PLSC 211
Horticulture Science Lab

LAB MANUAL

Fall Semester, 2009

Dr. Chiwon W. Lee

Department of Plant Sciences
North Dakota State University

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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, 2009
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*>

Craig Carlson, teaching assistant
Phone 701-361-9466, e-mail <*craig.carlson@ndsu.edu*>

Whitney Harchenko, teaching assistant
Phone 701-212-3915, e-mail <*whitney.harchenko@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/instruct/chlee/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/instruct/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

Chiwon W. Lee, 2009. PLSC 211 Horticulture Science Lab Manual, published by the NDSU Printing Shop, 104 pp.

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

	Points
Seven weekly lab reports	140
Horticulture article	30
Mid-term lab examination	65
Final lab examination	65
Total	*300*

Grading Scale	
A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	<60%

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/instruct/chlee/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).

PLSC 211-Horticulture Science Lab Schedule
Fall Semester, 2009

Week	Lab No.	**Sections I, II** (Mon)	**Sections III, IV** (Wed)	Lab Exercise
Wk 1	-	Aug 31	Sep 2	Plant Identification
Wk 2	-	(Sep 7)*	Sept 9	Local Greenhouse Tour
Wk 3	Lab 1	Sep 14	Sep 16	Sexual Propagation
Wk 4	Lab 2	Sep 21	Sep 23	Asexual Propagation
Wk 5	Lab 3	Sep 28	Sep 30	Horticulture Publication (IACC 114)
Wk 6	Lab 4	Oct 5	Oct 7	Plant Nutrition
Wk 7	Lab 5	Oct 12	Oct 14	Gardening (***Midterm Exam***)
Wk 8	Lab 6	Oct 19	Oct 21	Greenhouses
Wk 9	Lab 7	Oct 26	Oct 28	Landscape Design
Wk 10	Lab 8	Nov 2	Nov 4	Pruning and Training
Wk 11	Lab 9	Nov 9	(Nov 11)	Local Greenhouse Tour
Wk 12	Lab 10	Nov 16	Nov 18	Interior Plants
Wk 13	Lab 11	Nov 23	Nov 25	Lawn Care
Wk 14	Lab 12	Nov 30	Dec 2	Fruits and Nuts
Wk 15	Lab 13	Dec 7	Dec 9	Reviews and Free Lab
Wk 16	Lab 14	Dec 14	Dec 16	***Final Exam***

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:

Scientific Name	**Common Name**
Acer saccharinum	Silver maple
Acer platanoides	Norway maple
Tagetes erecta	African marigold
Tagetes patula	French marigold

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. silique** **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

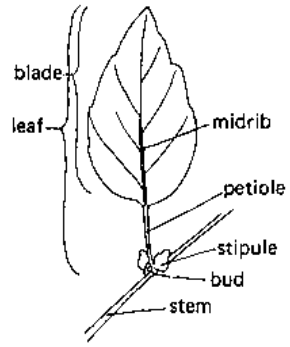
In order to successfully identify woody plants it is necessary for an individual to have a keen awareness (working knowledge) of taxonomic terminology and concise mental pictures of leaf, bud, stem, flower, and fruit morphology.

LEAF MORPHOLOGY

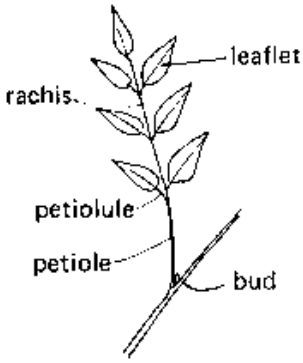
ANGIOSPERM LEAF TYPES

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.

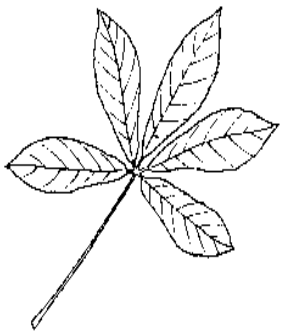


Simle Leaf

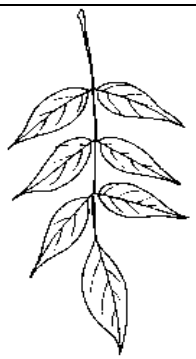


Compound Leaf

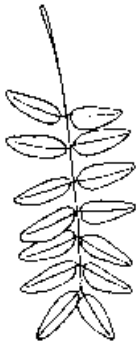
Variation in Compound Leaves



Palmate
Ex: *Acanthopanax*, *Parthenocissus*



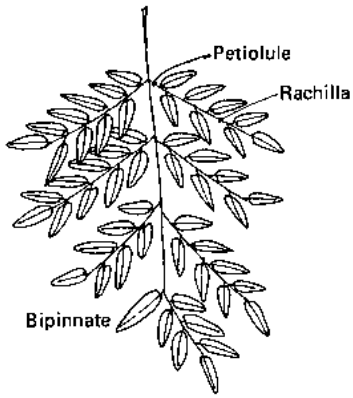
Odd Pinnate
Ex: *Acer negundo*, *Fraxinus*



Even Pennate
Ex: *Gleditsia*

Bipinnately Compound Leaves

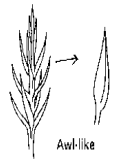
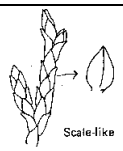
Bipinnately compound leaves are twice divided. What was considered the leaflet of the pinnately compound leaf is now another leaf-bearing axis to which additional leaflets are attached. The new leaf bearing axes are referred to as pinnae. Each pinna has a certain number of leaflets. Ex: *Gymnocladus,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



Bipinnately Compound
Ex: Gleditsia triacanthos, Honey-locust

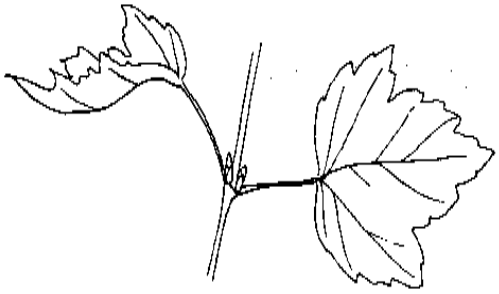
ANGIOSPERM LEAF TYPES

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)*.

	**The needles (leaves) are shaped like an awl. They are usually very sharp to the touch. Many *Juniperus* (Junipers) exhibit awl-shaped foliage. This character is manifested in juvenile forms of juniper, however, there are many species and cultivars (*Juniperus communis, J. Procumbens, J chinensis* 'Pyramidalis' to name a few) which possess the awl-like of needle foliage in youth and old age.**
	**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. *Thuja, Chamaecyparis, Cupressus, Calocedrus* and many *Juniperus* species exhibit this type of foliage.**
	**Needle-like foliage is typical of several evergreen genera and species. The drawing depicts the foliage of a 5-needled pine. In the genus *Pinus* the leaves (needles) are usually contained in fascicles of 2, 3, 2 and 3, or 5. Other species such as *Abies, Picea, Cedrus, Pseudotsuga,* and *Taxus* 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.**

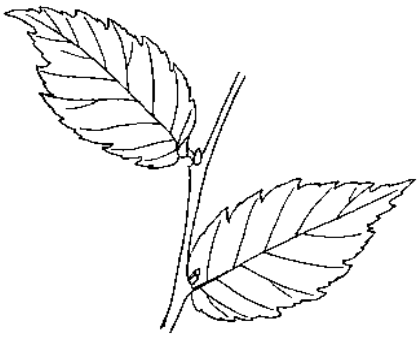
ARRANGEMENT OF LEAVES

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 catagorize plants into groups and assists in eliminating many plants from consideration in the process of positive identification.



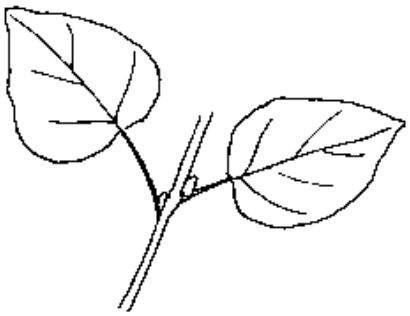
Opposite

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*.



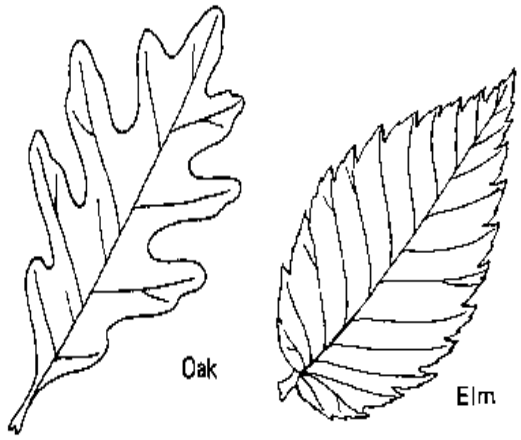
Subopposite

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

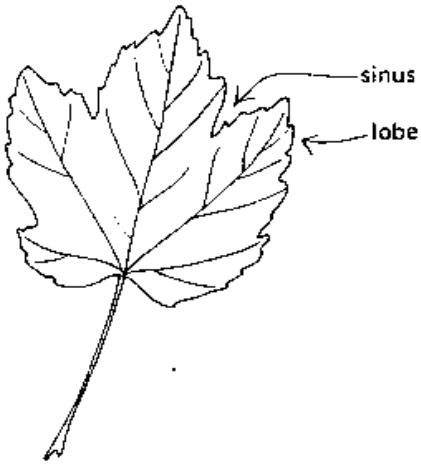
Whorled refers to a condition when three buds and leaves (or more) are present at a node. Ex: *Catalpa, Hydrangea paniculata* 'Grandiflora', *Cephalanthus occidentalis*.

LEAF VENATION



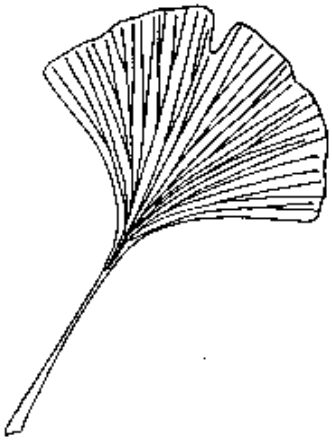
Pinnate

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.



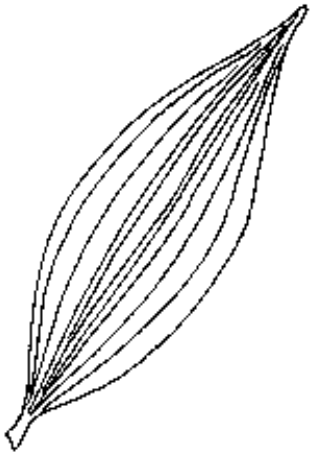
Palmate

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.

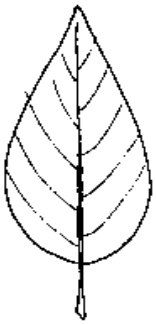
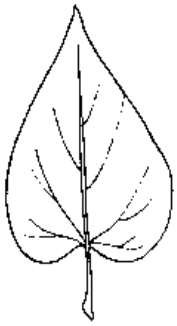
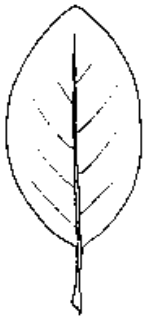
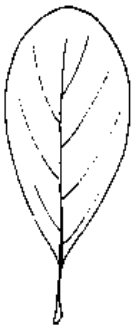
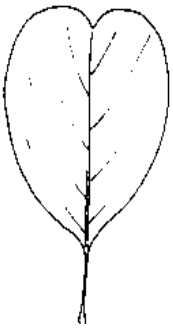
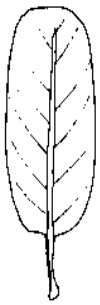
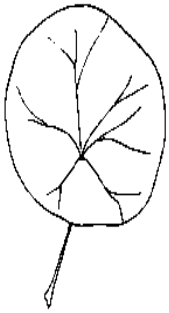
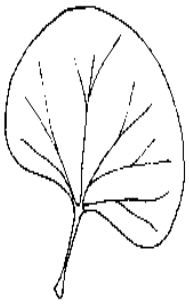
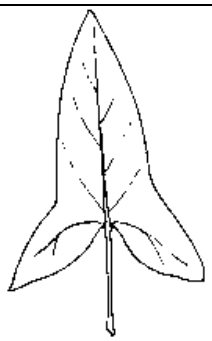


Parallel

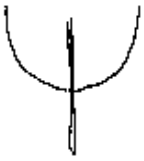
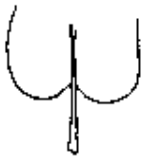
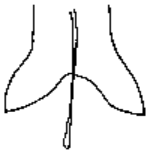
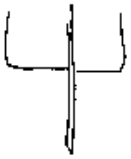
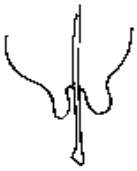
Typical of many monocotyledonous plants. The veins run essentially parallel to each other along the long axis of the leaf. Ex: *Zea* (corn), *Ruscus, Danae*.

LEAF SHAPES

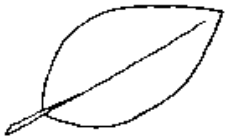
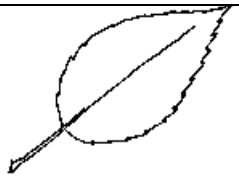
The tremendous quantity of terminology related to leaf shapes can be confusing. Association of the following pictures with the terms will help to alleviate the burden of strict terminology. This also applies to leaf bases, margins, and apices.

 **Ovate**	 **Lanceolate**	 **Cordate**	 **Elliptical**	 **Spatulate**
 **Obovate**	 **Oblanceolate**	 **Obcordate**	 **Oblong**	 **Linear**
 **Peltate**	 **Cuneate**	 **Reniform**	 **Hastate**	

LEAF BASIS

 **Cuneate**	 **Acute**	 **Rounded**	 **Cordate**	 **Oblique**
 **Sagitate**	 **Hastate**	 **Truncate**	 **Auriculate**	

LEAF MARGINS

 **Entire**	 **Serrate**	 **Serrulate**	 **Doubly-Serrate**
 **Dentate**	 **Crenate**	 **Incised**	 **Sinuate**
 **Undulate**	 **Lobed**		

LEAF APICES

 **Mucronate**	 **Cuspidate**	 **Acuminate**	 **Acute**
 **Obtuse**	 **Truncate**	 **Emarginate**	 **Obcordate**

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 hybrida*
2. Zinnia *Zinnia elegans*
3. Geranium *Pelargonium hortorum*
4. African Marigold *Tagetes erecta*
5. French Marigold *Tagetes patula*

Plant Identification Key

A. **Woody Plants**

#1 Name

Plant type_____Leaf arrangement_____Leaf type_____

Leaf margin_____ tip_____ shape_____Fruit type_____

Other characteristics:

#2 Name

Plant type_____Leaf arrangement_____Leaf type_____

Leaf margin_____ tip_____ shape_____Fruit type_____

Other characteristics:

#3 Name

Plant type_____Leaf arrangement_____Leaf type_____

Leaf margin_____ tip_____ shape_____Fruit type_____

Other characteristics:

#4 Name

Plant type_____Leaf arrangement_____Leaf type_____

Leaf margin_____ tip_____ shape_____Fruit type_____

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)

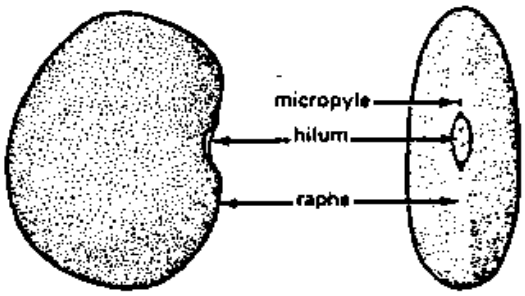
   b. Treatment 2- Seeds soaked in hot water

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

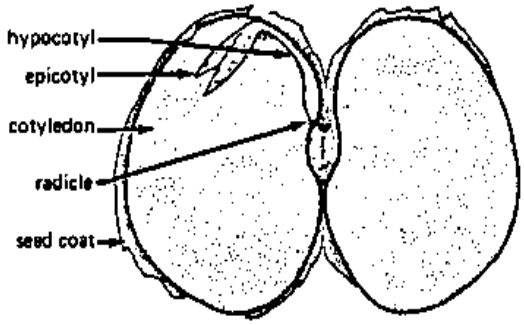
   d. Treatment 4- Mechanical scarification (use sandpaper, file, or clippers)

IV. **Results**

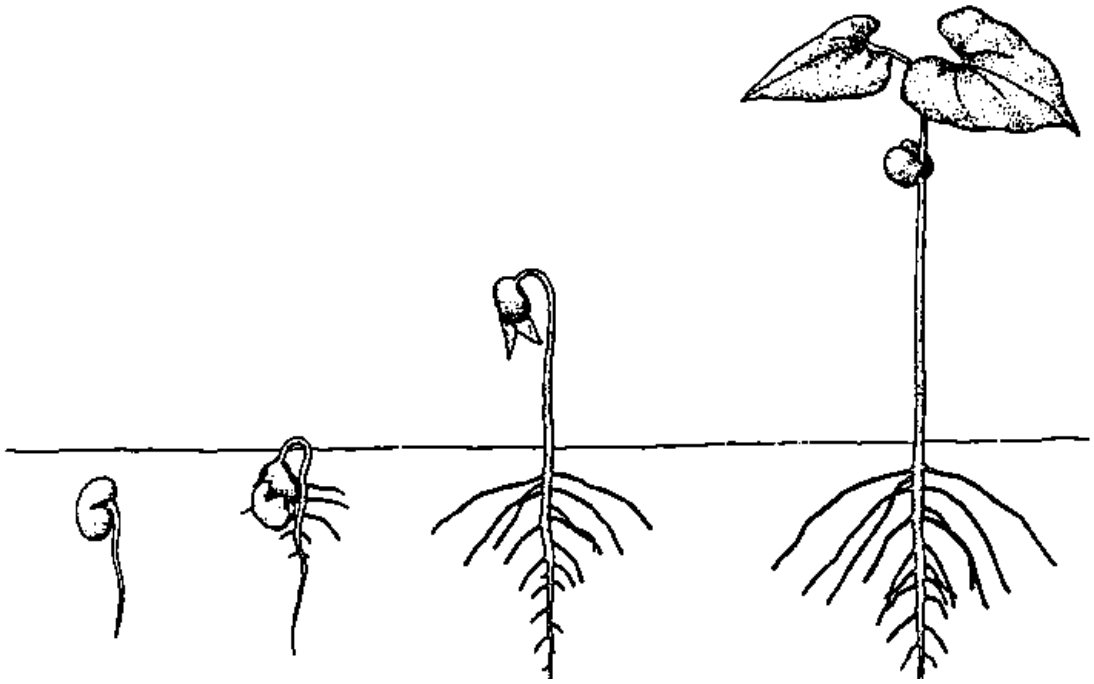
Obtain seed germination data for the steps 3 and 4 above for your group and the entire class. Use this information for your lab report.



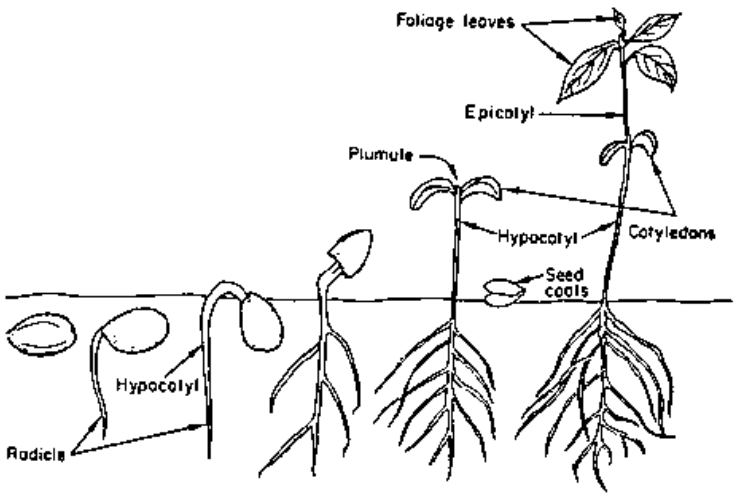
Bean Seed



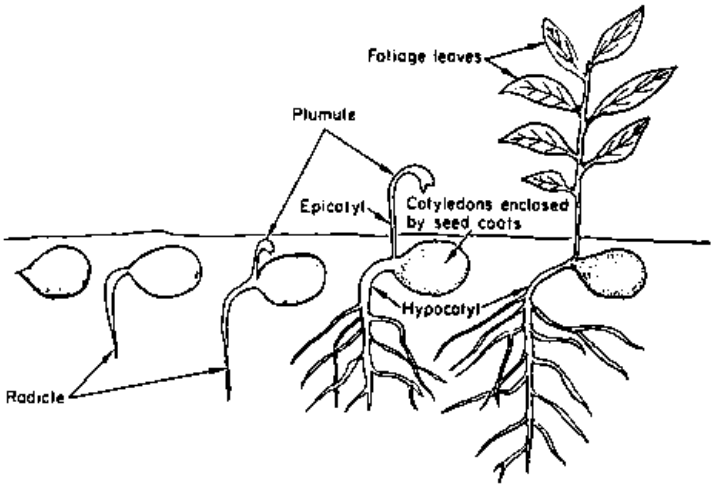
Structure of Bean Seed



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 bare 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 taxanomically. 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:

Species #1 (Herbaceous plant)

Treatment	Total no. of cuttings planted	No. of cuttings rooted	% rooting
1) Control, no bottom heat	_____	_____	_____
2) Control, bottom heat	_____	_____	_____
3) IBA, no bottom heat	_____	_____	_____
4) IBA, bottom heat			

Species #2 (Woody plant)

Treatment	Total no. of cuttings planted	No. of cuttings rooted	% rooting
1. Control, no bottom heat	_____	_____	_____
2. Control, bottom heat	_____	_____	_____
3. IBA, no bottom heat	_____	_____	_____
4. IBA, bottom heat			

   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.

Element	Chemical symbol	Atomic weight	Ionic forms Absorbed by plants	Approximate dry tissue concentration
			Macronutrients	
Nitrogen	N	14.01	NO_3^-, NH_4^+	4.0 %
Phosphorus	P	30.98	PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$	0.5 %
Potassium	K	39.10	K^+	4.0 %
Magnesium	Mg	24.32	Mg^{2+}	0.5 %
Sulfur	S	32.07	SO_4^{2-}	0.5 %
Calcium	Ca	40.08	Ca^{2+}	1.0 %
			Micronutrients	
Iron	Fe	55.85	Fe^{2+}, Fe^{3+}	200 ppm
Manganese	Mn	54.94	Mn^{2+}	200 ppm
Zinc	Zn	65.38	Zn^{2+}	30 ppm
Copper	Cu	63.54	Cu^{2+}	10 ppm
Boron	B	10.82	BO_3^{2-}, $B_4O_7^{2-}$	60 ppm
Molybdenum	Mo	95.95	MoO_4^{2-}	2 ppm
Chlorine	Cl	35.46	Cl^-	3000 ppm
			Essential But Not Applied	
Carbon	C	12.01	CO_2	40 %
Hydrogen	H	1.01	H_2O	6 %
Oxygen	O	16.00	O_2, H_2O	40 %

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 ft^2
1 liter = l 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 kg = 1 kg x 1000 g/kg x 1000 mg/g = 1,000,000 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.

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

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 kg = 1,000,000 mg
1 liter water = 1 kg
therefore, 1 liter water = 1,000,000 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.

Chemical	Molecular or atomic weight
N	14.01
K^+	39.10
NH_4NO_3	80.05
NH_4^+	18.01
NO_3^-	62.01
Ca^{++}	40.08
Mg^{++}	24.32
S	32.07
SO_4^{-2}	96.07
$MgSO_47H_2O$	246.50

1 mM NH_4NO_3 = 80.05 mg per liter (mg/l)
1 mM NO_3^- = 62.01 mg/l
1 mM SO_4^{-2} = 96.07 mg/l
1 mM $MgSO_47H_2O$ = 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.

$NH_4NO_3 \longrightarrow NH_4^+ + NO_3^-$ (Monovalent ions)
(80) (18) (62)

$MgSO_47H_2O \longrightarrow Mg^{++} + SO_4^{-2}$ (Divalent ions)
(246.5) (24.3) (96.1)

1 meq/l NH_4NO_3 = 80 mg/l
1 meq/l NH_4^+ = 18 mg/l
1 meq/l NO_3^- = 62 mg/l

1 meq/l $MgSO_47H_2O$ = (246.5 mg/2)/l = 123.3 mg/l
1 meq/l Mg^{++} = (23.3 mg/2)/l = 11.6 mg/l
1 meq/l SO_4^{-2} = (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 (P_2O_5), and potassium (K_2O) in that order. For example, Peters 20-16-20 fertilizer contains 20% N, 16% P_2O_5, and 20% K_2O 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.

Nitrogen - always expressed as elemental N
Phosphorus - $P_2 / P_2O_5 = 0.44$, or $P_2O_5 / P = 2.99$
Potassium - $K_2 / K_2O = 0.83$, or $K_2O/K = 1.20$

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

$$20\% \text{ N} - 16\% \text{ } P_2O_5 - 20\% \text{ } K_2O = 20\% \text{ N} - 7.04\% \text{ P} - 16.6\% \text{ K}$$

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.

1 liter water = 1,000,000 mg, therefore, 200 mg of N are needed.
However, the fertilizer is only 20% N. So:

$$\frac{200}{.20} = \frac{x}{1.00} \qquad x = 1000 \text{ mg} = 1 \text{ g.}$$

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)

Nitrogen	=	200	ppm N			
Phosphorus	=	_____	ppm P_2O_5	=	_____	ppm P
Potassium	=	_____	ppm K_2O	=	_____	ppm K

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 5 --- 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 the 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).

Salt	Grade of salt	Approximate amount, in ounces	Approximate amount, in level tablespoons
Solution 1*			
Potassium phosphate (monobasic)	Technical	0.5	1
Potassium nitrate	Fertilizer	2	4
Calcium nitrate	Fertilizer	3	7
Magnesium sulfate (Epsom salt)	Technical	1.5	4
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 ($MnCl_2.4H_2O$) 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 ($ZnSO_4.7H_2O$) and 1 teaspoon of chemically pure copper sulfate ($CuSO_4.5H_2O$) 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.

	cc in a liter of nutrient solution
Solution 1	
1M KH_2PO_4, potassium acid phosphate	1
1M KNO_3, potassium nitrate	5
1 M $Ca(NO_3)_2$, calcium nitrate	5
1 M $MgSO_4$, magnesium sulfate	2
Solution 2	
1M $NH_4H_2PO_4$, ammonium acid phosphate	1
1M KNO_3, potassium nitrate	6
1M $Ca(NO_3)_2$, calcium nitrate	4
1M $MgSO_4$, magnesium sulfate	2

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:

Compound	Grams dissolved in 1 liter of H_2O
H_3BO_3, boric acid	2.86
$MnCl_2.7H_2O$, manganese chloride	1.81
$ZnSO_4.5H_2O$, zinc sulfate	0.22
$CuSO_4.5H_2O$, copper sulfate	0.08
$H_2MoO_4.H_2O$, molybdic acid	0.09

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:

Element	**Parts per million of nutrient solution**
Boron	0.5
Manganese	0.5
Zinc	0.05
Copper	0.02
Molybdenum	0.05

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 H_2SO_4 (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. (In all nutrient-solution work, the solvent is water.) 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, $MgSO_4.7H_2O$ 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 $MgSO_4.7H_2O$ in water and make to 1 liter volume.

Example 2, how to make a one-twentieth molar (0.05 M) solution of monocalcium phosphate, $Ca(H_2PO_4)_2.H_2O$ (used in deficiency studies, below): The molecular weight of monacalcium phosphate, $Ca(H_2PO_4)_2.H_2O$ is 252.17. Hence 0.05 mol of $Ca(H_2PO_4)_2.H_2O$ is 525.17 grams/20 = 12.61 grams. Therefore, to make a 0.05 M solution of monocalcium phosphate, dissolve 12.61 grams of $Ca(H_2PO_4)_2.H_2O$ 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.

		cc in a liter of nutrient solution
a.	**Solution lacking nitrogen**	
	0.5 M K_2SO_4	5
	1 M $MgSO_4$	2
	0.05 M $Ca(H_2PO_4)_2$	10
	0.01 M $CaSO_4$	200
b.	**Solution lacking phosphorus**	
	1M $Ca(NO_3)_2$	4
	1M KNO_3	6
	1M $MgSO_4$	2
c.	**Solution lacking potassium**	
	1M $Ca(NO_3)_2$	5
	1M $MgSO_4$	2
	O.O5M $Ca(H_2PO_4)_2$	10
d.	**Solution lacking calcium**	
	1M KNO_3	5
	1M $MgSO_4$	2
	1M KH_2PO_4	1
e.	**Solution lacking magnesium**	
	1M $Ca(NO_3)_2$	4
	1M KNO_3	6
	1M KH_2PO_4	1
	0.5M K_2SO_4	3
f.	**Solution lacking sulfur**	
	1M $Ca(NO_3)_2$	4
	1M KNO_3	6
	1M KH_2PO_4	1
	1M $Mg(NO_3)_2$	2

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 zone 3 (some of the more hardy zone 4 plants may be considered in sheltered places.)

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

LAB 6 - FLOWER GARDEN DESIGN
Lab Report

Name _____ Lab Section _____

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 the 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.

	Bloom		Plant	
Plant name (Scientific preferable)	Period	Color	Height	Spread

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 suns 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, CO_2)

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.

Low light: 75-200 foot-candles. Reflected light or inner rooms. Chinese evergreen, philodendron, cast-iron plant.

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.

Lemon juice	2
Tomato juice	4.5
Blood	6.6
Soap	9
Household ammonia	12

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.

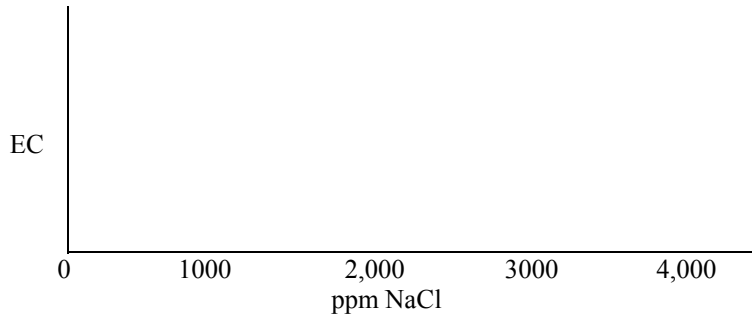
Water or soil sample	pH	Electrical conductivity mmho/cm	Electrical conductivity µmho/cm	TDS (ppm)
a. RO water	_____	_____	_____	_____
b. Bottled water (Aquafina)	_____	_____	_____	_____
c. Tap water	_____	_____	_____	_____
d. Fertilizer water (greenhouse)	_____	_____	_____	_____
e. House plant soil extract	_____	_____	_____	_____
f. Sunshine mix extract	_____	_____	_____	_____
g. Peat extract	_____	_____	_____	_____
h. Pointsettia pot soil extract				

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

3. Establish relationship between NaCL concentration and electrical conductivity.

Solution no.	ppm	g L^{-1}	EC (µmho/cm)	EC (mmho/cm)
1	0	0	_____	_____
2	500	0.5	_____	_____
3	1,000	1	_____	_____
4	2,000	2	_____	_____
5	4,000	4	_____	_____
6	6,000	6	_____	_____
7	8,000	8	_____	_____
8	10,000	10		

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



b. Derive regression equations for estimating salinity using EC readings:

1) y = _____ x.
2) x = _____ y, where y = electrical conductivity in mmho/cm
x = parts per million (ppm) salt

3) 1 mmho/cm = _____ ppm NaCl
1 µmho/cm = _____ ppm NaCl

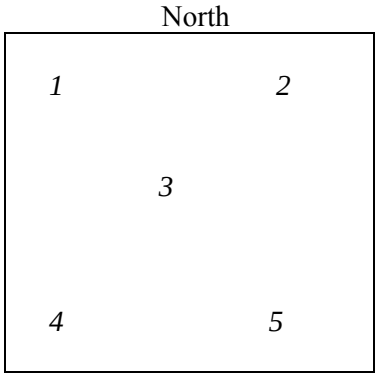
Lab 7 - Greenhouse Production Lab Exercises
Light Measurements

Name _____ Lab Section _____

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.



Location	Foot-candle	Lux	µmol m^{-2} s^{-1}
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
Average	_____	_____	_____
Outside	_____	_____	_____
% reduction	_____	_____	_____

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

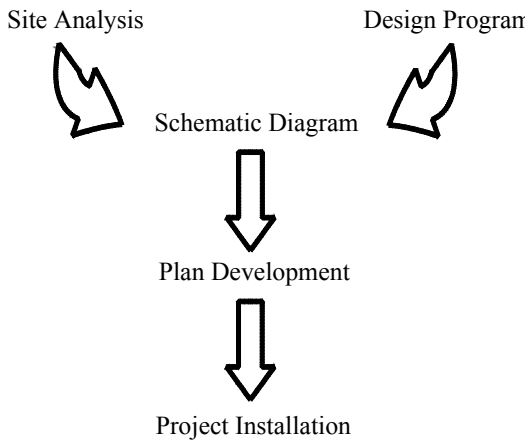
c. Texture

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)

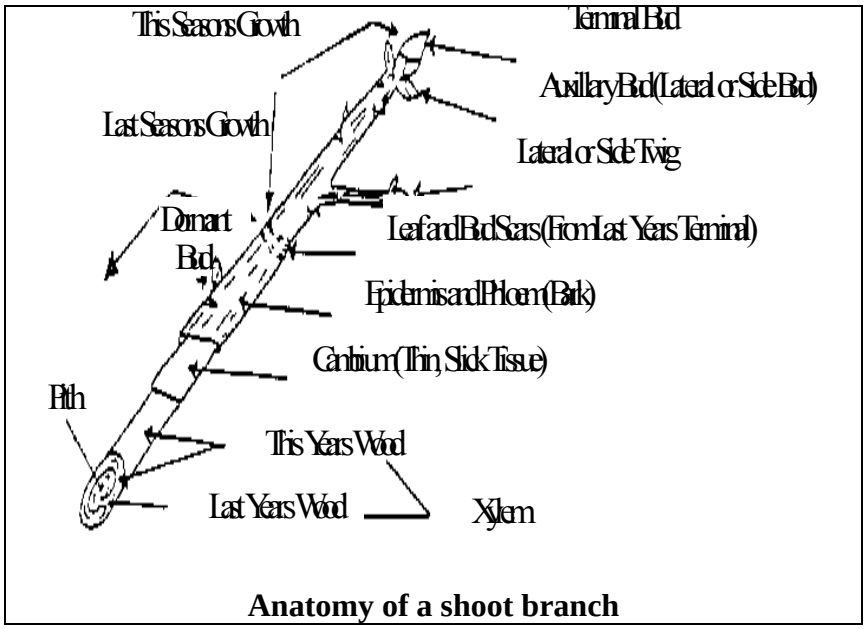
Botany of Pruning

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

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

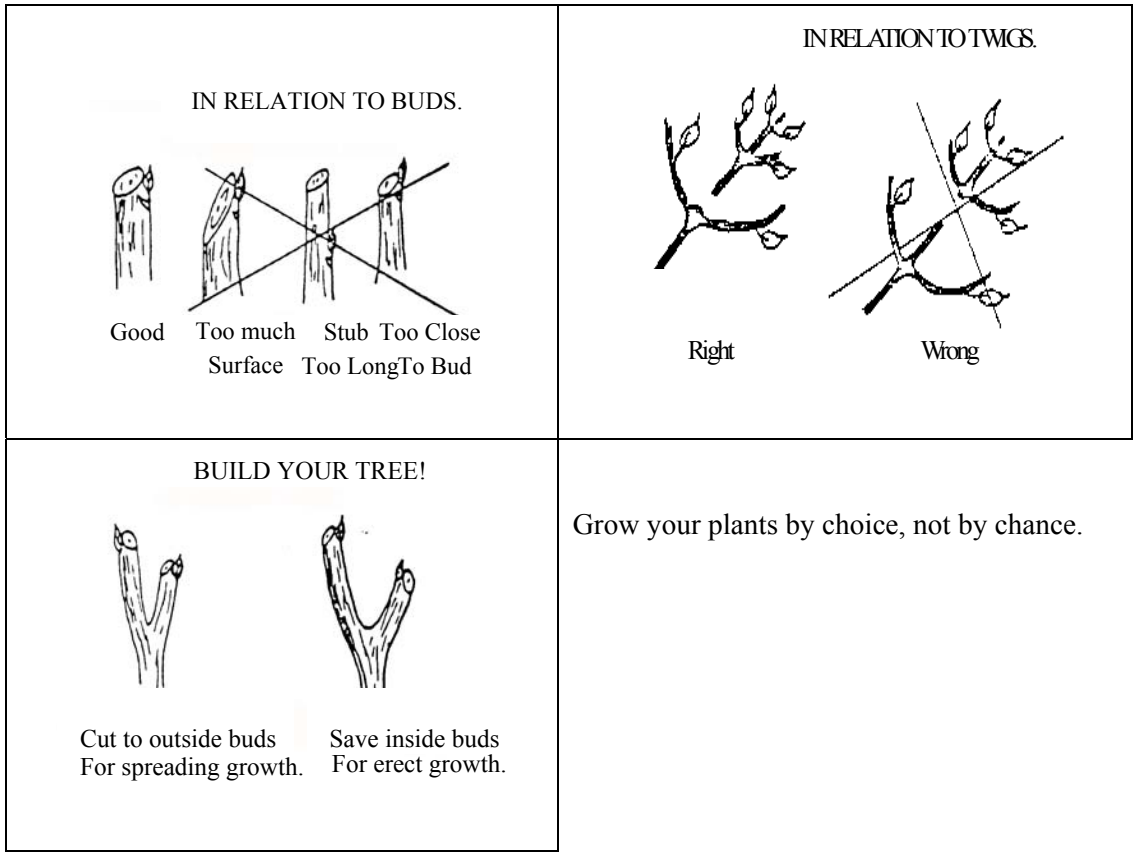
Water and mineral nutrients travel up from the roots through the wood or xylem into the leaves. Here, in the leaves, food is manufactured and sent back through the phloem out to feed all parts of the plant, twigs, buds, flowers, roots, etc.

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.



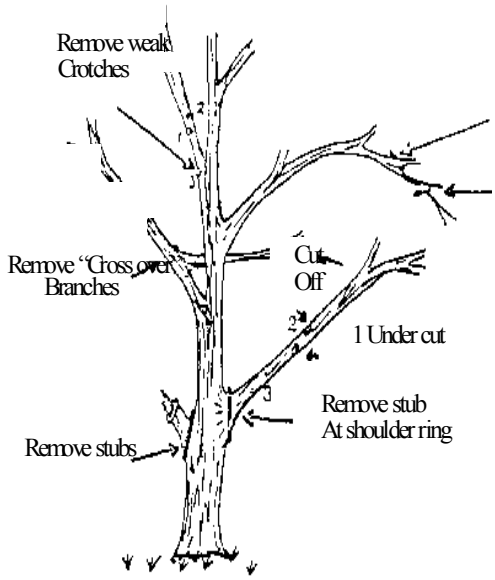
Anatomy of a shoot branch

Where to Cut



Grow your plants by choice, not by chance.

General Pruning



On all "heavy cuts," make removal in three teps:

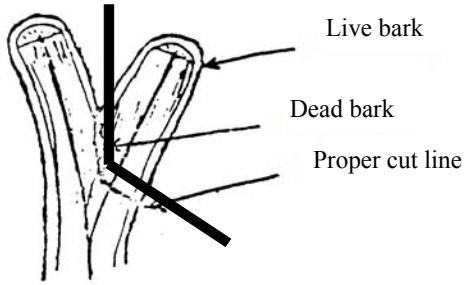
1. Under Cut
2. Over-cut off
3. Stub removal at shoulder ring

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

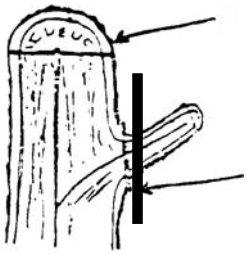
Avoid weak crotch branching and remove "cross over" or "interfering" branches.

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

Big Cuts

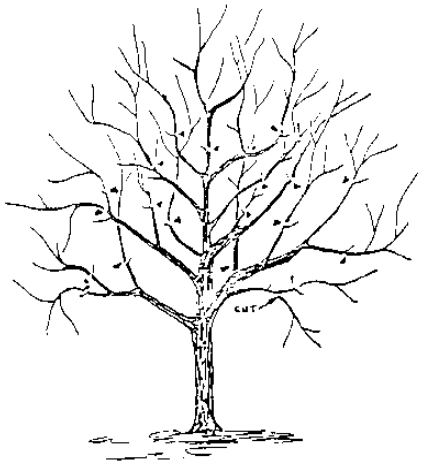


Tight-weak crotch

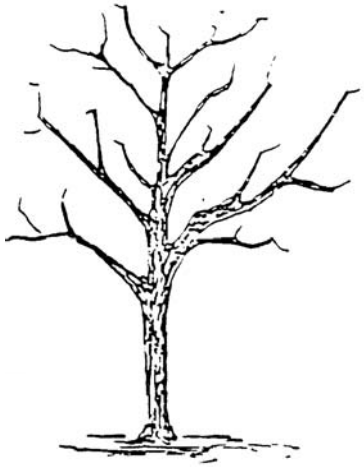


Proper cut line. Cut at "shoulder ring," area of rapid growth and heal over.

Directional Pruning (Trees)

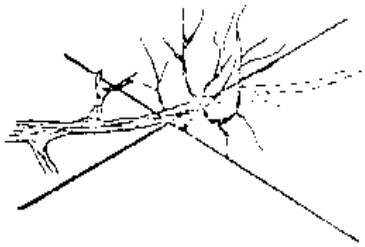


Top work to reduce size, clear lines, etc.



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

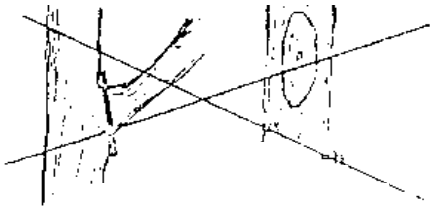
Good



Stub pruning causes
"bird nesting"

Prune to Side Branches

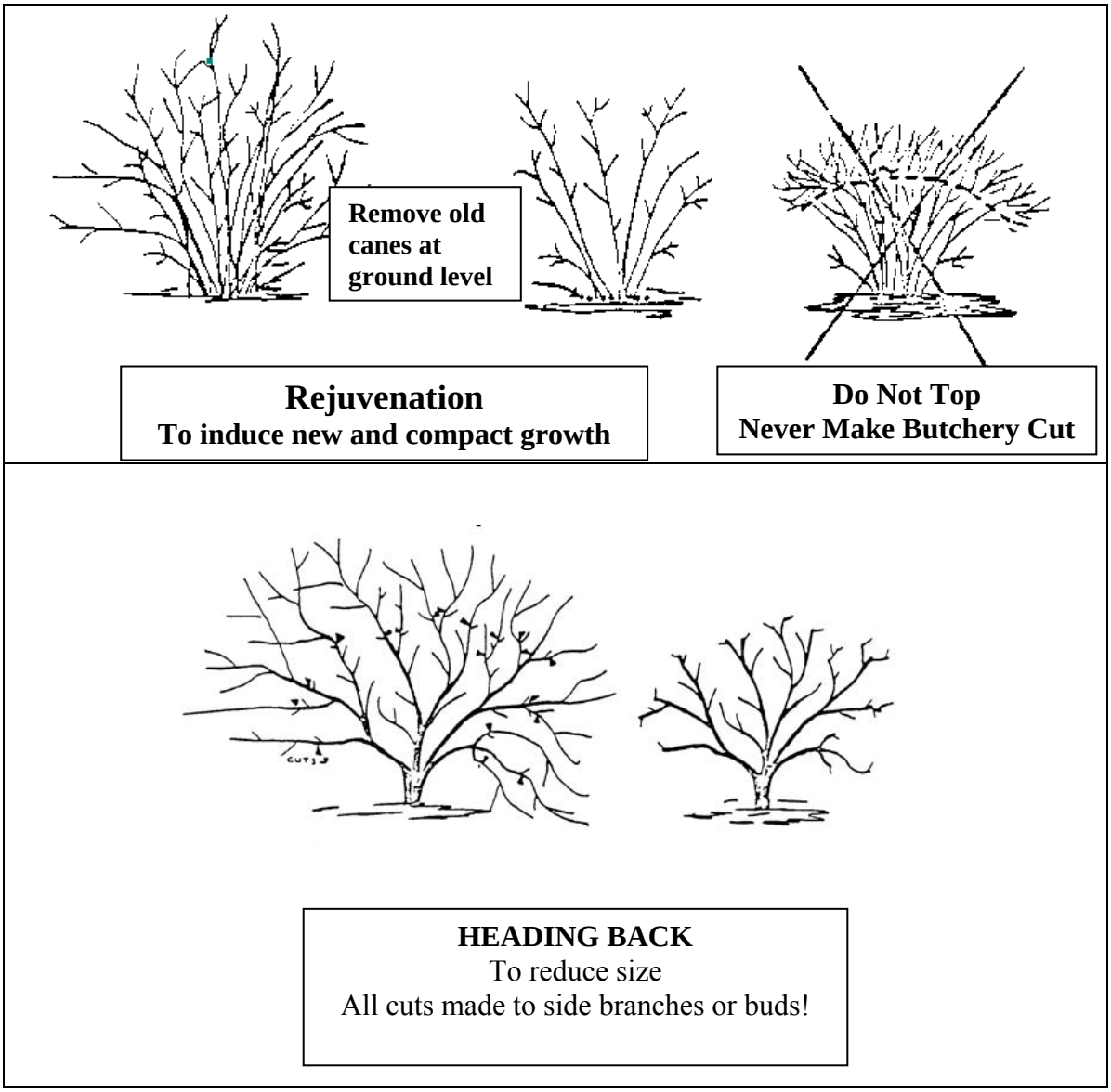
Shouler Ring
Cut to leave small surface area



Excessive flush cut
Too much surface
Slow heel over

Prune Limbs to Soulder Rings

Deciduous Shrubs
Prune for Form



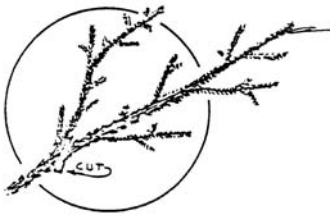
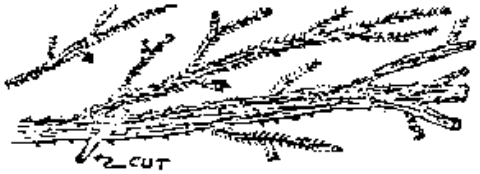
NOTE: When shrubs get old and leggy - one of three things may be done.

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.

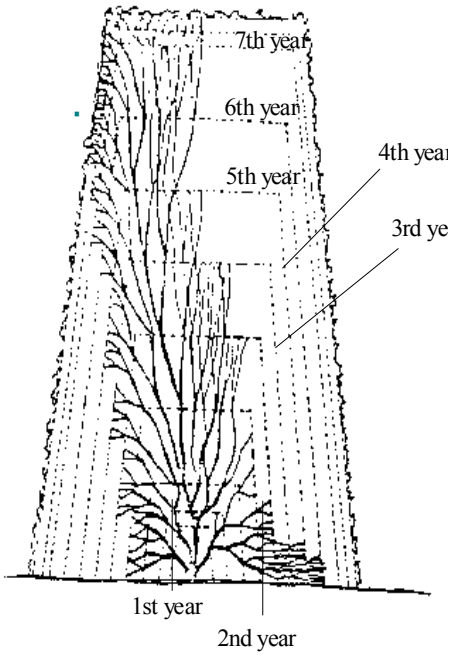
Prune with a purpose on Junipers

***Discipline**: "Training which corects, molds, strengthens, or perfects" (Webster)*

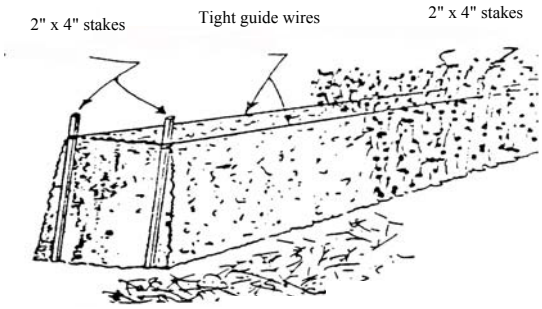
Start when plants are young, if possible! Strive for a disciplined form. Avoid neglect and abuse.

	Prune "deep" enough to hide all cuts Cut "Back In" to a top growing twig! Be careful not to leave unsightly "Holes"
 **Neglect (left), disciplined (center), abuse (right)**	The form to achieve on uprights is with a single - center trunk, and a "controlled" natural look.
 **Neglect (left), disciplined (center), abuse (right)**	In maintaining spreading junipers, strive for the "disciplined" look. Avoid "butch" cut and "scalp jobs".
Avoid Shearded and Ugly Ends! 	Make a cut deep enough to avoid the look of truncation. Remove a stem at the branching point.
	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.

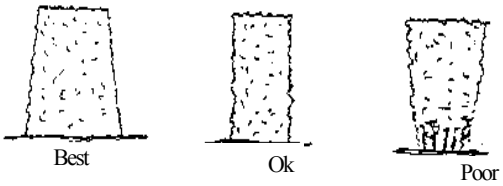
Building a Hedge



Prune when planted and each year after



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

Low hedge (2 to 4 feet)
- Pygmy Peashrub
- Alpine Current
- Fritsch Spirea
- Dakota Sunset Potentilla
- Little Giant Arborvitae
- Hetz Midget Arborvitae
- Emerald Carousel Barberry
- Dwarf Gooseberry

Medium hedge (4 to 6 feet)
- Globe peashrub
- Threelobe Spirea
- Triumph Potentilla
- Globe Arborvitae
- Miniglobe Honeysuckle
- Palibin Dwarf Lilac

Large hedge (over 6 feet)
- Miss Kim Lilac
- Minuet Lilac

Large hedge (over 6 feet, continued.)
- Medora Juniper
- Chinese Lilac
- Fragrant Sumac
- Siberian Arborvitae
- Bergeson Compact Dogwood
- Wayfaring Tree Viburnum

Screening (over 10 ft tall)
- Eastern Red Cedar
- Medora Juniper
- Grizzly Bear Juniper
- Miss Canada Late Lilac
- Embers (or Redwing) Amur Maple
- Siberian Peashrub (Caragana)
- Black Hills Spruce
- Colorado Spruce
- Pyramidal Arborvitae
- Bailey Compact Amur Maple
- Techny Arborvitae

LAB 9 - PRUNING AND TRAINING
Lab Report

Name_____ Lab Section_____

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?

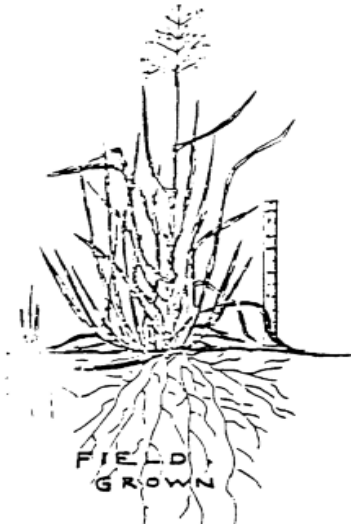
Lab Exercise 11

LAWN CARE

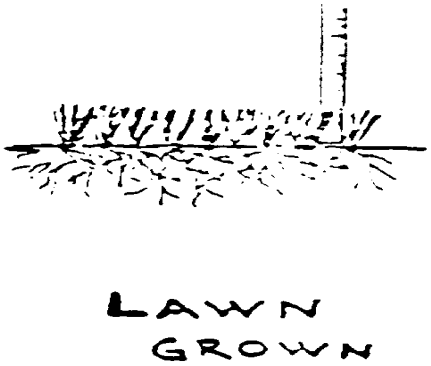
1. Lawn Grass

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. Lawans must have desirable soil conditions.
e. Lawns must be mowed regularly.
f. Lawns must have adequet top growth.



Naturally grown grass



Grasses in the lawn

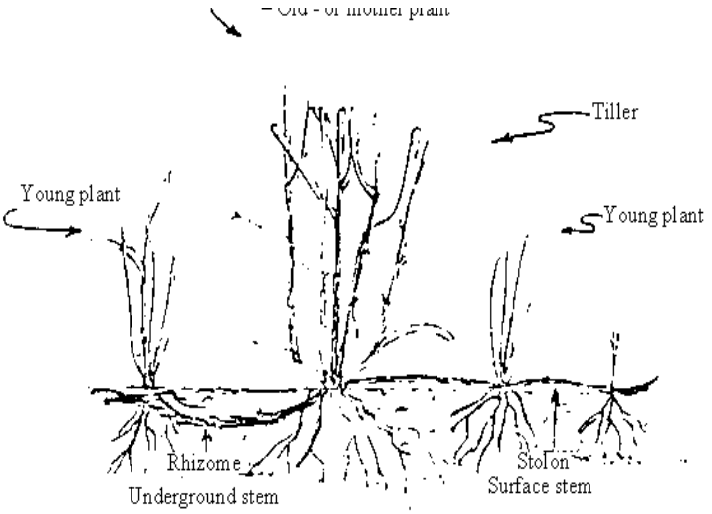
Not just the lawn collectively, but each plant in this actual "forest" needs to be supplied with all of these in proper amounts, and at all times to some degree. Many factors tend to restrict or prevent full use of these things, even when they are available.

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. Groth characteristics

Bunch-type,
Rhizome-forming
Stolon-froming

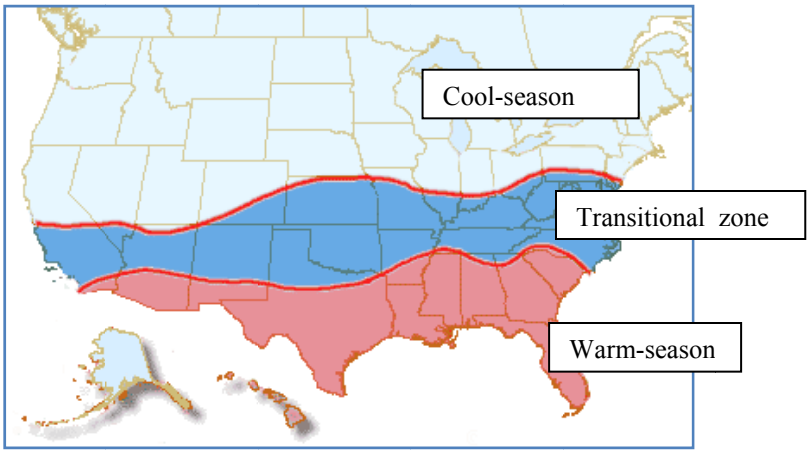


b. Temperature requirement

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.

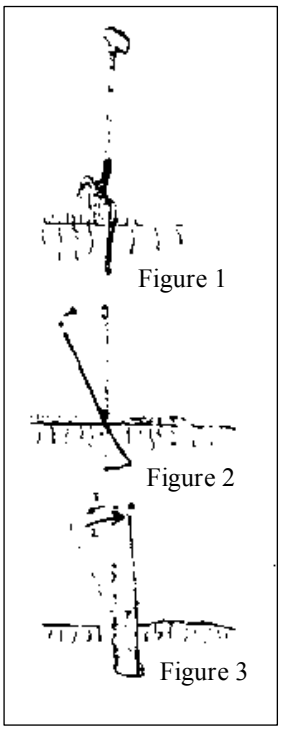
   a. Water the area.

   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.



LAWN CARE VIDEO

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. <u>cool season</u>:
      Bluegrass-Kentucky bluegrass
      Perennial rye
      Fescue-fine fescue

   b. <u>warm season</u>:
      Bermudagrass
      Zoysiagrass
      Buffalograss
      St. Augustine grass

   c. <u>transitional</u>:

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

Lab Exercise 10

PLANTS FOR INTERIORS

	Scientific	Name Family	Common Name
1.	*Beloperone guttata*	Acanthaceae	Shrimp Plant
2.	*Dracaena marginata*	Agavaceae	Dragon Tree of Madagascar
3.	*Sansevieria trifasciata*	Agavaceae	Snake Plant
4.	*Dieffenbachia amoena*	Araceae	Giant Dumbcane
5.	*Philodendron scandens oxycardium*	Araceae	Heart-leaf Philodendron
6.	*Epipremnum aureum*	Araceae	Golden Pothos
7.	*Spathyphyllum clevelandii*	Araceae	Peace Lily or White Flag
8.	*Brassaia arboricola*	Araliaceae	Hawaiian Schefflera
9.	*Hedera helix*	Araliaceae	English Ivy
10.	*Araucaria heterophylla*	Araucariaceae	Norfolk Island Pine
11.	*Begonia masoniana*	Begoniaceae	Iron Cross Begonia
12.	*Aechmea fasciata*	Bromeliaceae	Silver Vase
13.	*Mammillaria albilanata*	Cactaceae	Mammillaria Cactus
14.	*Crassula argentea*	Crassulaceae	Jade Plant
15.	*Euphorbia splendens*	Euphorbiaceae	Crown-of-Thorns
16.	*Euphorbia trigona*	Euphorbiaceae	African Milktree
17.	*Saintpaulia ionantha*	Gesneriaceae	African Violet
18.	*Plectranthus australis*	Lamiaceae	Swedish Ivy
19.	*Chlorophytum comosum* 'Vittatum'	Liliaceae	Variegated Spider Plant
20.	*Asparagus densifloris* ‘Sprengeri’	Liliaceae	Sprenger Asparagus
21.	*Ficus benjamina*	Moraceae	Weeping Fig
22.	*Ficus elastica*	Moraceae	Rubber Plant
23.	*Cattleya spp.*	Orchidaceae	Cattleya Orchid
24.	*Peperomia obtusifolia variegata*	Piperaceae	Variegated Peperomia
25.	*Nephrolepis exaltata* 'Dallas'	Polypodiaceae	Dallas Fern
26.	*Platycerium bifurcatum*	Polypodiaceae	Staghorn Fern

Lab 10: Guidelines for Completing Plant ID Sheets

Names:

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

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) Oval (Ov)
   - Spreading (Spr) Round (R)
   - Cascading or Weeping (Cas) Irregular (Ir)
   - Climbing (Cl) 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 ^{o}F); produces oxalic acid crystals that are toxic to skin (causes inflamation).

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*

Family - Araceae
Temp. Medium
Light Medium
Moist. Medium
Pests-Dis. Mealybug, root rot
Prop. Tip and nodal cuttings; tissue culture
Notes Used for terrarium, atrium, hanging baskets; easy to grow.

7. **Peace Lily or White Flag** *Spathyphyllum 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
80 genera of dicots - herbs, shrubs, trees, vines
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
Two genera of gymnosperms. Large pine-like trees; high light; won't take a freeze
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
3 genera of dicots; herbs with lopsided leaves
Temp. High
Light Medium to high
Moist. Moist

Pests-Dis. Mealybug, aphid, whitefly, root rot, powdery meldew
Prop. Leaf sections
Notes Used for terrarium, pot plants; best in cool greenhouse, need high humidity; attractive foliage accent.

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. milii 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

Light High
Moist. Dry
Pests-Dis. Spider mite, mealybug, root rot
Prop. Stem cuttings
Notes Prefers dry, high-light areas; durable; latex poisonous.

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 rhizomes, 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
53 genera of dicots; trees and shrubs - rarely herbs; milky sap
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
735 genera of monocots; herbaceous perennials; epiphytic, saprophytic, or terrestrial; stem often with pseudobulbs and aerial roots; one of the largest families of flowering plants
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
tropical herbs and vines; small flowers without petals or sepals
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** *Nephrolepis 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	Zebra Plant
Beloperone guttata	Shrimp Plant
Crossandra infundibuliformis	Crossandra
Fittonia minima	Miniature Silver Nerve Fittonia
Fittonia vershaffeltii 'Pearlei'	Pink Nerve Fittonia
Fittonia vershaffeltii 'Argyroneura'	White Nerve Fittonia
Graptophylum pictum	Caricature Plant
Hemigraphis 'Exotica'	Purple Waffle Plant
Hypoestes sanguinolenta	Polka Dot Plant or Freckle Face
Pachystachys lutea	Lollipop Plant
Jacobinia carnea	Pink Lollipop Plant
Pseuderanthemum atropurporeum tricolor	
Sanchezia speciosa	Tiger Plant
AGAVACEAE	
Agave americana	Century Plant
Agave angustifolia marginata	Variegated Caribbean Agave
Agave attenuata	Dragon Tree Agave
Beaucarnea recurvata	Ponytail or Elephant-Foot Tree
Cordyline terminalis	Baby Doll Dracaena
Cordyline stricta	Cordyline
Dracaena craigii 'Compacta'	Compact Dracaena
Dracaena deremensis 'Bausei'	Striped Dracaena
Dracaena deremensis 'Janet Craig'	Janet Craig Dracaena
Dracaena deremensis 'Warneckii'	Warneckii Dracaena
Dracaena fragrans 'Massangeana'	Corn Plant
Dracaena godseffiana 'Florida Beauty'	Gold Dust Dracaena
Dracaena marginata	Dragon Tree of Madagascar
Dracaena marginata 'Tricolor'	Tricolor Dragon Tree
Dracaena sanderiana	Ribbon Plant
Dracaena thalioides	Lance Dracaena
Pleomele reflexa	Pleomele
Pleomele reflexa 'Variegata'	Song of India Pleomele
Sansevieria intermedia	Pygmy Bowstring
Sansevieria trifasciata	Snake Plant
Sansevieria trifasciata 'Golden Hahnii'	Golden Birdsnest Sansevieria
Sansevieria trifasciata laurentii	Variegated Snake Plant or Birdsnest Sansevieria
Yucca elephantipes	False Agave
AIZOACEAE	
Lithops leslii	Living Stones
AMARANTHACEAE	
Alternanthera versicolor	Joseph's Coat
Iresine herbstii 'Aureo-reticulata'	Clown Plant
Iresine lindenii	Bloodleaf or Achyranthus
Iresine lindenii formosa	Bloodleaf or Achyranthus
AMARYLLIDACEAE	
Clivia miniata	Kaffir Lily
Eucharis grandiflora	Eucharis Lily
Hippeastrum spp.	Amaryllis
Nerine bowdenii	Naked Lady Lily

APOCYNACEAE

Mandevilla splendens	Alice DuPont Mandevilla
Mandevilla sanderi 'Rosea'	Rose Dipladenia
Nerium oleander	Oleander

ARACEAE

Aglaonema commutatum maculatum	Silver Chinese Evergreen
Aglaonema commutatum 'Pseudo bracteum'	Golden Chinese Evergreen
Aglaonema commutatum 'Treubii'	Variegated Chinese Evergreen
Aglaonema crispum	Painted Droptongue
Aglaonema modestum	Chinese Evergreen
Anthurium scherzeranum	Flamingo Flower
Caladium spp.	Caladium
Diffenbachia amoena	Giant Dumbcane
Dieffenbachia 'Exotica'	Dumbcane
Dieffenbachia oerstedii 'Variegata'	Velvet Dumbcane
Dieffenbachia maculata	Spotted Dumbcane
Dieffenbachia maculata 'Rudolph Roehrs'	Gold Dieffenbachia
Epipremnum aureum	Golden Pothos
Epipremnum aureum 'Marble Queen'	Marble Queen Pothos
Monstera deliciosa 'Variegata'	Variegated Split-Leaved Philodendron
Monstera deliciosa	Split-Leaved Philodendron
Monstera guttiferum	Angel Winged Philodendron
Monstera friedrichsthalii	Windowleaf Philodendron
Philodendron bipennifolium	Horsehead Philodendron
Philodendron x 'Burgundy'	Purple Prince Philodendron
Philodendron cannifolium	Flask Philodendron
Philodendron hastatum	Spade-Leaf Philodendron
Philodendron scandens oxycardium	Heart-Leaf Philodendron
Philodendron micans	Velvet-Leaf Philodendron
Philodendron mortianum	Giant Philodendron
Philodendron panduraeforme	Fiddle-Leaf Philodendron
Philodendron selloum	Tree Philodendron
Philodendron squamiferum	Red Bristly Philodendron
Scindapsus pictus 'Argyraeus'	Satin Pathos
Spathiphyllum clevelandii	Peace Lily or White Flag
Syngonium auritum	Five Fingers Syngonium
Syngonium podophyllum	Arrowhead or Nephthytis
Syngonium podophyllum 'White Butterfly'	White Butterfly Nephthytis
Zamioculcas zamiifolia	ZZ Plant

ARALIACEAE

Brassaia actinophylla	Schefflera or Umbrella Tree
Brassaia arboricola	Hawaiian Schefflera
Dizygotheca elegantissima	False Aralia
Fatsia japonica	Japanese Aralia
Fatshedera x *lizei*	Tree Ivy, Botanical Wonder
Hedera canariensis	Algerian Ivy
Hedera canariensis variegata	Variegated Algerian Ivy
Hedera helix	English Ivy
Hedera helix 'Glacier'	Glacier Ivy
Hedera helix 'Golddust'	Golddust Ivy
Hedera helix 'Needlepoint'	Needlepoint Ivy
Hedera helix 'Scutifolia'	Sweetheart Ivy
Polyscias balfouriana	Balfour Aralia
Polyscias balfouriana marginata	Variegated Balfour Aralia
Polyscias fruticosa	Ming Aralia
Polyscias guilfoylei 'Victoriae'	Lace Aralia
Tupidanthus calyptratus	Tupidanthus

ARAUCARIACEAE

Araucaria bidwillii	Monkey Puzzle, Bunya Bunya Tree
Araucaria heterophylla	Norfolk Island Pine

ARECACEAE

Caryota mitis	Cluster Fishtail Palm
Caryota obtusa	Fishtail Palm
Chamaedorea elegans 'bella'	Neanthe Bella Palm
Chamaedorea seifrizii	Bamboo Palm
Chamaerops humilis	European Fan Palm
Chrysalidocarpus lutescens	Areca Palm, Butterfly Palm
Howea forsteriana	Kentia Palm
Phoenix roebelenii	Pigmy Date Palm, Dwarf Date Palm
Rhapis excelsa	Lady Palm

ASCLEPIADACEAE

Ceropegia ampliata	Lantern Flower
Ceropegia woodii	String of Hearts
Hoya bella	Miniature Wax Plant
Hoya carnosa	Wax Plant
Hoya carnosa rubra	
Hoya carnosa 'Tricolor'	Tricolor Wax Plant
Hoya carnosa 'Variegata'	Variegated Wax Plant
Hoya compacta	Hindu Rope
Hoya compacta 'Variegata'	Variegated Wax Plant
Hoya keysii	Queensland Wax Plant
Hoya 'Silver Pink'	Silver Pink Hoya
Stapelia gigantea	Giant Toad Plant
Stephanotis floribunda	Stephanotis, Wedding Flower

ASTERACEAE

Gynura aurantiaca	Velvet Plant
Gynura sarmentosa	Trailing Velvet Plant
Senecio macroglossus variegatus	Variegated Wax Ivy
Senecio mikaioides	Parlor Ivy, German Ivy
Senecio herreianus	String of Beads
Senecop rowleyanus	String of Pearls
Senecio serpens	Blue Chalksticks

BEGONIACEAE

Begonia bowerii	Eyelash Begonia
Begonia 'Chantilly Lace'	
Begonia foliosa	
Begonia 'Lucerna'	Angelwing Begonia
Begonia masoniana	Iron Cross Begonia
Begonia rex	Rex Begonia
Begonia semperflorens 'Charm'	Charm Begonia

BIGNONIACEAE

Radermachera sinica	China Doll

BROMELIACEAE

Aechmea chantinii	
Aechmea rhodocyanea	Silver Urn Plant
Aechmea fulgens discolor	Coralberry
Ananas comosus	Pineapple
Ananas comosus variegatus	Variegated Pineapple
Billbergia nutans	Queen's Tears
Cryptanthus roseus pictus	Earth Star
Gusmania musaica	Mosaic Vase
Neoregelia carolinae 'Tricolor'	Tricolor Neoregelia

BUXACEAE

Buxus microphylla japonica	Japanese Little Leaf Boxwood

CACTACEAE

Astrophytum myriostigma	Bishop's Cap
Cephatocereus senilis	Oldman's Cactus
Cereus peruvianus 'Monstrosus'	Giant Club

Echinocactus grusonii	Golden Barrel
Epiphyllum ackermannii	Red Orchid Cactus
Epiphyllum cooperi	White Orchid Cactus
Ferocactus lastispinus	Devil's Tongue
Gymnocalycium mihanovichii	Plain Chin Cactus
Mammilaria celsian	
Mammilaria collinsii	
Mammilaria elongata	Golden Star
Opuntia basilaris	
Opuntia microdasys 'Albispina'	Bunny Ears
Opuntia microdasys rufida	Red Bunny Ears
Opuntia subulata	Eve's Pin Cactus
Rhipsalis cereuscula	Coral Cactus
Schlumbergera bridgesii	Christmas Cactus
Schlumbergera truncata	Thanksgiving Cactus

CELASTRACEAE

Euonymus japonicus	Euonymus
Euonymus japonicus variegatus	Variegated Euonymus

CLUSIACEAE

Clusia rosea	Fat Pork Tree

COMMELINACEAE

Callisia elegans	Striped Inch Plant
Cyanotis kewensis	Teddy Bear Plant
Rheo spathaceae	Moses on a Raft
Setcreasea purpurea	Purple Heart
Tradescantia albiflora 'Albo-Vittata'	Giant White Inch Plant
Tradescantia fluminensis 'Variegata'	Variegated Wandering Jew
Tradescantia multiflora	Tahitian Bridal Veil
Tradescantia silamontana	White Velvet Tradescantia
Zebrina pendula	Wander Jew

CORNACEAE

Aucuba japonica 'Variegata'	Gold Dust Tree

CRASSULACEAE

Aeonium arboreum 'Atropurpureum'	Tree Aeonium
Aeonium hawarthii	Pinwheel
Crassula arborescens	Silver Dollar
Crassula argentea	Jade Plant
Crassula argentea 'Variegata'	Variegated jade Plant
Crassula flacata	Propeller Plant
Crassula tetragona	Miniature Pine Tree
Echeveria 'Doris Taylor'	Wooly Rose
Echeveria gilva	Green Mexican Rose
Echeveria pulvinata	Plush Plant
Graptopetalum paraguayense	Ghost Plant, Mother-of-Pearl
Gassulaceae huerina spp.	Dragon Flower
Kalanchoe beharensis	Velvet Leaf
Kalanchoe daigremonitana	Maternity Plant
Kalanchoe marmorata	Pen Wiper
Kalanchoe tomentosa	Panda Bear Plant
Kalanchoe tubiflora	Chandelier Plant
Pachyphytum oviferum	Moonstones
Sedum morganianum	Burro Tail

CYCADACEAE

Cycas circinalis	Fern Palm
Cycas revoluta	Sago Palm

CYPERACEAE

Cyperus alternifolius	Umbrella Plant
Cyperus papyrus	Papyrus

EUPHORBIACEAE

Acalypha hispida	Chenille Plant, Foxtail
Acalypha wikesiana macafeana	Copper Leaf
Codiauem variegatum pictum 'Bravo'	Croton
Euphorbia mammilaris	Indian Corncob
Euphorbia pseudocactus	
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
Columnea microphylla	Miniature Lipstick Plant
Episcia cupreata	Flame Violet
Nautilocalyx lynchii	Purple Shrub Violet
Saintpaulia ionantha	African Violet
Sinningia speciosa	Gloxinia
Streptocarpus rexii	Cape Primrose
Streptocarpus saxorum	False 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 ‘Sprengeri’	Sprenger Asparagus
Asparagus setaceus	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
Chlorphytum comosum 'Vittatum'	Variegated Spider Plant
Haworthia cuspidata	Star Window Plant
Haworthia fasciata	Fairy Washboard
Haworthia margaritifera	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	Rattlesnake Plant
Calathea makoyana	Peacock Plant
Calathea picturata 'Argentea'	
Calathea roseo-picta	
Maranta leuconeura 'Erythroneura'	Red-Veined Prayer Plant
Maranta leuconeura kerchoveana	Prayer Plant

MORACEAE

Ficus benjamina	Weeping fig
Ficus benjamina 'Exotica'	Javan Fig
Ficus deltoidea	Mistletoe Fig
Ficus elastica 'Decora'	Rubber Plant
Ficus elastica 'Honduras'	Variegated Rubber Plant
Ficus elastica 'Variegata'	Variegated Rubber Tree
Ficus lyrata	Fiddle Leaf Fig
Ficus palmeri	Mexican Blue Fig
Ficus petiolaris	Redvein Mexican Blue Fig
Ficus pumila	Creeping Fig
Ficus retusa nitida	Indian Laurel
Ficus rubignosa	Rusty Fig
Ficus rubignosa 'Variegata'	Variegated Rusty Fig

MUSACEAE

Musa acuminata	Dwarf Banana

MYRSINACEAE

Ardisia crispa	Coral Berry

NICTAGINACEAE

Bougainvillea glabra	Bougainvillea
Bougainvillea glabra 'Raspberry Ice'	Variegated Bougainvillea
Pisonia umbellifera 'Variegata'	Bird Catcher Tree

OLEACEAE

Jasminum sambac	Arabian Jasmine
Jasminum polyanthum	Pink Jasmine

ORCHIDACEAE

Cattleya spp.	Lady of the Night Orchid
Cymbidium spp.	Cymbidium Orchid
Dendrobium spp.	Dendrobium Orchid
Epidendrum spp.	Fiery Reed Orchid
Miltonia spp.	Pansy Orchid
Oncidium spp.	Dancing Doll Orchid
Paphiopedilum spp.	Lady Slipper Orchid
Phalaenopsis spp.	Moth Orchid
Vanda spp.	Vanda Orchid
Vanilla planifolia	Vanilla Orchid

OXALIDACEAE

Oxalis regnellii 'rubra alba'	Oxalis
Oxalis rubra	Pink Oxalis

PANDANACEAE

Pandanus veitchii	Veitch Screw Pine

PASSIFLORACEAE

Passiflora caerulea	Passion Flower

PIPERACEAE

Peperomia astrid	
Peperomia caperata 'Emerald Ripple'	Emerald Ripple Peperomia
Peperomia griseoargentea	Silver Leaf Peperomia
Peperomia griseoargentea 'Blackie'	Dark Silver Leaf Peperomia

Peperomia incana	Felted Peperomia
Peperomia obtusifolia	Baby Rubber Plant
Peperomia obtusifolia variegata	Variegated Baby Rubber Plant
Peperomia rubella	Pepe Peperomia
Peperomia sandersii	Watermelon Peperomia
Peperomia scandens	Philodendron Peperomia
Peperomia scandens 'Variegata'	Variegated Philodendron Peperomia
Peperomia viridis	

PITTOSPORACEAE

Pittosporum tobira	Mock Orange
Pittosporum tobira 'Variegata'	Variegated Mock Orange

POACEAE

Oplismenus hirtellus 'Variegatus'	Ribbon Grass

PODOCARPACEAE

Podocarpus macrophylla	Buddhist Pine
Podocarpus macrophyllus 'Maki'	Japanese Yew Pine
Podocarpus gracilior	Fern Pine

POLYGONACEAE

Coccoloba latifolia	Sea Grape

POLYPODIACEAE

Adiatum cuneatum	Delta Maidenhair Fern
Adiatum mircophyllum	Maidenhair Fern
Alsophila australis	Australia Tree Fern
Asplenium nidus	Birdnest Fern
Asplenium bulbiferum	Mother Fern
Crytomium falcatum 'Rochefordianum'	Rochford Holly Fern
Davallia fejeensis	Rabbit's Foot Fern
Davallia trichomanoides	Squirrel's Foot Fern
Nephrolepis exaltata bostoniensis	Boston Fern
Nephrolepis exaltata 'Florida Ruffles'	Florida Ruffles Fern
Nephrolepis exaltata 'Fluffy Ruffles'	Dwarf Feather Fern
Nephrolepis exaltata 'Whitmanii'	Feather Fern
Pellaea rotundifolia	Button Fern
Phlebodium aureum	Hare's Foot Fern
Platycerium wilhelminae reginae	Staghorn Fern
Polystichum tsus-simense	Leather Fern
Pteris cretica	Table Fern
Pteris ensiformis 'Victoria'	Victoria Table Fern
Stenochlaena palustris	Climbing Fern

PORTULACACEAE

Portulacaria afra	Elephant Bush
Portulacaria afra 'Variegata'	Variegated Elephant Bush

PRIMULACEAE

Cyclamen percicum	Cyclamen

RUBIACEAE

Gardenia jasminoides	Gardenia
Ixora spp.	Jungle Geranium
Coffea arabica	Coffee Plant

RUTACEAE

Citrus mitis	Calamondin

SAXIFRAGACEAE

Saxifraga stolonifera	Strawberry Begonia
Saxifraga stolonifera 'Tricolor'	Variegated Strawberry Begonia
Tolmiea menziesii	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.

Abutilon hybridum 'Fireball'	Chinese Lantern
Abutilon pictum 'Thompsonii'	Flowering Maple
Acalypha hispida	Chenille Plant or Foxtail
Acalypha wikesiana macafeana	Copper Leaf
Aeonium arboreum 'Atropurpreum'	Tree Aeonium
Aeonium hawarthii	Pinwheel
Agave americana	Century Plant
Agave angustifolia marginata	Variegated Caribbean Agave
Agave attenuata	Dragon Tree Agave
Agave victoriae-reginae	
Aloe aristida	Lace Aloe
Aloe barbadensis	Aloe Vera
Aloe variegata	Tiger Aloe
Alternanthera versicolor	Joseph's Coat
Aphelandra squarrosa	Zebra Plant
Araucaria bidwilli	Monkey Puzzle
Araucaria heterophylla	Norfolk Island Pine
Ardisia crispa	Coral Berry
Asparagus meyeri	Plume Asparagus Fern
Asparagus plumosus	Plumosa Fern
Asparagus sprengeri	Sprenger Asparagus
Aspidistra elatior	Cast Iron Plant
Aspidistra elatior 'Variegata'	Variegated Cast Iron Plant
Beaucarnea recurvata	Ponytail or Elephant-Foot Tree
Beloperone guttata	Shrimp Plant
Bougainvillea glabra	Bougainvillea
Brassaia actinophylla	Schefflera or Umbrella Tree
Brassaia arboricola	Hawaiian Schefflera
Buxus microphylla japonica	Japanese Little Leaf Boxwood
Caryota obtusa	
Cephatocereus senilis	Oldman's Cactus
Chlorophytum comosum	Spider Plant
Chlorophytum comosum 'Variegatum'	Inside-Out Spider Plant
Chlorophytum comosum 'Vittatum'	Variegated Spider Plant
Chrysal idocarpus lulescens	
Cissus antarctica	Kangaroo Vine
Cissus arabica	Arabian Wax Cissus
Cissus rhombifolia	Grape Ivy
Cissus rhombifolia	Oak-Leaf Grape Ivy
Citrus mitis	Calamondin
Clusia rosea	Fat Pork Tree
Coffea arabica	Coffea Plant
Coldiaeum variegatum pictum 'Bravo'	Croton
Cordyline terminalis	Baby Doll Dracaena
Crassula arborescens	Silver Dollar
Crassula argentea	Jade Plant
Crassula argentea 'Variegata'	Variegated Jade Plant
Crassula falcata	Propeller Plant
Crassula tetragona	Miniature Pine Tree
Dieffenbachia picta 'Rudolph Roehrs'	Gold Dieffenbachia
Dipteracanthus portellae	Monkey Plant
Dizygotheca elegantissima	False Aralia
Dracaena craigii 'Compacta'	Compact Dracaena
Dracaena deremensis 'Bausei'	Stripped Dracaena
Dracaena deremensis 'Janet Craig'	Janet Craig Dracaena
Dracaena deremensis 'Warneckei'	Warneckei Dracaena
Dracaena fragrans massangeana	Corn Plant
Dracaena godseffiana 'Florida Beauty'	Gold Dust Dracaena
Dracaena marginata	Dragon Tree of Madagascar

Dracaena marginata 'Tricolor'	Tricolor Dragon Tree
Dracaena sanderiana	Ribbon Plant
Dracaena thalioides	Lance Dracaena
Echeveria 'Doris Taylor'	Wooly Rose
Echeveria gilva	Green Mexican Rose
Echeveria pulvinata	Plush Plant
Epidendrum spp.	
Euphorbia mammilaris	Indian Corncob
Euphorbia pseudocactus	
Euphorbia pulcherrima	Poinsettia
Euphorbia splendens prostrata	Crown of Thorns
Euphorbia tirucalli	Pencil Tree
Fatshedera lizei	Tree Ivy
Fatsia japonica	Japanese Aralia
Ficus benjamina	Weeping Fig
Ficus benjamina 'Exotica'	Weeping Fig
Ficus deltoides	Mistletoe Fig
Ficus elastica 'Decora'	Rubber Plant
Ficus elastica 'Honduras'	Variegated Rubber Plant
Ficus elastica variegata	Variegated Rubber Tree
Ficus lyrata	Fiddle Leaf Fig
Ficus petifolia	
Ficus petiolaris var. *petiolaris*	Redvein Mexican Blue Fig
Ficus petiolaris var. *palmeri*	Mexican Blue Fig
Ficus pumila	Creeping Fig
Ficus retusa nitida	Indian Laurel
Ficus rubignosa	Rusty Fig
Ficus rubignosa 'Variegata'	Variegated Rusty Fig
Gardenia jasminoides	Gardenia
Graptopetalum paraguayense	Ghost Plant or Mother-of-Pearl
Gynura aurantiaca	Velvet Plant
Gynura sarmentosa	Trailing Velvet Plant
Haworthia cuspidata	Star Window Plant
Haworthia fasciata	Fairy Washboard
Hawthoria margaritifera	Pearl Plant
Haworthia reinwardtii	
Hedera canariensis variegata	Algerian Ivy
Hedera helix	English Ivy
Hedera helix 'Golddust'	Golddust Ivy
Hedera helix 'Needlepoint'	Needlepoint Ivy
Hedera helix 'Scutifolia'	Sweetheart Ivy
Hemigraphis 'Exotica'	Purple Waffle Plant
Hibiscus rosa-sinensis	
Huerina spp.	Dragon Flower
Iresine lindenii	Bloodleaf or Achyranthus
Iresine lindenii formosa	Bloodleaf or Achyranthus
Ixora spp.	Jungle Geranium
Jasminum sambac	Arabian Jasmine
Kalanchoe beharensis	Velvet Leaf
Kalanchoe daigremontiana	Maternity Plant
Kalanchoe marmorata	Pen Wiper
Kalanchoe tomentosa	Panda Bear Plant
Kalanchoe tubiflora	Chandelier Plant
Musa acuminata	Dwarf Banana
Oxalis regnellii 'Rubra Alba'	Oxalis
Oxalis rubra	Pink Oxalis
Pachyphytum oviferum	Moonstones
Pedilanthus tithymaloides 'Variegatus'	Redbird Cactus or Devil's Backbone
Pisonia umbellifera 'Variegata'	Bird Catcher Tree
Pittosporum tobira	Mock Orange
Pittosporum tobira 'Variegatum'	Variegated Mock Orange
Pleomele angustifolia honoriae	Narrow-Leaved Pleomele
Polyscias balfouriana	Balfour Aralia
Polyscias balfouriana marginata	Variegated Balfour Aralia
Polyscias fruticosa	Ming Aralia

Polyscias quilfoylei 'Victoriae'	Lace Aralia
Portulacaria afra	Elephant Bush
Portulacaria afra 'Variegata'	Variegated Elephant Bush
Sansevieria intermedia	Pygmy Bowstring
Sansevieria trifasciata	Snake Plant
Sansevieria trifasciata 'Golden Hahnii'	Golden Birdsnest Sansevieria
Sansevieria trifasciata hahnii	Birdsnest Sansevieria
Sansevieria trifasciata laurentii	Snake Plant
Sedum morganianum	Burro Tail
Senecio macroglossus variegatus	Variegated Wax Ivy
Senecio mikaioides	Parlor Ivy or German Ivy
Senecio rowleyanus	String of Pearls
Senecio serpens	Blue Chalksticks
Strelitzia reginae	Bird of Paradise
Syngonium podophyllum	Arrowhead or Nephthytis
Tupidanthus calyptratus	Tupidanthus
Vanda spp.	Vanda Orchids
Yucca elephantipes	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	Coralberry
Aglaonema commutatum 'Psuedo bracteum'	Golden Chinese Evergreen
Aglaonema commutatum 'Treubii'	
Aglaonema commutatum macultatum	Silver Chinese Evergreen
Aglaonema crispum	
Aglaonema modestum	Chinese Evergreen
Aspidistra elatior	Cast Iron Plant
Aspidistra elatior 'Variegata'	Variegated Cast Iron Plant
Aucuba japonica variegata	Gold Dust Tres
Chlorophytum comosum	Spider Plant
Clivia miniata	
Epipremnum aureus	Golden Pothos
Epipremnum aureus 'Marble Queen'	Marble Queen Pothos
Ficus elastica 'Decora'	Rubber Plant
Maranta leuconeura kerchoveana	Prayer Plant
Monstera deliciosa	Split-Leaved Philodendron
Peperomia obtusifolia	Baby Rubber Plant
Philodendron cannifolium	Flask Philodendron
Philodendron oxycardium	Heart-Leaf Philodendron
Rhoeo spathaceae	Moses on a Raft
Spathiphyllum clevelandii	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	
Asparagus sprengeri	Sprenger Asparagus
Astrophytum myriostigma	Bishop's Cap
Bougainvillea glabra	Bougainvillea
Caryota mitis	Cluster Fishtail Palm
Caryota obtusa	Fishtail Palm
Cephatocereus senillis	Oldman's Cactus
Cereus peruvianus 'Mostrosus'	Giant Club
Coldiaeum variegatum pictum 'Bravo'	Croton
Crassula argentea	Jade Plant
Crassula argentea 'Variegata'	Variegated Jade Plant
Echinocactus grusonii	Golden Barrel
Ferocactus lastispinus	Devil's Tongue
Ficus benjamina	Weeping Fig
Ficus benjamina 'Exotica'	Weeping Fig
Ficus deltoides	Mistletoe Fig
Ficus rubignosa	Rusty Fig
Hibiscus rosa-sinensis	
Jasminum sambac	Arabian Jasmine
Kalanchoe beharensis	Velvet Leaf
Kalanchoe tomentosa	Panda Bear Plant
Lithops leslii	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

PLANTS FOR COOL SITUATIONS

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'	Chinese Lantern
Abutilon pictum 'Thompsonii'	Flowering Maple
Adiatum cuneatum	Delta Maidenhair Fern
Adiatum microphyllum	Maidenhair Fern
Ardisia crispa	Coral Berry
Asparagus meyeri	Plume Asparagus Fern
Asparagus plumosus	Plumosa Fern
Asparagus sprengeri	Sprenger Asparagus
Aspidistra elatior	Cast Iron Plant
Aspidistra elatior 'Variegata'	Variegated Cast Iron Plant
Asplenium nidus	Birdsnest Fern
Aucuba japonica variegata	Gold Dust Tres
Beloperone guttata	Shrimp Plant
Brassaia actinophylla	Schefflera or Umbrella Tree
Brassaia arboricola	Hawaiian Schefflera
Calthea clossonii	
Calthea insignis	Rattlesnake Plant
Calthea makoyana	Peacock Plant
Calthea picturata 'Argentea'	
Calthea roseo-picta	
Ceropegia woodii	String of Hearts
Chlorophytum comosum	Spider Plant
Chlorophytum comosum 'Variegatum'	Inside-Out Spider Plant
Chlorophytum comosum 'Vittatum'	Variegated Spider Plant
Cycas revoluta	Sago Palm
Cyclamen percicum	Cyclamen
Cyrtomium falcatum 'Rochefordianum'	Rochford Holly Fern
Davallia fejeensis	Rabbit's Foot Fern
Davallia trichomanoides	Squirrel's Foot Fern
Dizygotheca elegantissima	False Aralia
Dracaena deremensis 'Janet Craig'	Janet Craig Dracaena
Dracaena deremensis 'Warneckei'	Warneckei Dracaena
Dracaena fragrans massangeana	Corn Plant
Dracaena godseffiana 'Florida Beauty'	Gold Dust Dracaena
Dracaena marginata	Dragon Tree of Madagascar
Epiphyllum ackermannii	Red Orchid Cactus
Epiphyllum cooperi	White Orchid Cactus
Euonymus japonicus	Euonymus
Fatshedera lizei	Tree Ivy
Fatsia japonica	Japanese Aralia
Hedera canariensis variegata	Algerian Ivy
Hedera helix	English Ivy
Hedera helix 'Golddust'	Golddust Ivy
Hedera helix 'Needlepoint'	Needlepoint Ivy
Hedera helix 'Scutifolia'	Sweetheart Ivy
Helxine soleirolii	Baby's Tears
Hippeastrum spp.	Amaryllis
Hoya carnosa	Wax Plant
Hypoestes sanguinolenta	Polka-Dot Plant or Freckle Face
Leea coccinea	West Indian Holly
Maranta leuconeura 'Erythroneura'	Red-Veined Prayer Plant
Maranta leuconerua kerchoveana	Prayer Plant
Mimosa pudica	Sensitive Plant
Musa acuminata	Dwarf Banana
Nephrolepis exaltata 'Florida Ruffles'	Flordia Ruffles Fern
Nephrolepis exaltata 'Fluffy Ruffles'	Dwarf Feather Fern
Nephrolepis exaltata 'Whitemanii'	Feather Fern
Nephrolepis exaltata bostoniensis	Boston Fern
Oplismenus hirtelus 'Variegatus'	Ribbon Grass
Oxalis regnellii 'Rubra Alba'	Oxalis

Oxalis rubra	Pink Oxalis
Passiflora caerulea	Passion Flower
Pellaea rotundifolia	Button Fern
Pellionia pulchera	Satin Pellionia
Phlebodium aureum	Hare's Foot Fern
Pilea 'Moon Valley'	Moon Valley Pilea
Pilea 'Silver Tree'	Silver Tree Pilea
Pilea cadierei	Aluminum Plant
Pilea depressa	Creeping Pilea
Pilea involucrata	Friendship Plant
Pilea microphylla	Artillery Plant
Pilea spruceana 'Norfolk'	Norfolk Pilea
Pittosporum tobira	Mock Orange
Pittosporum tobira 'Variegatum'	Variegated Mock Orange
Platycerium wilhelminae reginae	Staghorn Fern
Plectranthus australis	Swedish Ivy or Creeping Charlie
Podocarpus macrophylla	Buddhist Pine
Podocarpus macrophylla maki	Japanese Yew Pine
Polystichum tsus-simense	Leather Fern
Pteris cretica	Table Fern
Pteris ensiformis 'Victoria'	Victoria Table Fern
Sansevieria trifasciata	Snake Plant
Sansevieria trifasciata laurentti	Snake Plant
Saxifraga stolonifera	Strawberry Begonia
Saxifraga stolonifera 'Tricolor'	Variegated Strawberry Geranium
Stenochlaena palustris	Climbing Fern
Tolmiea menziesii	Piggy-back Plant
Tradescantia albiflora 'Albo-Vittata'	Giant White Inch Plant
Tradescantia fluminensis 'Variegata'	Variegated Wandering Jew
Tradescantia multiflora	Tahitian Bridal Veil
Tupidanthus calyptratus	Tupidanthus
Zamia furfuraceae	Cardboard Palm
Zebrina pendula	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	Coralberry
Aechmea rhodocyanea	Silver Urn Plant
Aeonium arboreum 'Atropurpreum'	Tree Aeonium
Aeonium hawarthii	Pinwheel
Agave americana	Century Plant
Agave angustifolia	Variegated Caribbean Agave
Agave attenuata	Dragon Tree Agave
Agave victoriae-reginae	
Aloe aristida	Lace Aloe
Aloe barbadensis	Aloe Vera
Aloe variegata	Tiger Aloe
Ananas comosus	Pineapple
Ananas comosus variegatus	Variegated Pineapple
Asparagus densiflorus ‘Myers’	Myers Asparagus
Asparagus densiflorua ‘Sprengeri’	Sprenger Asparagus
Asparagus setaceus	Asparagus Fern
Aspidistra elatior	Cast Iron Plant
Aspidistra elatior 'Variegata'	Variegated Cast Iron Plant
Astrophytum myriostigma	Bishop's Cap
Beaucarnea recurvata	Ponytail or Elephant-Foot Tree
Bilibergia nutans	Queen's Tears
Brassaia arboricola	Hawaiian Schefflera
Cephatocereus senilis	Oldman's Cactus
Cereus peruvianus 'Mostrosus'	Giant Club
Ceropegia woodii	String of Hearts
Chamaedorea elegans 'Bella'	Neanthe Bella Palm
Chamaerops humilis	European Fan Palm
Chlorophytum comosum	Spider Plant
Chlorophytum comosum 'Variegatum'	Inside-Out Spider Plant
Chlorophytum comosum 'Vittatum'	Variegated Spider Plant
Cordyline terminalis	Baby Doll Dracaena
Crassula arborescens	Silver Dollar
Crassula argentea	Jade Plant
Crassula argentea 'Variegata'	Variegated Jade Plant
Crassula falcata	Propeller Plant
Crassula tetragona	Miniature Pine Tree
Cryptanthus roseus pictus	Earth Star
Cycas revoluta	Sago Palm
Dracaena craigii 'Compacta'	Compact Dracaena
Dracaena deremensis 'Bausei'	Stripped Dracaena
Dracaena deremensis 'Janet Craig'	Janet Craig Dracaena
Dracaena deremensis 'Warneckei'	Warneckei Dracaena
Dracaena fragrans massangeana	Corn Plant
Dracaena godseffiana 'Flordia Beauty'	Gold Dust Dracaena
Dracaena marginata	Dragon Tree of Madagascar
Dracaena marginata 'Tricolor'	Tricolor Dragon Tree
Dracaena sanderiana	Ribbon Plant
Dracaena thalioides	Lance Dracaena
Echeveria 'Doris Taylor'	Wooly Rose
Echeveria gilva	Green Mexican Rose
Echeveria pulvinata	Plush Plant
Echinocactus grusonii	Golden Barrel
Epiphyllum ackermannii	Red Orchid Cactus
Epiphyllum cooperi	White Orchid Cactus
Euphorbia mammilaris	Indian Corncob
Euphorbia tirucalli	Pencil Tree
Ferocactus lastispinus	Devil's Tongue
Graptopetalum paraguavense	Ghost Plant or Mother-of-Pearl
Gymnocalcycium mihanovichii	Plain Chin Cactus
Haworthia cuspidata	Star Window Plant

Haworthia fasciata	Fairy Washboard
Haworthia margaritifera	Pearl Plant
Haworthia reinwardtii	
Hoya 'Silver Pink'	
Hoya bella	Miniature Wax Plant
Hoya carnosa	Wax Plant
Hoya carnosa rubra	
Hoya carnosa tricolor	Tricolor Wax Plant
Hoya carnosa variegata	Variegated Wax Plant
Hoya compacta	Hindu Rope
Hoya keysii	
Huerina spp.	Dragon Flower
Kalanchoe beharensis	Velvet Leaf
Kalanchoe daigremontiana	Maternity Plant
Kalanchoe marmorata	Pen Wiper
Kalanchoe tomentosa	Panda Bear Plant
Kalanchoe tubiflora	Chandelier Plant
Lithops leslii	Living Stones
Mammilaria celsian	
Mammilaria collinsii	
Mammilaria elongata	Golden Star
Neoregelia carolinae tricolor	
Opuntia basilaris	
Opuntia microdasys 'Albispina'	Bunny Ears
Opuntia microdasys rufida	Red Bunny Ears
Opuntia subulata	Eve's Pin Cactus
Pachyphytum oviferum	Moonstones
Pandanus veitchii	Veitch Screw Pine
Pedilanthus tithymaloides 'Variegatus'	Redbird Cactus or Devil's Backbone
Phoenix roebelenii	Pigmy Date Palm or Dwarf Date
Palm	
Pleomele angustifolia honoriae	Narrow-Leaved Pleomele
Polyscias balfouriana	Balfour Aralia
Polyscias balfouriana marginata	Variegated Balfour Aralia
Polyscias fruticosa	Ming Aralia
Portulacaria afra	Elephant Bush
Portulacaria afra 'Variegata'	Variegated Elephant Bush
Rhipsalis cereuscula	Coral Cactus
Sansevieria intermedia	Pygmy Bowstring
Sansevieria trifasciata	Snake Plant
Sansevieria trifasciata 'Golden Hahnii'	Golden Birdsnest Sansevieria
Sansevieria trifasciata hahnii	Birdsnest Sansevieria
Sansevieria trifasciata laurentii	Snake Plant
Schlumbergera bridgesii	Christmas Cactus
Schlumbergera truncata	Thanksgiving Cactus
Sedum morganianum	Burro Tail
Stapelia gigantea	Giant Toad Plant
Stephanotis floribunda	Stephanotis
Strelitzia reginae	Bird of Paradise
Yucca elephantipes	False Agave
Zamia furfuraceae	Cardboard Palm

PLANTS FOR SMALL SPACES

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

Adiatum cuneatum	Delta Maidenhair Fern
Adiatum microphyllum	Maidenhair Fern
Aechmea rhodocyanea	Coralberry
Aglaonema commutatum 'Pseudo-bracteum'	Golden Chinese Evergreen
Aglaonema commutatum 'Treubii'	
Aglaonema commutatum macultatum	Silver Chinese Evergreen
Aglaonema crispum	
Aglaonema modestum	Chinese Evergreen
Asparagus meyeri	Plume Asparagus Fern
Aspidistra elatior	Cast Iron Plant
Aspidistra elatior 'Variegata'	Variegated Cast Iron Plant
Asplenium nidus	Birdsnest Fern
Aucuba japonica variegata	Gold Dust Tres
Buxus microphylla japonica	Japanese Little Leaf Boxwood
Calthea insignis	Rattlesnake Plant
Calthea makoyana	Peacock Plant
Chlorophytum comosum	Spider Plant
Chlorophytum comosum 'Variegatum'	Inside-Out Spider Plant
Chlorophytum comosum 'Vittatum'	Variegated Spider Plant
Cissus rhombifolia	Grape Ivy
Cissus rhombifolia 'Danica'	Oak-Leaf Grape Ivy
Clivia miniata	Cafir Lily
Cordyline terminalis	Baby Doll Dracaena
Crassula argentea	Jade Plant
Crassula argentea 'Variegata'	Variegated Jade Plant
Cycas revoluta	Sago Palm
Dieffenbachia 'Exotica'	Dumbcane
Dracaena craigii 'Compacta'	Compact Dracaena
Dracaena deremensis 'Warneckei'	Warneckei Dracaena
Echinocactus grusonii	Golden Barrel
Fatsia japonica	Japanese Aralia
Ficus pumila	Creeping Fig
Kalanchoe tomentosa	Panda Bear Plant
Maranta leuconeura 'Erythroneura'	Red Veined Prayer Plant
Maranta leuconeura kerchoveana	Prayer Plant
Nephrolepis exaltata bostoniensis	Boston Fern
Peperomia astrid	
Peperomia caperata 'Emerald Ripple'	Emerald Ripple Peperomia
Peperomia griseoargentea	Silver Leaf Peperomia
Peperomia griseoargentea 'Blackie'	Dark Silver Leaf Peperomia
Peperomia incana	Felted Peperomia
Peperomia obtusifolia	Baby Rubber Plant
Peperomia obtusifolia variegata	Variegated Baby Rubber Plant
Peperomia rubella	Pepe Peperomia
Peperomia sandersii	Watermelon Peperomia
Peperomia scandens	
Peperomia scandens 'Variegata'	
Peperomia viridis	
Philodendron cannifolium	Flask Philodendron
Rhoeo spathaceae	Moses on a Raft
Sansevieria trifasciata	Snake Plant
Sansevieria trifasciata laurentti	Snake Plant
Schlumbergera bridgesii	Christmas Cactus
Schlumbergera truncata	Thanksgiving Cactus
Scindapsis aurerus	Golden Pothos
Scindapsis aureus 'Marble Queen'	Marble Queen Pathos
Spathiphyllum clevelandii	Peace Lily or White Flag

PLANTS FOR USE IN SITUATIONS REQUIRING HEIGHT

These plants, in general, can be easily purchased in sizes that allow for a five foot plant or taller.

Araucaria bidwilli	Monkey Puzzle
Araucaria heterophylla	Norfolk Island Pine
Bougainvillea glabra	Bougainvillea
Brassaia actinophylla	Schefflera or Umbrella Tree
Brassaia arboricola	Hawaiian Schefflera
Caryota obtusa	Fishtail Palm
Chamaedorea seifrizii	Bamboo Palm
Chrysalidocarpus lulescens	Areca Palm or Butterfly Palm
Coffea arabica	Coffea Plant
Coldiaeum variegatum pictum 'Bravo'	Croton
Dizygotheca elegantissima	False Aralia
Dracaena fragrans massangeana	Corn Plant
Dracaena marginata	Tricolor Dragon Tree
Ficus benjamina	Weeping Fig
Ficus benjamina 'Exotica'	Weeping Fig
Ficus elastica 'Decora'	Rubber Plant
Ficus elastica 'Honduras'	Variegated Rubber Plant
Ficust elastica variegata	Variegated Rubber Plant
Ficus lyrata	Fiddle Leaf Fig
Ficus retusa nitida	Indian Laurel
Gardenia jasminoides	Gardenia
Hibiscus rosa-sinensis	
Howea belmoreana	Pigmy Date Palm or Dwarf Date
Palm	
Leea coccinea	West Indian Holly
Musa acuminata	Dwarf Banana
Pandanus veitchii	Veitch Screw Pine
Pisonia umbellifera 'Variegata'	Bird Catcher Tree
Pleomele angustifolia honoriae	Narrow-Leaved Pleomele
Podocarpus macrophylla	Buddhist Pine
Podocarpus macrophylla maki	Japanese Yew Pine
Polyscias balfouriana	Balfour Aralia
Polyscias balfouriana marginata	Variegated Balfour Aralia
Polyscias fruticosa	Ming Aralia
Rhapis excelsa	Lady Palm
Strelitzia reginae	Bird of Paradise
Tupidanthus calyptratus	Tupidanthus
Yucca elephantipes	False Agave

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 ^{o}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 ^{o}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 then 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 CO_2 and O_2 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 crisp 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 strawberries.

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.