Palibin Dwarf Lilac</td>
<td></td>
</tr>
<tr>
<td>Large hedge (over 6 feet)</td>
<td>Screening (over 10 ft tall)</td>
</tr>
<tr>
<td>Miss Kim Lilac</td>
<td>Eastern Red Cedar</td>
</tr>
<tr>
<td>Minuet Lilac</td>
<td>Medora Juniper</td>
</tr>
<tr>
<td></td>
<td>Grizzly Bear Juniper</td>
</tr>
<tr>
<td></td>
<td>Miss Canada Late Lilac</td>
</tr>
<tr>
<td></td>
<td>Embers (or Redwing) Amur Maple</td>
</tr>
<tr>
<td></td>
<td>Siberian Peashrub (Caragana)</td>
</tr>
<tr>
<td></td>
<td>Black Hills Spruce</td>
</tr>
<tr>
<td></td>
<td>Colorado Spruce</td>
</tr>
<tr>
<td></td>
<td>Pyramidal Arborvitae</td>
</tr>
<tr>
<td></td>
<td>Bailey Compact Amur Maple</td>
</tr>
<tr>
<td></td>
<td>Techny Arborvitae</td>
</tr>
</tbody>
</table>
1. Diagram the procedure for removing a large limb from a tree. Explain why large limbs are removed in this way.

2. Why are narrow crotches undesirable in a tree? What are two ways to deal with them?

3. List three ways to deal with overgrown shrubs. What would be the result of each treatment?

4. If you have an old apple tree in the yard of the house you just bought, how are you going to decide which branches to prune?
Lab Exercise 11
LAWN CARE

1. Lawn Grass

By definition, a lawn is “a plot of closely mown grasses.” Actually, a lawn is composed of thousands of individual plants crowded and forced into a very unnatural growth habit. To achieve the desired results for an attractive turf, we should know a few of other facts:

a. Lawns must have irrigation water.
b. Lawns must have fertilizer.
c. Lawns must have light.
d. Lawns must have desirable soil conditions.
e. Lawns must be mowed regularly.
f. Lawns must have adequate top growth.

Not just the lawn collectively, but each plant in this actual “forest” needs to be supplied with all of these in proper amounts, and at all times to some degree. Many factors tend to restrict or prevent full use of these things, even when they are available.

Lawns need fertilizers to grow properly. Fertilizers are not “food” but raw materials used in the manufacturing of foods by the plants. Sugars, starches, proteins, etc. are the real foods. Both made and used by the plant for growth and production.

2. The Turfgrasses

a. Growth characteristics

Bunch-type,
Rhizome-forming
Stolon-forming
b. Temperature requirement

Cool-season grasses

Transitional zone grasses

Warm-season grasses
3. **General Lawn Care**

1. Mow often enough that you never remove more than one-third of the total height at any one cutting.

2. If and when irrigation is needed - water deep. Roots cannot get water or nutrients out of dry soil. In areas where tree and shrub roots compete with the lawn, extra deep irrigation can be of great worth.

3. Do not starve your lawn. But do not overfeed either. A good lawn is judged by its color and density, not by how often it has to be mowed. The even cut tops, not the closeness of cut, gives a lawn a more tailored look.

4. Soil compaction should be avoided where practical. Healthy grass can do much to avoid problems and resist compaction. Dry soils compact less than wet soils. If heavy use is expected for a special occasion try to have the lawn on the “dry side”, even if it requires an extra irrigation in your schedule. Avoid the use of lawn rollers, in most cases rollers do more damage then good. Lawns should be left to grow a little long before times of heavy use. Extra top growth gives extra padding and encourages better root condition.

5. Leave the clippings on your lawn if they are short enough to sift into the grass. However, any clippings that remain on the top after an hour or so should be removed.

6. Rake all leaves and debris from the lawn to avoid “burned” and “smothered” spots.

7. Compaction problems can be relieved by aeration and soil conditioning.

8. Aeration can be done with one of many tools. For general use, the tool found easiest and most practical is the common garden digging fork.
   a. Water the area.
   b. Insert fork into the soil six to eight inches holding the fork in a near vertical position (figure 1).
   b. Pull handle back twelve to eighteen inches (figure 2). If condition is not too bad remove fork. Repeat every eight to twelve inches over the compacted area.
   c. If compaction is severe or soil is very heavy, push handle forward and fill with a mixture of 50% peat moss and 50% sand. Remove fork.

Note: This process breaks plant roots and may necessitate supplemental irrigation.
I. EVALUATING

Problems

1. 
2. 
3. 

Tests to evaluate lawn:

1. Visual 
2. Thatch 
3. Conditions beneath soil 
4. Compaction 
5. Earthworms 
6. Soil test 

II. SEED

Two questions to ask before deciding on type of seed:

1. Which grasses work for your area of the country? 
2. How old is existing lawn? 

Other factors in determining type of grass seed:

1. Three growing areas:
   a. cool season:
      Bluegrass-Kentucky bluegrass 
      Perennial rye 
      Fescue-fine fescue 
   b. warm season:
      Bermudagrass 
      Zoysiagrass 
      Buffalograss 
      St. Augustine grass 
   c. transitional:

2. Shade vs. sun 
3. Time 
4. Decoration or recreation
III. PREPARING LAWN

Renovate or Redo?
Renovation best done in early spring or early fall
1. scalp
2. remove thatch
3. aerate soil-1/4"deep
4. fertilize and lime if needed

Special steps for bare spots:
1. remove debris and rocks
2. add organic matter to depth of 6-8"
3. rake smooth

IV. SEEDING

Best done in early spring or early fall
If overseeding use half recommended rate
Water in thoroughly
Roll it
flattens
increases contact between seed and soil

Bare spot/brand new lawn:
1.
2.
3.
4.
5.

V. SODDING

VI. MOWING

Frequency:
Height:
Taller grass:
1.
2.
3.

Seasonal Mowing:
Summer:
Fall:
Final mowing:
Shady areas:

Proper Maintenance:
VII. WATERING

Best Way:
Best Time:

VIII. FEEDING

Only need to fertilize once or twice a season
Timing:
   Warm season:
   Cool season:
Results:
   Fall fertilizing:
   Spring fertilizing:
North area:
NOTE: Clippings return 50% of N back into soil.
Types of nutrition:

IX. PEST/DISEASE CONTROL

Backyard Pest Management
   1.
   2.

Insects:
   1. Above soil:
      Cinchbugs, armyworm, sod webworm
   2. Below Soil:
      Billbug grub, white grub

Method to check for bugs:

Contact Insecticides include Safer's Insecticidal Soap and Pyrethrums

Weeds:
   Compacted Soil
   Improper watering or fertilizing
   1. Annual Weeds:
      Crabgrass, chickweed, knotweed
   2. Perennial Weeds:
      Dandelions, thistle, plantain, buckhorn
<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beloperone guttata</td>
<td>Acanthaceae</td>
<td>Shrimp Plant</td>
</tr>
<tr>
<td>Dracaena marginata</td>
<td>Agavaceae</td>
<td>Dragon Tree of Madagascar</td>
</tr>
<tr>
<td>Sansevieria trifasciata</td>
<td>Agavaceae</td>
<td>Snake Plant</td>
</tr>
<tr>
<td>Dieffenbachia amoena</td>
<td>Araceae</td>
<td>Giant Dumbcane</td>
</tr>
<tr>
<td>Philodendron scandens oxycardium</td>
<td>Araceae</td>
<td>Heart-leaf Philodendron</td>
</tr>
<tr>
<td>Epipremnum aureum</td>
<td>Araceae</td>
<td>Golden Pothos</td>
</tr>
<tr>
<td>Spathiphyllum clevelandii</td>
<td>Araceae</td>
<td>Peace Lily or White Flag</td>
</tr>
<tr>
<td>Brassia arboricola</td>
<td>Araliaceae</td>
<td>Hawaiian Schefflera</td>
</tr>
<tr>
<td>Hedera helix</td>
<td>Araliaceae</td>
<td>English Ivy</td>
</tr>
<tr>
<td>Araucaria heterophylla</td>
<td>Araucariaceae</td>
<td>Norfolk Island Pine</td>
</tr>
<tr>
<td>Begonia masoniana</td>
<td>Begoniaceae</td>
<td>Iron Cross Begonia</td>
</tr>
<tr>
<td>Aechmea fasciata</td>
<td>Bromeliaceae</td>
<td>Silver Vase</td>
</tr>
<tr>
<td>Mammillaria albilanata</td>
<td>Cactaceae</td>
<td>Mammillaria Cactus</td>
</tr>
<tr>
<td>Crassula argentea</td>
<td>Crassulaceae</td>
<td>Jade Plant</td>
</tr>
<tr>
<td>Euphorbia splendens</td>
<td>Euphorbiaceae</td>
<td>Crown-of-Thorns</td>
</tr>
<tr>
<td>Euphorbia trigona</td>
<td>Euphorbiaceae</td>
<td>African Milktree</td>
</tr>
<tr>
<td>Saintpaulia ionantha</td>
<td>Gesneriaceae</td>
<td>African Violet</td>
</tr>
<tr>
<td>Plectranthus australis</td>
<td>Lamiaceae</td>
<td>Swedish Ivy</td>
</tr>
<tr>
<td>Chlorophytum comosum 'Vittatum'</td>
<td>Liliaceae</td>
<td>Variegated Spider Plant</td>
</tr>
<tr>
<td>Asparagus densifloris ‘Sprengeri’</td>
<td>Liliaceae</td>
<td>Sprenger Asparagus</td>
</tr>
<tr>
<td>Ficus benjamina</td>
<td>Moraceae</td>
<td>Weeping Fig</td>
</tr>
<tr>
<td>Ficus elastica</td>
<td>Moraceae</td>
<td>Rubber Fig</td>
</tr>
<tr>
<td>Cattleya spp.</td>
<td>Orchidaceae</td>
<td>Cattleya Orchid</td>
</tr>
<tr>
<td>Peperomia obtusifolia variegata</td>
<td>Piperaceae</td>
<td>Variegated Peperomia</td>
</tr>
<tr>
<td>Nephrolepis exaltata 'Dallas'</td>
<td>Polypodiaceae</td>
<td>Dallas Fern</td>
</tr>
<tr>
<td>Platycerium bifurcatum</td>
<td>Polypodiaceae</td>
<td>Staghorn Fern</td>
</tr>
</tbody>
</table>
Lab 10: Guidelines for Completing Plant ID Sheets

Names:
Family Name:  Origin:
Scientific Name:  Cultivar:
Common Name:

Environmental Requirements:
1. Temperature:  
   Cool (C)......................... 50-60°F
   Medium (M) ................... 60-70°F
   High (H) ......................... 70-80°F
2. Light:  
   Low (L) ...................... Minimum 50 fc (recommended 70-150 fc)
   Medium (M) ................... Minimum 100 fc (recommended 200 fc)
   High (H) ............. Minimum 200 fc (recommended 500 fc)
   Very High (VH) Minimum 500 fc (recommended 1000+ fc)
3. Moisture:  
   Dry (D)  Let dry completely between watering
   Moist (M)  Keep uniformly moist but not wet
   Wet (W)  Never let soil dry out
4. Humidity:  
   Low (L) Up to 40% RH
   Medium (M) 60-70% RH
   High (H) 70-80% RH
5. Medium:  
   Heavy (H) High in soil for wet conditions
   Medium (M) Well drained, moist conditions
   Light (L) Dry, sandy conditions

Plant Characteristics:
1. Plant Type:  
   Tree (Single-stem, Multi-stem) (Tr)
   Shrub (Shr)
   Ground Cover (GC)
   Vine (V)
2. Shape/Form:  
   Upright (Up)
   Spreading (Spr)
   Cascading or Weeping (Cas)
   Climbing (Cl)
   Oval (Ov)
   Round (R)
   Irregular (Ir)
   Pyramidal (Py)
3. Plant Size:  
   Very Tall (VT) Greater than 6 feet
   Tall (T) 4-6 feet
   Medium (M) 2-4 feet
   Short (S) 1-2 feet
   Creeping (C) Shorter than 1 foot
4. Growth Rate:  
   Slow (S)
   Medium (M)
   Fast (F)
5. Leaf Texture:  
   Pubescent (P), Waxy (W), Dull (D), Thick (T)
6. Plant Texture:  
   Fine (F), Medium (M), Coarse (C)
1. **Shrimp Plant** *Beloperone guttata* (also *Justicia brandegeana*)  
   Family - Acanthaceae  
   250 Genera of dicots-herbs or shrubs-perfect flowers  
   Temp. Medium  
   Light High  
   Moist. Dry  
   Pests-Dis  
   Prop. Cutting  
   Notes Keep plants on dry side. Cut back 1/3 of plants in the spring.

2. **Dragon Tree of Madagascar** *Dracaena marginata*  
   Family - Agavaceae  
   20 Genera of monocots - leaves mostly narrow  
   Temp. Med  
   Light Medium  
   Moist Moist  
   Pests-Dis  
   Prop. Tip cutting  
   Notes Pointed leaves, sensitive to fluoride

3. **Snake Plant** *Sansevieria trifasciata*  
   Family - Agavaceae (also found it listed in Liliaceae family in two references)  
   Temp. Cool to high  
   Light low to high  
   Moist. Dry to medium dry  
   Pests-Dis. Mealybug, root rot if too wet  
   Prop. Division, leaf cutting  
   Notes Excellent low light plant; used for terrarium, dish garden, atrium; slow-growing; durable; does best in peat containing soil.

4. **Giant Dumbcane** *Dieffenbachia amoena*  
   Family - Araceae - Arum or Philodendron family  
   13 genera of monocots - herbs -stemless or erect and climbing stems; inflorescence spadix usually subtended by a spathe; genera include *Anthurium* plus others listed.  
   Temp. Medium to high  
   Light Medium  
   Moist. Moist  
   Pests-Dis. Mealybug, root rot and stem rot  
   Prop. Tip cutting, stem cutting  
   Notes Can be tall (15 ft); susceptible to cold (at 55 °F); produces oxalic acid crystals that are toxic to skin (causes inflammation).

5. **Heart-leaf Philodendron** *Philodendron scandens oxycardium*  
   Family - Araceae  
   Temp. Medium to high  
   Light Low to medium  
   Moist. Medium  
   Pests-Dis. Mealybug, root rots  
   Prop. Tip or nodal cuttings  
   Notes Very tolerant to all indoor conditions including low light; most comon of all philodendrons.

6. **Golden Pothos** *Epipremnum aureum*
7. **Peace Lily or White Flag** *Spathiphyllum clevelandii*
   - Family: Araceae
   - Temp.: Medium to high
   - Light: Low to medium
   - Moist.: Moist
   - Pests-Dis.: Mealybug, root rot
   - Prop.: Tissue culture, division
   - Notes: Very tolerant to low light conditions; use well-drained medium.

8. **Hawaiian Schefflera** *Brassaia arboricola*  
   (also *B. actinophylla, Schefflera arboricola*)
   - Family: Araliaceae
   - Temp.: Cool to medium
   - Light: Medium to high
   - Moist.: Medium
   - Pests-Dis.: Spider mite, scale, root rot
   - Prop.: Seed, cutting
   - Notes: More bushy and compact than *B. actinophylla*; attractive shrub.

9. **English Ivy** *Hedera helix*
   - Family: Araliaceae
   - Temp.: Cool to medium
   - Light: Medium to very high
   - Moist.: Medium
   - Pests-Dis.: Spider mite, scale
   - Prop.: Tip cutting, nodal cuttings
   - Notes: Used as for hanging basket, dish gardens; terrariums; does poorly in low light

10. **Norfolk Island Pine** *Araucaria heterophylla*
    - Family: Araucariaceae
    - Temp.: Medium
    - Light: High
    - Moist.: Moist
    - Pests-Dis.: Spider mite
    - Prop.: Tip cuttings, seed
    - Notes: Used for specimen, atrium, terrarium; seasonal use as Christmas tree

11. **Iron Cross Begonia** *Begonia masoniana*
    - Family: Begoniaceae
    - Temp.: High
    - Light: Medium to high
    - Moist.: Moist
12. **Silver Vase** *Aechmea fasciata*

   **Family - Bromeliaceae - Pineapple Family**
   44 genera of monocots; mostly epiphytic; stiff leaves which are colored toward base; leaves basal or rosette forming to hold water
   **Temp.** Cool to medium
   **Light** Medium to high
   **Moist.** Dry
   **Pests-Dis.** No insect problem, root rot
   **Prop.** Tissue culture, division
   **Notes** Floral accent, pot plant; flowers last 4 - 6 months, easy to grow

13. **Mammillaria Cactus** *Mammillaria albilanata*

    **Family - Cactaceae - Cactus Family**
    50 to 150 genera of dicots; succulents found in drier regions of tropical areas; leaves reduced to spines; flowers showy and solitary
    **Temp.** High
    **Light** Very high
    **Moist.** Dry
    **Pests-Dis.** Mealybug, root rot
    **Prop.** Seed, division
    **Notes** Very attractive; used for dish garden and as a pot plant; keep dry during winter months.

14. **Jade Plant** *Crassula argentea*

   **Family - Crassulaceae - Orpine Family**
   35 genera of succulent herbs or undershrubs; annuals or perennials; includes *Sedum, Sempervivum, Kalanchoe*
   **Temp.** Cool, medium, high
   **Light** Medium to very high
   **Moist.** Dry
   **Pests-Dis.** Mealybug, scale aphid, spider mite; root and stem rot
   **Prop.** Stem cuttings
   **Notes** Very tolerant of all conditions; prefers high light; sensitive to salty soil; used for bonsai, specimen.

15. **Crown of Thorns** *Euphorbia splendens (E. mili splendens)*

    **Family - Euphorbiaceae - Spurge Family**
    290 genera of dicots with often milky sap; herbs, shrubs and trees; frequently cactus-like
    **Temp.** Medium to high
    **Light** High to very high
    **Moist.** Medium
    **Pests-Dis.** Mealybug, root rot
    **Prop.** Stem cuttings
    **Notes** Thorny; very good indoor plant for warm sunny areas

16. **African Milk Tree** *Euphorbia trigona*

    **Family - Euphorbiaceae**
    **Temp.** Medium to high
17. **African Violet** *Saintpaulia ionantha*
   
   **Family** - Gesneriaceae
   moist tropical herbs and creepers; leaves frequently colored above or below and hairy
   
   **Temp.**  Medium to high
   **Light**  Very high
   **Moist.**  Medium
   **Pests-Dis.**  Spider mite, cyclamen mite, root and stem rot
   **Prop.**  Tissue culture, seed, leaf cuttings
   **Notes**  Most popular flowering house plant; avoid chilling.

18. **Swedish Ivy** *Plectranthus australis*
   
   **Family** - Lamiaceae - Mint Family
   180 genera of dicots with square stems; aromatic
   
   **Temp.**  Medium to high
   **Light**  Low to high
   **Moist.**  Moist
   **Pests-Dis.**  Mealybug, spider mite, root rot
   **Prop.**  Tip cutting; nodal cutting
   **Notes**  Very easy to grow, does not like chilling; sap stains skin and clothing orange.

19. **Variegated Spider Plant** *Chlorophytum comosum 'Vittatum'*
   
   **Family** - Liliaceae - Lily Family
   335 genera of monocots; herbaceous perennials; flowers often showy; grow from rhiomes, corms or bulbs; includes lily, daylily, tulip, onion, daffodil, hyacinth
   
   **Temp.**  Cool to high
   **Light**  Medium to high
   **Moist.**  Medium
   **Pests-Dis.**  Scale, mealybug, spider mite
   **Prop.**  Division, stolons; tissue culture
   **Notes**  Good for hanging basket; sensitive to fluoride damage.
20. **Sprenger Asparagus**  *Asparagus densiflorus* 'Sprengeri'

- **Family**: Liliaceae
- **Temp.**: Cool to high
- **Light**: High to very high
- **Moist.**: Dry
- **Pests-Dis.**: Spider mite
- **Prop.**: Seed
- **Notes**: Used for hanging baskets and cut foliage; very durable; easy to grow; does best under high light conditions.

21. **Weeping Fig**  *Ficus benjamina*

- **Family**: Moraceae - Mulberry Family

- **Temp.**: Cool to high
- **Light**: Medium to very high
- **Moist.**: Medium
- **Pests-Dis.**: Spider mite, mealybug, scale
- **Prop.**: Tip cutting, air layering
- **Notes**: Most common indoor tree; used as specimen, bonsai, pot plant; avoid drying, drafts, low lights; requires acclimatization; grow up to 70 feet.

22. **Rubber Plant**  *Ficus elastica*

- **Family**: Moraceae
- **Temp.**: Cool to high
- **Light**: Medium to very high
- **Moist.**: Moist
- **Pests-Dis.**: Scale, mealybug
- **Prop.**: Air-layering, tip cuttings; tissue culture
- **Notes**: Many different cultivars; used as specimen, pot plant; can be used for exterior.

23. **Cattleya Orchid**  *Cattleya sp.*

- **Family**: Orchidaceae - Orchid Family

- **Temp.**: High
- **Light**: Very high
- **Moist.**: Medium
- **Pests-Dis.**: Scale, spider mite, mealybug
- **Prop.**: Division, protocorm culture; seed
- **Notes**: Flower initiation takes place at 2000-3500 fc; a large number of hybrids exists; used for flowering pot or corsages; slow growing.

24. **Variegated Peperomia**  *Peperomia obtusifolia* 'Variegata'

- **Family**: Piperaceae

- **Temp.**: Medium to high
- **Light**: High to very high
- **Moist.**: Medium to dry
- **Pests-Dis.**: Mealybug, spider mite, root and stem rot
- **Prop.**: Tip cuttings, leaf cuttings
- **Notes**: Used for terrarium, dish gardens.
25. **Dallas Fern** *Neprolepis exaltata* 'Dallas'
   - Family - Polypodiaceae - Ferns (Pteridophytes)-Common Fern Family
     - most common ferns; no distinct trunk; nonflowering plants reproducing from spores
   - Temp. Medium to high
   - Light High to very high
   - Moist. Medium
   - Pests-Dis. Spider mite, mealybug, scale, whitefly, root rot
   - Prop. Division, tissue culture
   - Notes Used for hanging basket, pot plant; burns in direct sun; more compact than the Boston fern.

26. **Staghorn Fern** *Platycerium bifurcatum*
   - Family - Polypodiaceae
   - Temp. Medium to high
   - Light Medium to very high
   - Moist. Medium
   - Pests-Dis. Spider mite, scale, root rot
   - Prop. Spore, division
   - Notes Used for hanging basket or slab; epiphytic; attractive fronds.
PLANTS FOR INTERIORS

LISTING BY PLANT FAMILIES

ACANTHACEAE
Aphelandra squarrosa
Beloperone guttata
Crossandra infundibuliformis
Fittonia minima
Fittonia verschaffeltii 'Pearlei'
Fittonia verschaffeltii 'Argyoneura'
Graphiophyllum pictum
Hemigraphis 'Exotica'
Hypoestes sanguinolenta
Pachystachys lutea
Jacobinia carnea
Pseuderanthemum atropurpureum tricolor
Sanchezia speciosa

AGAVACEAE
Agave americana
Agave angustifolia marginata
Agave attenuata
Beaucarnea recurvata
Cordyline terminalis
Cordyline stricta
Dracaena craigii 'Compacta'
Dracaena deremensis 'Bausei'
Dracaena deremensis 'Janet Craig'
Dracaena deremensis 'Warneckii'
Dracaena fragrans 'Massangeana'
Dracaena godseffiana 'Florida Beauty'
Dracaena marginata
Dracaena marginata 'Florida Beauty'
Dracaena sanderiana
Dracaena thaliioides
Pleomele reflexa
Pleomele reflexa 'Variegata'
Sansevieria intermedia
Sansevieria trifasciata
Sansevieria trifasciata 'Golden Hahnii'
Sansevieria trifasciata laurertii
Yucca elephantipes

AIZOACEAE
Lithops lesii

AMARANTHACEAE
Alternanthera versicolor
Iresine herbstii 'Aureo-reticulata'
Iresine lindenii
Iresine lindenii formosa

AMARYLLIDACEAE
Clivia miniata
Eucharis grandiflora
Hippaeastrum spp.
Nerine bowdenii

Zebra Plant
Shrimp Plant
Crossandra
Miniature Silver Nerve Fittonia
Pink Nerve Fittonia
White Nerve Fittonia
Caricature Plant
Purple Waffle Plant
Polka Dot Plant or Freckle Face
Lollipop Plant
Pink Lollipop Plant

Century Plant
Variegated Caribbean Agave
Dragon Tree Agave
Ponytail or Elephant-Foot Tree
Baby Doll Dracaena
Cordyline
Compact Dracaena
Striped Dracaena
Janet Craig Dracaena
Warneckii Draecaena
Corn Plant
Gold Dust Draecaena
Dragon Tree of Madagascar
Tricolor Dragon Tree
Ribbon Plant
Lance Draecaena
Pleomele
Song of India Pleomele
Pygmy Bowstring
Snake Plant
Golden Birdnest Sansevieria
Variegated Snake Plant or Birdnest Sansevieria
False Agave

Living Stones

Joseph's Coat
Clown Plant
Bloodleaf or Acharanthus
Bloodleaf or Acharanthus

Kaffir Lily
Eucharis Lily
Amaryllis
Naked Lady Lily
APOCYNACEAE
Mandevilla splendens
Mandevilla sanderi 'Rosea'
Nerium oleander

ARACEAE
Aglaonema commutatum maculatum
Aglaonema commutatum 'Pseodo bracteum'
Aglaonema commutatum 'Treubii'
Aglaonema crispum
Aglaonema modestum
Anthurium scherzeranum
Caladium spp.
Difffenbachia amoena
Dieffenbachia 'Exotica'
Dieffenbachia oerstedii 'Variegata'
Dieffenbachia maculata
Dieffenbachia maculata 'Rudolph Roehrs'
Epipremnum aureum
Epipremnum aureum 'Marble Queen'
Monstera deliciosa 'Variegata'
Monstera deliciosa
Monstera guttata
Monstera friedrichsthalii
Philodendron bipennifolium
Philodendron x Burgundy
Philodendron cannifolium
Philodendron hastatum
Philodendron scandens oxycardium
Philodendron micans
Philodendron mortianum
Philodendron panduriforme
Philodendron selloa
Philodendron squamiferum
Scindapsus pictus 'Argyraeus'
Spathiphyllum clevelandii
Syngonium auritum
Syngonium podophyllum
Syngonium podophyllum 'White Butterfly'
Zamioculcas zamiifolia

ARALIACEAE
Brassaia actinophylla
Brassaia arboricola
Dizygotheca elegantissima
Fatsia japonica
Fatshedera x lizei
Hedera canariensis
Hedera canariensis variegata
Hedera helix
Hedera helix 'Glacier'
Hedera helix 'Golddust'
Hedera helix 'Needlepoint'
Hedera helix 'Scutifolia'
Polyscias balfouriana
Polyscias balfouriana marginata
Polyscias fruticosa
Polyscias guilfoylei 'Victoriae'
Tupidanthus calytratus

ARUCARIACEAE
Araucaria bidwillii
Araucaria heterophylla

Alice DuPont Mandevilla
Rose Dipladenia
Oleander
Silver Chinese Evergreen
Golden Chinese Evergreen
Variegated Chinese Evergreen
Painted Droptongue
Chinese Evergreen
Flamingo Flower
Caladium
Giant Dumbcane
Dumbcane
Velvet Dumbcane
Spotted Dumbcane
Gold Dieffenbachia
Golden Pothos
Marble Queen Pothos
Variegated Split-Leafed Philodendron
Split-Leafed Philodendron
Angel Winged Philodendron
Windowleaf Philodendron
Purple Prince Philodendron
Flask Philodendron
Spade-Leaf Philodendron
Heart-Leaf Philodendron
Velvet-Leaf Philodendron
Giant Philodendron
Fiddle-Leaf Philodendron
Tree Philodendron
Red Brishly Philodendron
Satin Pathos
Peace Lily or White Flag
Five Fingers Syngonium
Arrowhead or Nephthytis
White Butterfly Nephthytis
ZZ Plant
Schefflera or Umbrella Tree
Hawaiian Schefflera
False Aralia
Japanese Aralia
Tree Ivy, Botanical Wonder
Algerian Ivy
Variegated Algerian Ivy
English Ivy
Glacier Ivy
Golddust Ivy
Needlepoint Ivy
Sweetheart Ivy
Balfour Aralia
Variegated Balfour Aralia
Ming Aralia
Lace Aralia
Tupidanthus

Monkey Puzzle, Bunya Bunya Tree
Norfolk Island Pine
**ARECACEAE**
- Caryota mitis
- Caryota obtusa
- Chamaedorea elegans 'bella'
- Chamaedorea seifrizii
- Chamaerops humilis
- Chrysalidocarpus lutescens
- Howea forsteriana
- Phoenix roebelenii
- Rhapis excelsa

Cluster Fishtail Palm
Fishtail Palm
Nanthe Bella Palm
Bamboo Palm
European Fan Palm
Areca Palm, Butterfly Palm
Kentia Palm
Pigmy Date Palm, Dwarf Date Palm
Lady Palm

**ASCLEPIADACEAE**
- Ceropegia ampliata
- Ceropegia woodii
- Hoya bella
- Hoya carnosa
- Hoya carnosa rubra
- Hoya carnosa 'Tricolor'
- Hoya carnosa 'Variegata'
- Hoya compacta
- Hoya compacta 'Variegata'
- Hoya keysii
- Hoya 'Silver Pink'
- Stapelia gigantea
- Stephanotis floribunda

Lantern Flower
String of Hearts
Miniature Wax Plant
Wax Plant
Tricolor Wax Plant
Variegated Wax Plant
Hindu Rope
Variegated Wax Plant
Queensland Wax Plant
Silver Pink Hoya
Giant Toad Plant
Stephanotis, Wedding Flower

**ASTERACEAE**
- Gynura aurantiaca
- Gynura sarmentosa
- Senecio macroglossus variegatus
- Senecio mikaoides
- Senecio herreianus
- Senecio rowleyanus
- Senecio serpens

- Velvete Plant
- Trailing Velvet Plant
- Variegated Wax Ivy
- Parlor Ivy, German Ivy
- String of Beads
- String of Pearls
- Blue Chalksticks

**BEGONIACEAE**
- Begonia bowerii
- Begonia 'Chantilly Lace'
- Begonia foliosa
- Begonia 'Lucerna'
- Begonia masoniana
- Begonia rex
- Begonia semperflorens 'Charm'

Eyelash Begonia
Angelwing Begonia
Iron Cross Begonia
Rex Begonia
Charm Begonia

**BIGNONIACEAE**
- Radermachera sinica

China Doll

**BROMELIACEAE**
- Aechmea chantinii
- Aechmea rhodocyanea
- Aechmea fulgens discolor
- Ananas comosus
- Ananas comosus variegatus
- Billbergia nutans
- Cryptanthus roseus pictus
- Gusmania musaica
- Neoregelia caroliniae 'Tricolor'

Silver Urn Plant
Coralberry
Pineapple
Variegated Pineapple
Queen's Tears
Earth Star
Mosaic Vase
Tricolor Neoregelia

**BUXACEAE**
- Buxus microphylla japonica

Japanese Little Leaf Boxwood

**CACTACEAE**
- Astrophytum myriostigma
- Cephalocereus sentus
- Cereus peruvianus 'Monstrosus'

Bishop's Cap
Oldman's Cactus
Giant Club
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<th>Genus, Common Name</th>
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<td>Echinocactus grusonii</td>
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### EUPHORBIACEAE

- *Acalypha hispida*  
  Chenille Plant, Foxtail
- *Acalypha wikesiana macafeana*  
  Copper Leaf
- *Codiaeum variegatum pictum 'Bravo'*  
  Croton
- *Euphorbia mammilaris*  
  Indian Corncob
- *Euphorbia pulcherrima*  
  Poinsettia
- *Euphorbia splendens prostrata*  
  Crown of Thorns
- *Euphorbia tirucalli*  
  Pencil Tree
- *Euphorbia trigona*  
  African Milk Tree
- *Pedilanthus tithymaloides 'Variegatus'*  
  Redbird Cactus, Devil's Backbone

### FARBACEAE

- *Mimosa pudica*  
  Sensitive Plant

### GESNERIACEAE

- *Aeschynanthus lobbianus*  
  Lipstick Plant
- *Aeschynanthus marmoratus*  
  Black Pagoda
- *Chrysothemis folgens*  
  Sunset Plant
- *Columnnea microphylla*  
  Miniature Lipstick Plant
- *Episcia cupreata*  
  Flame Violet
- *Nautilocalyx lynchii*  
  Purple Shrub Violet
- *Saintpaulia ionantha*  
  African Violet
- *Sinningia speciosa*  
  Gloxinia
- *Sinningia species*  
  Cape Primrose
- *Streptocarpus rexii*  
  False African Violet
- *Streptocarpus saxorum*  
  African Violet

### LAMIACEAE

- *Coleus blumei*  
  Coleus
- *Plectranthus australis*  
  Swedish Ivy, Creeping Charlie
- *Plectranthus coleoides 'Marginatus'*  
  Candle Plant
- *Plectranthus oertendahii*  
  Prostrate Charlie
- *Plectranthus purpuratus*  
  Moth King

### LEEACEAE

- *Leea coccinea*  
  West Indian Holly

### LILIACEAE

- *Aloe aristata*  
  Lace Aloe
- *Aloe barbadensis*  
  Aloe Vera, Medicine Plant
- *Aloe variegata*  
  Tiger Aloe
- *Asparagus densiflorus 'Meyeri'*  
  Plume Asparagus Fern
- *Asparagus densiflorus 'Sprenger'*  
  Sprenger Asparagus
- *Asparagus setaceous*  
  Asparagus Fern
- *Aspidistra elatior*  
  Cast Iron Plant
- *Aspidistra elatior 'Variegata'*  
  Variegated Cast Iron Plant
- *Chlorophytum comosum*  
  Spider Plant
- *Chlorophytum comosum 'Variegatum'*  
  Inside-Out Spider Plant
- *Chlorophytum comosum 'Vittatum'*  
  Variegated Spider Plant
- *Haworthia cuspidata*  
  Star Window Plant
- *Haworthia fasciata*  
  Fairy Washboard
- *Haworthia marginifera*  
  Pearl Plant
- *Haworthia reinwardtii*  

### MALVACEAE

- *Abutilon x hybridum*  
  Chinese Lantern
- *Abutilon x hybridum 'Souvenir de Bonn'*  
  Variegated Flowering Maple
- *Abutilon megapotamicum*  
  Hanging Chinese Lantern
- *Abutilon pictum 'Thompsonii'*  
  Flowering Maple
- *Hibiscus rosa-sinensis*  
  Chinese Hibiscus, Rose of China
- *Hibiscus rosa-sinensis cooperi*  
  Variegated Hibiscus
MARANTACEAE
Calathea clossonii
Calathea insignis
Calathea makoyana
Calathea picturata 'Argentea'
Calathea roseo-picta
Maranta leuconeura 'Erythroneura'
Maranta leuconeura kerchoveana

MORACEAE
Ficus benjamina
Ficus benjamina 'Exotica'
Ficus deltoidea
Ficus elastica 'Decora'
Ficus elastica 'Honduras'
Ficus elastica 'Variegata'
Ficus lyrata
Ficus palmeri
Ficus petiolaris
Ficus pumila
Ficus retusa nitida
Ficus rubignosa
Ficus rubignosa 'Variegata'

MUSACEAE
Musa acuminata

MYRSINACEAE
Ardisia crispa

NICTAGINACEAE
Bougainvillea glabra
Bougainvillea glabra 'Raspberry Ice'
Pisonia umbellifera 'Variegata'

OLEACEAE
Jasminum sambac
Jasminum polyanthum

ORCHIDACEAE
Cattleya spp.
Cymbidium spp.
Dendrobium spp.
Epidendrum spp.
Miltonia spp.
Oncidium spp.
Paphiopedilum spp.
Phalaenopsis spp.
Vanda spp.
Vanilla planifolia

OXALIDACEAE
Oxalis regnellii 'rubra alba'
Oxalis rubra

PANDANACEAE
Pandanus veitchii

PASSIFLORACEAE
Passiflora caerulea

PIPERACEAE
Peperomia astrid
Peperomia caperata 'Emerald Ripple'
Peperomia griseoargentea
Peperomia griseoargentea 'Blackie'

Rattlesnake Plant
Peacock Plant
Red-veined Prayer Plant
Prayer Plant
Weeping fig
Javan Fig
Mistletoe Fig
Rubber Plant
Variegated Rubber Plant
Variegated Rubber Tree
Fiddle Leaf Fig
Mexican Blue Fig
Redvein Mexican Blue Fig
Creeping Fig
Indian Laurel
Rusty Fig
Variegated Rusty Fig
Dwarf Banana
Coral Berry
Bougainvillea
Variegated Bougainvillea
Bird Catcher Tree
Arabian Jasmine
Pink Jasmine
Lady of the Night Orchid
Cymbidium Orchid
Dendrobium Orchid
Fiery Reed Orchid
Pansy Orchid
Dancing Doll Orchid
Lady Slipper Orchid
Moth Orchid
Vanda Orchid
Vanilla Orchid
Pink Oxalis
Veitch Screw Pine
Passion Flower
Emerald Ripple Peperomia
Silver Leaf Peperomia
Dark Silver Leaf Peperomia
Peperomia incana
Peperomia obtusifolia
Peperomia obtusifolia variegata
Peperomia rubella
Peperomia sandersii
Peperomia scandens
Peperomia scandens 'Variegata'
Peperomia viridis

**PITOSPORACEAE**
Pittosporum tobira
Pittosporum tobira 'Variegata'

**POACEAE**
Oplismenus hirtellus 'Variegatus'

**PODOCARPACEAE**
Podocarpus macrophylla
Podocarpus macrophyllus 'Maki'
Podocarpus gracilior

**POLYGONACEAE**
Coccoloba latifolia

**POLYPODIACEAE**
Adiatum cuneatum
Adiatum micropyllum
Alsophila australis
Asplenium nidus
Asplenium bulbiferum
Crytomium falcatum 'Rochefordianum'
Davallia fejeensis
Davallia trichomanoides
Nephrolepis exaltata bostoniensis
Nephrolepis exaltata 'Florida Ruffles'
Nephrolepis exaltata 'Fluffy Ruffles'
Nephrolepis exaltata 'Whitmanii'
Pellaea rotundifolia
Phlebodium aureum
Platycerium wilhelminae reginae
Polystichum tsus-simense
Pteris cretica
Pteris ensiformis 'Victoria'
Stenochlaena palustris

**PORTULACACEAE**
Portulacaria afra
Portulacaria afra 'Variegata'

**PRIMULACEAE**
Cyclamen percicum

**RUBIACEAE**
Gardenia jasminoides
Ixora spp.
Coffee arabica

**RUTACEAE**
Citrus mitis

**SAXIFRAGACEAE**
Saxifraga stolonifera
Saxifraga stolonifera 'Tricolor'
Tolmiea menziesii

Pittosporum tobira
Pittosporum tobira 'Variegata'

**POACEAE**
Oplismenus hirtellus 'Variegatus'

**PODOCARPACEAE**
Podocarpus macrophylla
Podocarpus macrophyllus 'Maki'
Podocarpus gracilior

**POLYGONACEAE**
Coccoloba latifolia

**POLYPODIACEAE**
Adiatum cuneatum
Adiatum micropyllum
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Asplenium nidus
Asplenium bulbiferum
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**PORTULACACEAE**
Portulacaria afra
Portulacaria afra 'Variegata'

**PRIMULACEAE**
Cyclamen percicum

**RUBIACEAE**
Gardenia jasminoides
Ixora spp.
Coffee arabica

**RUTACEAE**
Citrus mitis

**SAXIFRAGACEAE**
Saxifraga stolonifera
Saxifraga stolonifera 'Tricolor'
Tolmiea menziesii

Mock Orange
Variegated Mock Orange

Ribbon Grass

Buddhist Pine
Japanese Yew Pine
Fern Pine

Sea Grape

Delta Maidenhair Fern
Maidenhair Fern
Australia Tree Fern
Birdnest Fern
Mother Fern
Rochford Holly Fern
Rabbit's Foot Fern
Squirrel's Foot Fern
Boston Fern
Florida Ruffles Fern
Dwarf Feather Fern
Feather Fern
Button Fern
Hare's Foot Fern
Staghorn Fern
Leather Fern
Table Fern
Victoria Table Fern
Climbing Fern

Elephant Bush
Variegated Elephant Bush

Cyclamen

Gardenia
Jungle Geranium
Coffee Plant

Calamondin

Strawberry Begonia
Variegated Strawberry Begonia
Piggy-back Plant
### SELAGENELLACEAE
- *Selaginella lepidophylla*  
  Resurrection Plant
- *Selaginella kraussiana*  
  Creeping Moss

### STRELITZIACEAE
- *Strelitzia nicolai*  
  Giant Bird of Paradise
- *Strelitzia reginae*  
  Bird of Paradise

### URTICACEAE
- *Helxine soleirolii*  
  Baby's Tears
- *Pellionia pulchera*  
  Satin Pellionia
- *Pilea cadierei*  
  Aluminum Plant
- *Pilea depressa*  
  Creeping Pilea
- *Pilea involucrata*  
  Friendship Plant
- *Pilea microphylla*  
  Artillery Plant
- *Pilea 'Moon Valley'*  
  Moon Valley Pilea
- *Pilea 'Silver Tree'*  
  Silver Tree Pilea
- *Pilea spruceana 'Norfolk'*  
  Norfolk Pilea

### VERBENACEAE
- *Clerodendrum thomsoniae*  
  Bleeding Heart Plant

### VITACEAE
- *Cissus adenopoda*  
  Pink Cissus
- *Cissus antarctica*  
  Kangaroo Vine
- *Cissus rotundifolia*  
  Arabian Wax Cissus
- *Cissus quadrangula*  
  Veldt Grape
- *Cissus rhombifolia*  
  Grape Ivy
- *Cissus rhombifolia 'Ellen Danica'*  
  Oak-Leaf Grape Ivy

### ZAMIACEAE
- *Zamia furfuracea*  
  Cardboard Palm
PLANTS FOR HIGH-LIGHT SITUATIONS

These plants will tolerate or excel in situations with an interior light level of 1000 Foot Candles or more. Remember that temperature levels are not a consideration for this list.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
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<td>Abutilon hybridum 'Fireball'</td>
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<td>Dragon Tree of Madagascar</td>
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Dracaena marginata 'Tricolor'
Dracaena sanderiana
Dracaena thalioides
Echeveria 'Doris Taylor'
Echeveria gilva
Echeveria pulvinata
Epidendrum spp.
Euphorbia mammilaris
Euphorbia pseudocactus
Euphorbia pulcherrima
Euphorbia splendens prostrata
Euphorbia tirucalli
Fatshedera lizei
Fatsia japonica
Ficus benjamina
Ficus benjamina 'Exotica'
Ficus deltoideas
Ficus elastica 'Decora'
Ficus elastica 'Honduras'
Ficus elastica variegata
Ficus lyrata
Ficus petiifolia
Ficus petiolaris var. petiolaris
Ficus petiolaris var. palmeri
Ficus pumila
Ficus retusa nitida
Ficus rubignosa
Ficus rubignosa 'Variegata'
Gardenia jasminoides
Graptopeatum paraguayense
Gynura aurantiaca
Gynura sarmentosa
Haworthia cuspidata
Haworthia fasciata
Haworthia margaritifera
Haworthia reinwardtii
Hedera canariensis variegata
Hedera helix
Hedera helix 'Golddust'
Hedera helix 'Needlepoint'
Hedera helix 'Scutifolia'
Hemigraphis 'Exotica'
Hibiscus rosa-sinensis
Huerina spp.
Iresine lindenii
Iresine lindenii formosa
Ixora spp.
Jasminum sambac
Kalanchoe beharensis
Kalanchoe daigremontiana
Kalanchoe marmorata
Kalanchoe tomentosa
Kalanchoe tubiflora
Musa acuminata
Oxalis regnelli 'Rubra Alba'
Oxalis rubra
Pachyphytum oviferum
Pedilanthus tithymaloids 'Variegatus'
Pisonia umbellifera 'Variegata'
Pittosporum tobira
Pittosporum tobira 'Variegatum'
Pleomele angustifolia honoriae
Polyscias balfouriana
Polyscias balfouriana marginata
Polyscias fruticosa

Tricolor Dragon Tree
Ribbon Plant
Lance Dracaena
Wooly Rose
Green Mexican Rose
Plush Plant

Indian Corncob
Poinsettia
Crown of Thorns
Pencil Tree
Tree Ivy
Japanese Aralia
Weeping Fig
Weeping Fig
Mistletoe Fig
Rubber Plant
Variegated Rubber Plant
Variegated Rubber Tree
Fiddle Leaf Fig

Redvein Mexican Blue Fig
Mexican Blue Fig
Creeping Fig
Indian Laurel
Rusty Fig
Variegated Rusty Fig
Gardenia
Ghost Plant or Mother-of-Pearl
Velvet Plant
Trailing Velvet Plant
Star Window Plant
Fairy Washboard
Pearl Plant

Algerian Ivy
English Ivy
Goldust Ivy
Needlepoint Ivy
Sweetheart Ivy
Purple Waffle Plant

Dragon Flower
Bloodleaf or Achyranthus
Bloodleaf or Achyranthus
Jungle Geranium
Arabian Jasmine
Velvet Leaf
Maternity Plant
Pen Wiper
Panda Bear Plant
Chandelier Plant
Dwarf Banana
Oxalis
Pink Oxalis
Moonstones
Redbird Cactus or Devil's Backbone
Bird Catcher Tree
Mock Orange
Variegated Mock Orange
Narrow-Leaved Pleomele
Balfour Aralia
Variegated Balfour Aralia
Ming Aralia
Polyscias quilfoylei 'Victoriae'  
Portulacaria afra  
Portulacaria afra 'Variegata'  
Sansevieria intermedia  
Sansevieria trifasciata  
Sansevieria trifasciata 'Golden Hahnii'  
Sansevieria trifasciata hahnii  
Sansevieria trifasciata laurentii  
Sedum morganianum  
Senecio macroglossus variegatus  
Senecio mikaioides  
Senecio rowleyanus  
Senecio serpens  
Strelitzia reginae  
Syngonium podophyllum  
Tupidanthus calyptratus  
Vanda spp.  
Yucca elephantipes  

Lace Aralia  
Elephant Bush  
Variegated Elephant Bush  
Pygmy Bowstring  
Snake Plant  
Golden Birdsnest Sansevieria  
Birdsnest Sansevieria  
Snake Plant  
Burro Tail  
Variegated Wax Ivy  
Parlor Ivy or German Ivy  
String of Pearls  
Blue Chalksticks  
Bird of Paradise  
Arrowhead or Nephthytis  
Tupidanthus  
Vanda Orchids  
False Agave

PLANTS FOR LOW-LIGHT SITUATIONS

These plants will tolerate light levels of less than 300 Foot Candles. Usually in these situations, plants will grow very slowly or not at all, and care should be taken not to apply too much water or fertilizer.

Aechmea rhodocyanea  
Aglaonema commutatum 'Psuedo bracteum'  
Aglaonema commutatum 'Treubii'  
Aglaonema commutatum maculatum  
Aglaonema crispum  
Aglaonema modestum  
Aspidistra elatior  
Aspidistra elatior 'Variegata'  
Aucuba japonica variegata  
Chlorophytum comosum  
Clivia miniata  
Epipremnum aureus  
Epipremnum aureus 'Marble Queen'  
Ficus elastica 'Decora'  
Maranta leuconeura kerchoveana  
Monstera deliciosa  
Peperomia obtusifolia  
Philodendron cannifolium  
Philodendron oxycardium  
Rhoeo spathaceae  
Spathiphyllum clevelandii  

Coralberry  
Golden Chinese Evergreen  
Silver Chinese Evergreen  
Chinese Evergreen  
Cast Iron Plant  
Variegated Cast Iron Plant  
Gold Dust Tres  
Spider Plant  
Golden Pothos  
Marble Queen Pothos  
Rubber Plant  
Prayer Plant  
Split-Leaved Philodendron  
Baby Rubber Plant  
Flask Philodendron  
Heart-Leaf Philodendron  
Moses on a Raft  
Peace Lily or White Flag
PLANTS FOR HIGH TEMPERATURE SITUATIONS

These plants will withstand average temperatures between 80° and 95° Fahrenheit. Remember that at approximately 95°F, plant metabolism stops for most plants, and cooler night temperatures are necessary for survival. With average temperatures over 100°F, few plants, if any, can be expected to survive.

*Agave americana*  
Century Plant  
*Agave angustifolia marginata*  
Variegated Caribbean Agave  
*Agave attenuata*  
Dragon Tree Agave  
*Agave victoriae-reginae*  
*Sprenger Asparagus*  
*Asparagus sprengeri*  
Bishop's Cap  
*Bougainvillea glabra*  
Bougainvillea  
*Caryota mitis*  
Cluster Fishtail Palm  
*Caryota obtusa*  
Fishtail Palm  
*Cephalocereus senilllis*  
Oldman's Cactus  
*Cereus peruviamus 'Mostrosus'*  
Giant Club  
*Coldiaeuvariegatumpictum 'Bravo'*  
*Crassula argentea*  
Croton  
*Crassula argentea 'Variegata'*  
Jade Plant  
*Echinocactus grusonii*  
Variegated Jade Plant  
*Ferocactus lastispinus*  
Golden Barrel  
*Ficus benjamina*  
Devil's Tongue  
*Ficus benjamina 'Exotica'*  
Weeping Fig  
*Ficus deltoides*  
Weeping Fig  
*Ficus rubignosa*  
Mistletoe Fig  
*Hibiscus rosa-sinensis*  
Rusty Fig  
*Jasminum sambac*  
Arabian Jasmine  
*Kalanchoe beharensis*  
Velvet Leaf  
*Kalanchoe tomentosa*  
Panda Bear Plant  
*Lithops lesii*  
Living Stones  
*Pandanus veitchii*  
Veitch Screw Pine  
*Pittosporum tobira*  
Mock Orange  
*Pittosporum tobira 'Variegatum'*  
Variegated Mock Orange  
*Sedum morganianum*  
Burro Tail  
*Yucca elephantipes*  
False Agave
These plants will tolerate average temperatures of 50°F to 65°F. They will also do well in normal interior temperature ranges but are good for placement near cooler windows and entryways.

Abutilon hybridum 'Fireball'
Abutilon pictum 'Thompsonii'
Adiantum cuneatum
Adiantum microphyllum
Ardisia crispa
Asparagus meyeri
Asparagus plumosus
Asparagus sprengeri
Aspidistra elatior
Aspidistra elatior 'Variegata'
Asplenium nidus
Aucuba japonica variegata
Beloperone guttata
Brassia actinophylla
Brassia arboricola
Calthea clossooni
Calthea insignis
Calthea makoyana
Calthea picturata 'Argentea'
Calthea roseo-picta
Ceropogia woodii
Chlorophytum comosum
Chlorophytum comosum 'Variegatum'
Chlorophytum comosum 'Vittatum'
Cycas revoluta
Cyclamen percicium
Cyrtomium falcatum 'Rochefordianum'
Davallia fejeensis
Davallia trichomanoides
Dizygotheca elegantissima
Dracaena deremensis 'Janet Craig'
Dracaena deremensis 'Warneckei'
Dracaena fragrans massangeana
Dracaena godseffiana 'Florida Beauty'
Dracaena marginata
Epiphyllum ackermannii
Epiphyllum cooperi
Euonymus japonicus
Fatshebera lizei
Fatsia japonica
Hedera canariensis variegata
Hedera helix
Hedera helix 'Goldust'
Hedera helix 'Needlepoint'
Hedera helix 'Scutifolia'
Helxine soleirolii
Hippeastrum spp.
Hoya carnosa
Hypoestes sanguinolenta
Leea coccinea
Maranta leuconeura 'Erythroneura'
Maranta leuconeura kerchoveana
Mimosa pudica
Musa acuminata
Nephrolepis exaltata 'Florida Ruffles'
Nephrolepis exaltata 'Fluffy Ruffles'
Nephrolepis exaltata 'Whitemani'
Nephrolepis exaltata bostoniensis
Opismenus hirtelus 'Variegatus'
Oxalis regnellii 'Rubra Alba'

Chinese Lantern
Flowering Maple
Delta Maidenhair Fern
Maidenhair Fern
Coral Berry
Plume Asparagus Fern
Plumosa Fern
Sprenger Asparagus
Cast Iron Plant
Variegated Cast Iron Plant
Birdsnest Fern
Gold Dust Tres
Shrimp Plant
Schefflera or Umbrella Tree
Hawaiian Schefflera
Rattlesnake Plant
Peacock Plant
String of Hearts
Spider Plant
Inside-Out Spider Plant
Variegated Spider Plant
Sago Palm
Cyclamen
Rochford Holly Fern
Rabbit's Foot Fern
Squirrel's Foot Fern
False Aralia
Janet Craig Dracaena
Warneckei Dracaena
Corn Plant
Gold Dust Dracaena
Dragon Tree of Madagascar
Red Orchid Cactus
White Orchid Cactus
Euonymus
Tree Ivy
Japanese Aralia
Algerian Ivy
English Ivy
Goldust Ivy
Needlepoint Ivy
Sweetheart Ivy
Baby's Tears
Amaryllis
Wax Plant
Polka-Dot Plant or Freckle Face
West Indian Holly
Red- Veined Prayer Plant
Prayer Plant
Sensitive Plant
Dwarf Banana
Florida Ruffles Fern
Dwarf Feather Fern
Feather Fern
Boston Fern
Ribbon Grass
Oxalis
Oxalis rubra
Passiflora caerulea
Pellaea rotundifolia
Pellionia pulchera
Phlebodium aureum
Pilea ‘Moon Valley’
Pilea ‘Silver Tree’
Pilea cadieri
Pilea depressa
Pilea involucrata
Pilea microphylla
Pilea spruceana ‘Norfolk’
Pittosporum tobira
Pittosporum tobira ‘Variegatum’
Platycerium wilhelminae reginae
Plectranthus australis
Podocarpus macrophylla
Podocarpus macrophylla maki
Polystichum tsus-simense
Pteris cretica
Pteris ensiformis ‘Victoria’
Sansevieria trifasciata
Sansevieria trifasciata laurentii
Saxifraga stolonifera
Saxifraga stolonifera ‘Tricolor’
Stenochlaena palustris
Tolmiea menziesii
Tradescantia albiflora ‘Albo-Vittata’
Tradescantia fluminensis ‘Variegata’
Tradescantia multiflora
Tupidanthus calyptratus
Zamia furfuraceae
Zebrina pendula

Pink Oxalis
Passion Flower
Button Fern
Satin Pellionia
Hare’s Foot Fern
Moon Valley Pilea
Silver Tree Pilea
Aluminum Plant
Creeping Pilea
Friendship Plant
Artillery Plant
Norfolk Pilea
Mock Orange
Variegated Mock Orange
Staghorn Fern
Swedish Ivy or Creeping Charlie
Buddhist Pine
Japanese Yew Pine
Leather Fern
Table Fern
Victoria Table Fern
Snake Plant
Snake Plant
Strawberry Begonia
Variegated Strawberry Geranium
Climbing Fern
Piggy-back Plant
Giant White Inch Plant
Variegated Wandering Jew
Tahitian Bridal Veil
Tupidanthus
Cardboard Palm
Wandering Jew
PLANTS WITH LOW WATER REQUIREMENTS

These plants tolerate low water situations and are valuable for hard to reach or low water areas.

*Aechmea chantinii*  
*Aechmea fulgens discolor*  
*Aechmea rhodocyanea*  
*Aeonium arboreum 'Atropurpureum'*  
*Aeonium hawarthii*  
*Agave americana*  
*Agave angustifolia*  
*Agave attenuata*  
*Agave victoriae-reginae*  
*Aloe aristida*  
*Aloe barbadensis*  
*Aloe variegata*  
*Ananas comosus*  
*Ananas comosus variegatus*  
*Asparagus densiflorus 'Myers'*  
*Asparagus densiflorus 'Sprengeri'*  
*Asparagus setaceus*  
*Aspidistra elatior*  
*Aspidistra elatior 'Variegata'*  
*Astrophytum myriostigma*  
*Beaucarnea recurvata*  
*Bilbergia nutans*  
*Brassia arboricola*  
*Cephalocereus senilis*  
*Cereus peruvianus 'Mostrosus'*  
*Ceropegia woodii*  
*Chamaedorea elegans 'Bella'*  
*Chamaerops humilis*  
*Chlorophytum comosum*  
*Chlorophytum comosum 'Variegatum'*  
*Chlorophytum comosum 'Vittatum'*  
*Cordyline terminalis*  
*Crassula arborescens*  
*Crassula argentea*  
*Crassula argentea 'Variegata'*  
*Crassula falcata*  
*Crassula tetragona*  
*Cryptanthus roseus pictus*  
*Cycas revoluta*  
*Dracaena craigii 'Compacta'*  
*Dracaena deremensis 'Bausei'*  
*Dracaena deremensis 'Janet Craig'*  
*Dracaena deremensis 'Warneckei'*  
*Dracaena fragrans massangeana*  
*Dracaena godseffiana 'Flordia Beauty'*  
*Dracaena marginata*  
*Dracaena marginata 'Tricolor'*  
*Dracaena sanderiana*  
*Dracaena thalioides*  
*Echeveria 'Doris Taylor'*  
*Echeveria gigya*  
*Echeveria pulvinata*  
*Echinocactus grusonii*  
*Epiphyllum ackermannii*  
*Epiphyllum cooperi*  
*Euphorbia mammilialis*  
*Euphorbia tirucalli*  
*Ferocactus lastispinus*  
*Graptopetalum paraguavense*  
*Gymnocalycium mihanovichii*  
*Haworthia cuspidata*  

*Coralberry*  
*Silver Urn Plant*  
*Tree Aeonium*  
*Pinwheel*  
*Century Plant*  
*Variegated Caribbean Agave*  
*Dragon Tree Agave*  
*Lace Aloe*  
*Aloe Vera*  
*Tiger Aloe*  
*Pineapple*  
*Variegated Pineapple*  
*Myers Asparagus*  
*Sprenger Asparagus*  
*Asparagus Fern*  
*Cast Iron Plant*  
*Variegated Cast Iron Plant*  
*Bishop's Cap*  
*Ponytail or Elephant-Foot Tree*  
*Queen's Tears*  
*Hawaiian Schefflera*  
*Oldman's Cactus*  
*Giant Club*  
*String of Hearts*  
*Neanthe Bella Palm*  
*European Fan Palm*  
*Spider Plant*  
*Inside-Out Spider Plant*  
*Variegated Spider Plant*  
*Baby Doll Dracaena*  
*Silver Dollar*  
*Jade Plant*  
*Variegated Jade Plant*  
*Propeller Plant*  
*Miniature Pine Tree*  
*Earth Star*  
*Sago Palm*  
*Compact Dracaena*  
*Stripped Dracaena*  
*Janet Craig Dracaena*  
*Warneckei Dracaena*  
*Corn Plant*  
*Gold Dust Dracaena*  
*Dragon Tree of Madagascar*  
*Tricolor Dragon Tree*  
*Ribbon Plant*  
*Lance Dracaena*  
*Wooly Rose*  
*Green Mexican Rose*  
*Plush Plant*  
*Golden Barrel*  
*Red Orchid Cactus*  
*White Orchid Cactus*  
*Indian Corncob*  
*Pencil Tree*  
*Devil's Tongue*  
*Ghost Plant or Mother-of-Pearl*  
*Plain Chin Cactus*  
*Star Window Plant*
Haworthia fasciata
Haworthia margaritifera
Haworthia reinwardtii
Hoya 'Silver Pink'
Hoya bella
Hoya carnosa
Hoya carnosa rubra
Hoya carnosa tricolor
Hoya carnosa variegata
Hoya compacta
Hoya keyssii
Huerina spp.
Kalanchoe beharensis
Kalanchoe daigremontiana
Kalanchoe marmorata
Kalanchoe tomentosa
Kalanchoe tubiflora
Lithops lesliei
Mammilaria celsian
Mammilaria collinsii
Mammilaria elongata
Neoregelia carolinae tricolor
Opuntia basilaris
Opuntia microdasys 'Albispina'
Opuntia microdasys rufida
Opuntia subulata
Pachyphytum oviferum
Pandanus veitchii
Pedilanthus tithymaloides 'Variegatus'
Phoenix roebelenii
Palm
Pleomele angustifolia honoriae
Polyscias balfouriana
Polyscias balfouriana marginata
Polyscias fruticosa
Portulacaria afra
Portulacaria afra 'Variegata'
Rhipsalis cereuscula
Sansevieria intermedia
Sansevieria trifasciata
Sansevieria trifasciata 'Golden Hahnii'
Sansevieria trifasciata hahnii
Sansevieria trifasciata laurentii
Schlumbergera bridgesii
Schlumbergera truncata
Sedum morganianum
Stapelia gigantea
Stephanotis floribunda
Strelitzia reginae
Yucca elephantipes
Zamia furfuraceae

Fairy Washboard
Pearl Plant
Miniature Wax Plant
Wax Plant
Tricolor Wax Plant
Variegated Wax Plant
Hindu Rope
Dragon Flower
Velvet Leaf
Maternity Plant
Pen Wiper
Panda Bear Plant
Chandelier Plant
Living Stones

Golden Star

Bunny Ears
Red Bunny Ears
Eve's Pin Cactus
Moonstones
Veitch Screw Pine
Redbird Cactus or Devil's Backbone
Pigmy Date Palm or Dwarf Date

Narrow-Leaved Pleomele
Balfour Aralia
Variegated Balfour Aralia
Ming Aralia
Elephant Bush
Variegated Elephant Bush
Coral Cactus
Pygmy Bowstring
Snake Plant
Golden Birdsnest Sansevieria
Birdsnest Sansevieria
Snake Plant
Christmas Cactus
Thanksgiving Cactus
Burro Tail
Giant Toad Plant
Stephanotis
Bird of Paradise
False Agave
Cardboard Palm
PLANTS FOR SMALL SPACES

These plants will keep a low bushy shape in most situations.

*Adiantum cuneatum*  
*Adiantum microphyllum*  
*Aechmea rhodocyaena*  
*Aglonema commutatum 'Pseudo-bracteum'*  
*Aglonema commutatum 'Treubii'*  
*Aglonema commutatum maculatum*  
*Aglonema crispum*  
*Aglonema modestum*  
*Asparagus meyeri*  
*Aspidistra elatior*  
*Aspidistra elatior 'Variegata'*  
*Aспленium nidus*  
*Aucuba japonica variegata*  
*Buxus microphylla japonica*  
*Calthea insignis*  
*Calthea makoyana*  
*Chlorophytum comosum*  
*Chlorophytum comosum 'Variegatum'*  
*Chlorophytum comosum 'Vittatum'*  
*Cissus rhombifolia*  
*Cissus rhombifolia 'Danica'*  
*Clivia miniata*  
*Cordyline terminalis*  
*Crassula argentea*  
*Crassula argentea 'Variegata'*  
*Cycas revoluta*  
*Dieffenbachia 'Exotica'*  
*Dracaena craigii 'Compacta'*  
*Dracaena deremensis 'Warneckei'*  
*Echinocactus grusonii*  
*Fatsia japonica*  
*Ficus pumila*  
*Kalanchoe tomentosa*  
*Maranta leuconeura 'Erythroneura'*  
*Maranta leuconeura kershoveana*  
*Nephrolepis exaltata bostoniensis*  
*Peperomia astrid*  
*Peperomia caperata 'Emerald Ripple'*  
*Peperomia griseoargentea*  
*Peperomia griseoargentea 'Blackie'*  
*Peperomia incana*  
*Peperomia obtusifolia*  
*Peperomia obtusifolia variegata*  
*Peperomia rubella*  
*Peperomia sandersii*  
*Peperomia scandens*  
*Peperomia scandens 'Variegata'*  
*Peperomia viridis*  
*Philodendron cannifolium*  
*Rhoeo spathaceae*  
*Sansevieria trifasciata*  
*Sansevieria trifasciata laurentii*  
*Schlumbergera bridgesii*  
*Schlumbergera truncata*  
*Scindapsis aurerus*  
*Scindapsis aureus 'Marble Queen'*  
*Spathiphyllum clevelandii*  

*Delta Maidenhair Fern*  
*Maidenhair Fern*  
*Coralberry*  
*Golden Chinese Evergreen*  
*Silver Chinese Evergreen*  
*Chinese Evergreen*  
*Plume Asparagus Fern*  
*Cast Iron Plant*  
*Variegated Cast Iron Plant*  
*Birdsnest Fern*  
*Gold Dust Tres*  
*Japanese Little Leaf Boxwood*  
*Rattlesnake Plant*  
*Peacock Plant*  
*Spider Plant*  
*Inside-Out Spider Plant*  
*Variegated Spider Plant*  
*Grape Ivy*  
*Oak-Leaf Grape Ivy*  
*Cafir Lily*  
*Baby Doll Dracaena*  
*Jade Plant*  
*Variegated Jade Plant*  
*Sago Palm*  
*Dumbcane*  
*Compact Dracaena*  
*Warnecke Dracaena*  
*Golden Barrel*  
*Japanese Aralia*  
*Creeeping Fig*  
*Panda Bear Plant*  
*Red Veined Prayer Plant*  
*Prayer Plant*  
*Boston Fern*  
*Emerald Ripple Peperomia*  
*Silver Leaf Peperomia*  
*Dark Silver Leaf Peperomia*  
*Felted Peperomia*  
*Baby Rubber Plant*  
*Variegated Baby Rubber Plant*  
*Pepe Peperomia*  
*Watermelon Peperomia*  
*Flask Philodendron*  
*Moses on a Raft*  
*Snake Plant*  
*Snake Plant*  
*Christmas Cactus*  
*Thanksgiving Cactus*  
*Golden Pothos*  
*Marble Queen Pathos*  
*Peace Lily or White Flag*
These plants, in general, can be easily purchased in sizes that allow for a five foot plant or taller.
Lab Exercise 12
EXERCISE ON FRUITS AND NUTS

I. FRUIT TYPES

Botanically speaking, the fruit of a flowering plant may be defined as a matured ovary and its contents, together with other flower parts that may sometimes adhere to it.

The ovary wall, known as the pericarp, consists of three layers in fruits: the exocarp, or outer layer, which is often the skin; the mesocarp, or middle layer, which may become fleshy; and the endocarp, or inner layer, which is sometimes modified in various ways.

The following is a list of the types of fruits we'll consider:

- **Achene** - a dry, simple fruit that does not dehisce when ripe. *(Example: sunflower)*

- **Aggregate** - a cluster of fruits derived from a single flower; the flower consists of many pistils on a common receptacle. The individual fruits of the aggregate may be drupes or achenes. *(Example: strawberry)*

- **Berry** - a simple fruit in which the entire pericarp is fleshy. It may contain one or more seeds. *(Example: tomato)*

- **Drupe** - a simple, fleshy fruit with a single seed enclosed in a stony endocarp or pit. The skin of these fruits is the exocarp; the fleshy edible portion is the mesocarp. *(Example: peach)*

- **Hesperidium** - A type of berry in which the rind is made up of exocarp and mesocarp; the "edible" portion is the endocarp. *(Example: orange)*

- **Legume** - a simple dry, dehiscent fruit usually splitting along two sutures. *(Example: pea)*

- **Multiple Fruit** - a fruit which is derived from many separate but closely clustered flowers. *(Example: pineapple)*

- **Nut** - a simple, dry indehiscent fruit with a bony shell. *(Example: chestnut)*

- **Pepo** - a berry with a hard rind made up of exocarp and receptacle tissue. *(Example: muskmelon)*

- **Pome** - a simple, fleshy fruit in which the inner portion of the pericarp forms a dry paper-like "core". *(Example: apple)*

Note the following fruit types:

- **Dehiscent fruits** are those which split apart when ripe.
- **Indehiscent fruits** are those which do not split apart when ripe.
- **Simple fruit** are those which are composed of a single ovary.
EDIBLE FRUITS

1. **Kumquat.** A small tropical citrus used for marmalade and for table decorations. They are rather bitter even after made into marmalade.

2. **Kiwifruit** (*Actinidia chinensis*). Imported from New Zealand. New Zealand has a law that their import-export ratio must balance so in order to sell them refrigerators and cars, etc., we must purchase something. The kiwi has caught the fancy of the Americans and most who taste it, like it. The small trees are now being planted in California.

3. **Grapefruit.** So called because the original "wild" type or Pomelo, bears its fruit in large bunches. The fruit is a citrus or hesperidium, a special type of berry. Note that it is divided into sections and that the pulp or juice is compartmented into large cell-like structures within the sections. The grapefruit is subtropical though it is often produced in more tropical areas. It is best when some cold weather is involved in its development. The trees are evergreen and develop in alternate "growth flushes" and "rest periods." It may be easily damaged while in a growth flush but may withstand 25-26 °F for considerable periods if in rest. The grapefruit is called the "wake up" fruit and is a favorite for breakfast. It has just a hint of bitterness if you think it is too sour, you are probably eating too much sugar laden food.

   The best grapefruit comes from Texas and the Indian River area of Florida. Look for smooth skin, slightly flattened, symmetrical shape, heavy for its size. Do not buy if light or has a sheep-nose shape. Scale insects on the surface should not affect the internal quality, nor should a russetted surface. Pits on the surface with a brown color indicate exposure to chilling temperatures and such fruit should be avoided.

4 **Mango.** A truly tropical fruit with a large flat seed. They generally are chilled to the point where they will rot before they ripen and develop their characteristically bright flavor. They are really good, so do not judge them by their "Fargo flavor".

5. **Mandarins.** Oranges with a particular bright flavor, generally very juicy and thin skinned. A different species from the true "orange." Mandarins include the Tangerine, King, Satsuma, etc., and usually cost more than oranges because they require special handling and have a short shelf life.

6. **Pineapple.** Native to Mexico and Central America. Now grown in Hawaii. They are easily chilled so are seldom good when purchased at Fargo stores. When imported by boat or from Mexico by train or truck, they may be picked very green if not chilled, they will ripen satisfactorily. Or they may be picked almost ripe and flown in, in which case they are very expensive and usually delicious. Even when fully ripe, they should not be chilled below 45°F. When green, they will chill at temperatures under 60°F. Each section appearing on the surface is a fruit, all are fused together in a giant multiple fruit.

7. **Pear.** A pome fruit. Note the structure of the core. Till recent years, pears were seasonal fruits, seen only for a week or two in the stores each year. Now they are harvested in a green mature condition and placed in a "controlled atmosphere" (CA) storage where the carbon dioxide is raised to about 3% and the oxygen is lowered to about 5% which puts the living tissue into a suspended state. They may be held this way for several months in almost perfect condition, then packed and sent to distant stores, they are still green and will stay "asleep" for two or three weeks. Take them
home and expose them to room temperatures till they turn yellow. Eat them when they become just slightly soft and be sure to eat the core and the seeds too. (In CA they are also kept cold, about 32°F.) What is the ambient concentration of CO₂ and O₂ in the atmosphere? If the CA is made to the specifications above, what material composes the remainder? The most popular and best tasting pear is the Bartlett, however, it does not store as well as the d'Anjou which is usually larger. The pears on exhibit may include a variety that is russetted, the Bosc.

8. **Tangelo.** A cross between the grapefruit (Pomelo) and the tangerine (Mandarin). There are many types. One called the Mineola has a characteristic sheep-nose. What kind of fruit is the Tangelo Hybrid?

9. **Temple Orange.** a cultivar with a bright flavor much like a Mandarin and highly colored and thin skinned, too.

10. **Nuts.** Define the nut as a type of fruit! Some of the nuts on exhibit may include the Coconut, English Walnut, Pecan, Almond, Brazil Nut and Filbert or Hazelnut. There are some trees of a wild Hazelnut that grow in North Dakota. Their nuts are very small and are not sold commercially. Acorns may be eaten, too, but sometimes must have their tannins extracted to avoid poisonous consequences. No other nut crops are produced in North Dakota. (Peanuts are not nuts, what are they?)

11. **Coconuts.** Grow on very tall "fan" palms. The white meat inside is the copra of commerce from which the oil is extracted. Inside is a liquid endosperm called "milk" because it is rich in vitamins and growth factors. Outside the copra is a hard shell which makes the best quality charcoal absorbent for use in gas masks. Surrounded the nut is a strong fibrous coating that enables the nut to survive falling from the 150 foot high trees or floating across the salty oceans.

   Open the coconut by first driving a nail into two eyes and draining the milk before smashing the shell with a hammer.

12. **Banana.** A berry (seeds embedded in the pulp) but the seeds in the popular fruit are mere remnants. The banana seen in our stores is a bland icky fruit that is almost flavorless compared to many good bananas. But so it is that it was so chosen you will have to go to the tropics yourself to partake of the heavenly goodness. As you see it, the fruit is sent here completely green and ripened when desired by exposure to ethylene gas. Bananas are easily chilled by putting them in the refrigerator where they will quickly blacken. If they are already ripe, it won't harm them internally, however. Bananas belong to the genus Musa. A similar plant of this genus is the source of Manilla Hemp.

13. **Lemons.** The variety most popular is the Eureka which normally has two puffy pointed ends. The Eureka is yellow, but all varieties are not. Lemons are tropical, injured by light frosts, so limited in the US to California. Highly acid, rich in Vitamin C. Recent research demonstrated that the Vitamin C is lost rapidly when the lemon is juiced, even when the juice is stored in cold temperatures! Vitamin C is water soluble, therefore, your body needs a daily supply.

14. **Honeydew Melon.** A pepo berry. The honeydew is very popular with the Semite peoples, but increasing in use by others as it becomes more available. Remember that it will not be good until it becomes soft. Put it out at room temperature and wait for it to
soften which may take 2 days to 2 weeks; be patient. There is a variety that will mature in North Dakota's short season. Of the melon fruits that can be produced in North Dakota include the muskmelon and the watermelon.

15. **Dried fruits.**

An old method of food preparation being revived. Fruits are the most easily prepared because they contain larger amounts of sugar than vegetables and meats. Drying was once done in the sun, but the task can be accomplished faster and with less loss of flavor and nutritious vitamins when forced air dried. The dried fruits on exhibit are those popularly sold in the grocery such as raisins (dried grapes), currants (miniature raisins), apricots, pears, apples, plums (prunes), peaches, figs and dates (fruit of a frond palm).

Drying removes the moisture and leaves the remaining fruit pulp which is very concentrated. Use care not to eat very much at one time, it is not natural to consume such highly concentrated foods. You may be surprised at the price of dried fruits, but if you could the numbers of fruits instead of thinking of it as weight or quantity, the price is rational. There is some savings in shipping costs of dried food, but it probably is not enough to balance the cost of drying. Some of the dried fruit is first sulfured by exposing the fresh material to sulfur dioxide fumes. This preserves the color, makes the fruit a little more tart, and preserves the vitamins, which ordinarily are lost in the drying process. There is no indication that sulfuring is deleterious to health, but some health food "purists" suggest that this might be a possibility.

16. **Limes.**

Small citrus, very sour, distinctive taste, high in vitamin C. Long before Vitamin C was understood, the British Navy rationed limes to their sailors to prevent them from becoming diseased from scurvy. This enables them to compete against the navies of the world and become superior in sea faring it also gave the British people the name of "Limey". Purchase limes when they are green. When they begin to ripen to a yellow color, they begin to dry and lose their juice. Do they lose their Vitamin C, too?

17. **Figs.**

Seldom seen fresh this far north. Dried figs have been in common use for ages though. The fig is another "Multiple Fruit". But different from the pineapple which has its stigmas facing inward. There is a small hole at the bottom of the fig through which a small wasp can fly to reach the pollen and stigmas and pollinate them. Considered a tropical fruit, figs can be grown in northern Texas.

18. **Apples.**

Pome fruits in shades of yellow, red and green. One of the more important tree fruits which can be grown in North Dakota. Haralson is the favorite variety. It is fairly tart and stays crispy for a considerable period. Haralson is excellent for cooking. Commercially the variety Delicious is sold most. Delicious is lovely to look at with its characteristic elongated cheeks on the blossom end.

19. **Quince.**

A pome of ancient history. Fruit which has merited little or no improvement. Used for cooking, jellies, preserves.

20. **Papaya.**

A tropical American fruit with some of the appearance of a small melon. If the sweetmushy flavor is objectionable to you, try adding some lemon juice or even salt and pepper or sugar. Papayas contain papain, an enzyme similar to pepsin, which is used to tenderize meat. The papaya is a giant herbaceous plant, 25-30 feet high and is grown in Florida, Texas, California and of course Hawaii from seed.
21. **Strawberry.** An aggregate in which the individual fruits are the achenes which are consumed along with the pulpy mass of receptacle tissue. Strawberries are being produced in North Dakota gardens, but are seldom sold in stores because of the high cost of harvesting. Commercial growers harvest by allowing the consumer to pick (PYO), then charging only a fraction of the cost that would be due a supermarket. The varieties grown most in North Dakota, Ogallala and Redcoat, are extra hardy. Strawberries contain more Vitamin C than oranges.

22. **Red Raspberry.** Another fruit being produced commercially in North Dakota. Raspberry fruits are aggregates of tiny drupes. Most popular variety is the Boyne because it withstands the winter and is disease resistant. Raspberries are customer picked and bring about twice the price of strawberies.

23. **Sweet Orange.** The most popular of the citrus fruits. Orange juice is fed to babies, often their first food after milk. It is high in Vitamin C. The most flavorsome varieties are the Blood (not seen in the USA), the Valencia, the Washington Navel, and the Temple. Other less flavorsome varieties are called "juice" oranges and their quality or soluble solids content is markedly lower.

24. **Gooseberry.** A fruit that is produced in North Dakota gardens but hasn't the popularity of raspberries and strawberries. Perhaps the most popular variety in the U.S. is "Pixwell" which originated at NDSU. Pixwell gooseberry fruits hang on long stems well below the thorny stems.

25. **Persimmon.** Native species are found in the southern states, generally with several seeds. They are very astringent and pucker your mouth when green. Kakis or Oriental species are much improved and considered by the Japanese to be one of their best fruits. The Khaki should be eaten when at the consistency of custard.

26. **Peach.** Very popular drupe fruit, seen in North Dakota stores in season but seldom of good quality because it is picked green for the long distance shipment.

27. **Cranberry.** A favorite at Thanksgiving and Christmas. They are grown in highly specialized bogs, areas where water for irrigation and flooding can be controlled and the soil is acid. Massachusetts, Wisconsin, and Washington State.

28. **Blueberry.** A more recent introduction to commerce. Blueberries are produced on acid soils. One of the top berry crops of Michigan but giving way to the Carolinas.

29. **Plantain (Musa paradisiaca).** Also known as the Cooking Banana and is not suitable to eat without cooking for its flesh is firm and not so sweet as the common banana.

30. **Avocado.** Contains up to 18% vegetable oil so considered more as a main course food than as a dessert. Most commonly used as a salad with the addition of salt, pepper, or lemon juice. The seed is not bony hard and so evaluation of the avocado as a drupe is not clear. Most texts dodge this issue and do not classify it.