AG 510

BOTANY/PLANT

AND

SOIL SCIENCE

FOR

IDAHO

SECONDARY AGRICULTURE INSTRUCTORS

Developed and written by:
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Administered through the
Department of Agricultural and Extension Education
University of Idaho
By
Douglas A. Pals, Project Director

FOREWORD

The Agricultural Science and Technology Curriculum Guides are the product of many years of careful planning and development. In 1987, an Agricultural Education Technical Committee was assembled to determine the competencies necessary to prepare students for careers in agriculture. In 1989, a committee of secondary agriculture instructors, state supervisory staff and University of Idaho Agricultural and Extension Education faculty arranged the competencies into an outline of courses appropriate for secondary agriculture programs in Idaho. These curriculum guides have been written to provide the secondary agriculture instructor with up-to-date instructional materials to be used in developing lessons for the student interested in pursuing a career in agriculture.

The arrangement of the guide follows the courses outlined in the Agricultural Science and Technology Curriculum Outline - The Guide to the 90's (Vo. Ed. #240) published in 1989. The format used in this guide was adapted from the curriculum guides developed for Idaho secondary agriculture instructors during the period of 1981-1985.

The original Idaho Agricultural Curriculum Guides used in the development of these materials were:

1981 - Livestock Production
1981 - Agricultural Mechanics
1982 - Farm Business Management
1985 - Crop and Soil Science

Many individuals made the original guides possible. The format used was adapted from curriculum developed by the Curriculum and Instructional Materials Center of the Oklahoma State Department of Vocational and Technical Education. Selected information and many of the transparency masters used in the guides were provided by the Vocational Instructional Services, Texas A & M University. Additional information and transparency masters were provided by the Department of Agricultural Communications and Education, College of Agriculture, University of Illinois and the Agricultural Education Program, Department of Applied Behavioral Sciences, University of California, Davis.

Laboratory exercises incorporated into the units of instruction were used from the Holt, Rinehart and Winston, Inc. book, Modern Biology, Biology Investigations and the Scott, Foresman, and Company Lab Manual for Biology. Credit appears on the first page of the materials used from these two sources.

Without the following individuals' dedication and commitment, this project would not have been completed.

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USE OF THIS PUBLICATION

Introduction

This material must be taught. It does not replace the teacher, nor the teacher's expertise. The teacher needs to adapt the material to the local area and individual students. The teacher must also provide the necessary motivating techniques to help the students learn the material.

The pages in the guide are color coded to assist in identifying and locating the desired pages. The colors used are:

Table of Contents	Ivory
Semester Course Title Page	Green
Foreword	Yellow
Use of Publication	Salmon
Divider Page Between Units	Tan
Refer to Another Unit Page	Grey
Unit Objectives/Specific Competencies	White
Suggested Activities	Blue
Information Sheets	White
Transparency Masters	White
Assignment Sheets	White
Answers to Assignment Sheets	Gold
Instructors Notes for Laboratory Exercises	Blue
Laboratory Exercises	White
Answers to Laboratory Exercises	Gold
Unit Test	White
Answers to Test	Gold

Instructional Units

These units are not geared to a particular age level and must be adapted for the students with whom they are used. Units include objectives and competencies, suggested activities for the instructor and students, information sheet, transparency masters, assignment sheets, laboratory exercises, instructor notes for laboratory exercises, answers to assignment sheets and laboratory exercises, test and answers to test. Units are planned for more than one lesson or class period.

The teacher should carefully study each instructional unit to determine:

A. The appropriateness of the material for the age level

B. The amount of material that can be covered during a class period

C. Additional objectives and/or assignments, which could be developed

D. The skills that must be demonstrated

1. Supplies needed
2. Equipment needed
3. Amount of practice needed
4. Amount of class time needed for demonstrations

E. Supplementary materials, such as pamphlets, filmstrips and slides that must be ordered

F. Resource people who must be contacted

<u>Objectives and Competencies</u>

Each unit of instruction is based on stated objectives. These objectives state the goals of the unit, thus providing a sense of direction and accomplishment for the student.

The objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performances necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms that may have been used in this material:

Name	Identify	State a Rule	Apply a Rule
Label	Select	Calculate	
List in writing	Mark		
List orally	Point out		
Letter	Pick out		
Record	Choose		
Repeat	Locate		
Give	Match		

Describe	Order	Distinguish
Define	Arrange	Discriminate
Discuss in writing	Sequence	
Discuss orally	List in order	
Interpret	Classify	
Tell how	Divide	
Tell what	Isolate	
Explain	Sort	

Construct		Demonstrate	
Draw	Transcribe	Show your work	Replace
Make	Reduce	Show procedure	Turn on/off
Build	Increase	Perform an experiment	(Dis) assemble
Design	Figure	Perform the steps	(Dis) connect
Formulate	Conduct	Operate	
Reproduce	Compare	Remove	

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives, which will fit the material to the needs of the students and community. When a teacher adds objectives, he/she should remember to supply the needed information, assignment sheets and/or laboratory exercises and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of the instructor will vary according to the particular unit. However, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and laboratory exercises; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheet

The information sheet provides content essential for meeting the cognitive (knowledge) requirements of the unit. The teacher will find that the information sheet serves as an excellent guide for presenting the background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheet before the information is discussed in class. Students may take additional notes on the information sheet.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion. (NOTE: Stand away from the overhead projector when discussing transparency material. The noise of the projector may cause the teacher to speak too loudly.)

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Laboratory Exercises

Laboratory exercises are found in selected units. The laboratory exercises include both science and agricultural mechanics activities. The science laboratory exercises often have instructions to the instructor prior to the actual laboratory. Procedures outlined in the laboratory exercise for agricultural mechanics give direction to the skill being taught and allow both student and teacher to check student program toward the accomplishment of the skill.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and can help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teachers should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

Care of Materials

The cost of reproduction of this guide prohibits the replacement of these materials. Therefore, please be extremely careful in handling originals. Make the necessary copies of the information sheets, transparencies, assignments and tests and replace originals in the curriculum guide notebook. Take extra care in keeping originals clear for future reproduction.

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ELEMENTARY STUDY OF SOILS

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UNIT OBJECTIVE

After completion of this unit, students should be able to select from a list reasons that soils are important. Students should also be able to discuss soil formation, physical properties and label layers of a soil profile. This knowledge will be demonstrated by completion of assignments sheets, laboratory exercises and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with soils to the correct definitions.
2. Select reasons that soils are important.
3. Discuss the function of soil as related to plant growth, development and maintenance.
4. Label a drawing showing the composition of an average soil.
5. Select factors that affect soil formation.
6. Name the four physical properties of soil.
7. Identify soil particles according to size.
8. List two methods used to determine soil texture.
9. Identify six kinds of soil structure.
10. Match terms indicating soil depth to their correct descriptions.
11. Match colors of soil to their correct descriptions.
12. Label an illustration showing the layers of a soil profile.
13. Identify on a pH scale the areas of acidity and alkalinity.
14. Discuss the liming of soils to correct soil acidity.
15. Name three types of alkali soils.
16. Discuss reclamation of alkali soils.
17. Use a textural triangle.
18. Explain general laboratory procedures, equipment and report writing.
19. Demonstrate the use of a compound microscope.

20. Determine soil textural class by mechanical analysis.
21. Determine soil textural class by feel.
22. Study soil samples.
23. Study the origin and meaning of color in soil.

ELEMENTARY STUDY OF SOILS

AG 510 - A

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Conserving Soil*, 16-page pamphlet including spirit mastersand overhead transparencies; available from U.S. Department of Agriculture, Soil Conservation Service.

b. *Experiments in Soil Science*, 259 pages; available from VEP, Cal Poly State University, San Luis Obispo, California 93407; approximate cost $10.75; order no. 1-522-820.

c. *Idaho Soils Atlas*, 148 pages of Idaho soil series with color photos; available from University Press of Idaho, University of Idaho, Moscow, Idaho 83843.

d. *Implications of Acidification of Farmland in Northern Idaho,* available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $.35; order no. CIS 629.

e. *Liming Materials,* available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $.25; order no. CIS 787.

f. *The Relationship of Soil pH and Crop Yields in Northern Idaho,* available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $.35; order no. CIS 811.

g. *Salt- and Sodium-affected Soils*, available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $1.00; order no. EXT 703.

h. *Soil Characterization Laboratory Procedures Manual*, available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $10; order no. MS 122.

i. *Soil and Land Judging Handbook,* available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $.50; order no. MS 52.

j. Soils, instructional unit; available from Agri-Farm Publications, Inc., 1019 Market Street, Gowrie, Iowa 50543; approximate cost $19.50; order no. 211. Also available--soil class activity packet, approximate cost $8.25; order no. 1108; and soil guide, approximate cost $11.30; order no. 2106.

k. *University of Idaho Soils Handbook,* includes basic soils information and soils-related Current Information Series (CIS) publications published by the College of Agriculture; available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843; approximate cost $27.

2. Filmstrips, slideshows, etc.

a. Introduction to Soils, 27 slides and cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $36.40; order no. D14.

b. Soil and Its Properties, slides and script; available from Ohio Agricultural Education Curriculum Materials Service, Room 254, 2120 Fyffe Rd., Ohio State University, Columbus, Ohio 43210; approximate cost $16.75; order no. 50085.

c. Soil Color, 47-frame filmstrip; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801; approximate cost $7.05; order no. F708.

d. Soil Components, 34 slides and 22-minute cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $46.80; order no. D15.

e. Soil Moisture, 21 slides and 38-minute cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $41.60; order no. D18.

f. Soil Structure, 22 slides and 28-minute cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $41.60; order no. D17.

g. Soil Texture, 44 slides and 34-minute cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $83.20; order no. D16.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information and assignment sheets, and laboratory exercises.

E. Discuss information and assignment sheets.

F. Demonstrate and discuss procedures outlined in laboratory exercises.

G. Arrange for a field trip to land site for evaluation.

H. Review and give test.

I. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Why Soils Are Important
2. TM 2--Soil-Plant-Animal Cycle
3. TM 3--Composition of Average Soil
4. TM 4--Soil Origins
5. TM 5--Physical Breakdown of Rocks
6. TM 6--The Relative Sizes of Sand, Silt and Clay Particles
7. TM 7--Soil Texture
8. TM 8--Characteristics of the Various Soil Classes
9. TM 9--Permeability Related to Nutrient Capacity
10. TM 10--The Texture Triangle
11. TM 11--Soil Structure
12. TM 12--Hard Pans Effect on Soil Depth
13. TM 13--Soil Profile
14. TM 14--pH Scale
15. TM 15--pH Scale - Relative Strength
16. TM 16--pH Scale - Familiar Products
17. TM 17--pH Scale for Soil Reaction
18. TM 18--pH Requirements of Crops
19. TM 19--Soil pH Governs Nutrient Release...

20. TM 20--Low pH Limits Root Growth

21. TM 21--Ion Exchange of Soil Particles

E. Assignment sheet

1. AS 1--Using the Textural Triangle

F. Answers to assignment sheet

G. Instructor notes for laboratory exercises

H. Laboratory exercises

1. LE 1--General Laboratory Procedures, Equipment and Report Writing

2. LE 2--Using a Compound Microscope

3. LE 3--Determine Soil Textural Class by Mechanical Analysis

4. LE 4--Determine Soil Textural Class by Feel

5. LE 5--Studying Soil Samples

6. LE 6--The Origin and Meaning of Color in Soil

I. Answers to laboratory exercises

J. Test

K. Answers to test

III. Unit references

A. *Agronomy Curriculum Workshop*, Iowa State University, Department of Agricultural Education, Ames, Iowa, 1980.

B. Cooper, Elmer L., *Agriscience Fundamentals and Applications,* Delmar Publishers, Inc., Albany, New York 12212, 1990.

C. *Crops, Soils, and Fertilizers Resource Manual,* Vo-Ed No. 73, University of Idaho, Department of Agricultural Education, Moscow, Idaho, 1978.

D. Donahue, Roy L., Follett, Roy H., Tulloch, Rodney W., *Our Soils and Their Management*, 5th edition, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1983.

E. Hartmann, Hudson T., et al., Plant Science: *Growth, Development and Utilization of Cultivated Plants,* 2nd edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

F. Knuti, Williams and Hide, *Profitable Soil Management*, 4th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

G. Loreen, C.O., Our Soils: *Their Management and Conservation*, Northwest Vocational Curriculum Management Center, Olympia, Washington, 1975.

H. *Oklahoma Curriculum Guides,* Oklahoma State University and the Oklahoma State Board for Vocational Education, Stillwater, Oklahoma.

I. *Resource Unit on Soils for Core Curriculum*, Montana State University, Agricultural and Industrial Education, Bozeman, Montana, 1975.

J. *Resource Unit on Soils for Core Curriculum*, No. 10, University of Arizona, Department of Agricultural Education, Tucson, Arizona, 1970.

K. *Soils Handbook*, University of Idaho College of Agriculture, Moscow, Idaho 83843, 1988.

L. *Soils Unit for the Plant Science Core Curriculum*, Vol. 9, No. 7, University of Missouri - Columbia, Instructional Materials Laboratory, Columbia, Missouri.

M. *Texas Curriculum Guides,* Vocational Instruction Services, Texas State Board for Vocational Education.

N. *Western Fertilizer Handbook,* 6th edition, California Fertilizer Association, Interstate Printers and Publishers, Danville, Illinois, 1980.

ELEMENTARY STUDY OF SOILS

AG 510 - A

INFORMATION SHEET

I. Terms and definitions

A. Soil--The mineral and organic matter that supports plant growth on the earth's surface; it is a mixture of particles of rock, organic materials, living organisms, air and water

B. Mineral matter--General term for the inorganic elements in the soil, for example: nitrogen, phosphorus, potassium

C. Organic matter--General term for plant and animal material in or on the soil in all stages of decomposition

D. Parent material--The rock and other unconsolidated material from which the soil has developed

E. Soil texture--A name given a textural group based on the relative proportions of the various soil separates (sand, silt and clay)

F. Soil structure--The combination or arrangement of soil particles into aggregates

G. Aggregate--Mass or cluster of soil particles such as a clod, crumb or granule

H. Soil depth--Total thickness of a soil from the topsoil to the parent material

I. Soil color--Indication of the amount of organic matter and moisture of the soil

J. Soil profile--A vertical cross-section of the soil from the surface through all its horizons

K. Soil horizon--A layer of soil approximately parallel to the land surface, differing from other layers in color, structure, texture, pH, etc.

L. Topsoil--The "A" horizon of the soil profile; dark colored upper layer of soil that may vary from several inches to 2 or more feet thick

M. Subsoil--The "B" horizon of the soil profile; the layer of soil directly beneath the topsoil

N. Acid soil--Soil with a pH of less than 7.0; for practical purposes, a soil with a pH of less than 6.6

O. Alkaline soil--Soil having a pH value of greater than 7.0; for practical purposes, a soil having a pH above 7.3

P. Leaching--Removal of water soluble soil components from the soil by the downward action of water

Q. Reclamation--Restoration to a better or useful state, as of wasteland, desert, alkali, etc.

R. Cation--An ion that has lost an electron and has a positive (+) charge, for example: potassium, calcium and magnesium

(Note: Cations are positively (+) charged and attracted to negative (-) sites on clays and organic matter.)

S. Anion--An ion that has gained an electron and has a negative (-) charge, for example: nitrogen, phosphorus and sulphur

(Note: Anions are negatively (-) charged and attracted to positive (+) sites.)

T. Exchange capacity--The ability of a soil to absorb ions to the surface of the soil particle

(Note: Cation exchange capacity is most important in agricultural soils. Anion exchange is very low and confined to low pH soils.)

II. Importance of soils (Transparencies 1, 2)

A. Plants grow in and on soil

B. Plants support animal life

C. Plants and animals support human life

D. World population is rapidly increasing and/or has inadequate nutrition

E. Supply of productive soil is limited

F. Improved soil management could feed more people

III. Function of soil as related to plant growth, development and maintenance

A. Media for seed germination

B. Media for support of plants

C. Storehouse of plant nutrients

D. Storehouse of water for the plant

IV. Soil composition (Transparency 3)

A. Solids--Approximately 50%

1. Mineral matter

2. Organic matter

3. Living organisms

B. Pore space--Approximately 50%

1. Water

2. Air

V. Factors affecting soil formation (Transparencies 4, 5)

A. Parent materials (Transparency 4)

1. Residual

a. Igneous--Derived from molten materials in the center of the earth's crust (granitic, basaltic)

b. Metamorphic--Formed from the pre-existing rocks through the action of extreme heat and pressures (quartzite, schist)

c. Sedimentary--Formed from sediments deposited by wind, water or ice (shale, sandstone, limestone)

2. Transported

a. Wind (loess)

b. Water (alluvial)

c. Glaciers (glacial drift)

d. Gravity (colluvial)

B. Decomposition by weathering

1. Physical weathering (Transparency 5)

a. Wind

b. Plants and animals

c. Heating and cooling

d. Freezing and thawing

e. Wetting and drying

2. Chemical weathering--Chemical reactions of water, oxygen and carbon dioxide

3. Biological weathering--Micro-organisms secrete a gummy substance which aids in decomposing rocks

C. Climate

1. Temperature

2. Rainfall

D. Vegetation and organisms

1. Plant--Lichens, mosses, weeds, grasses, shrubs, trees

2. Animal--Bacteria, fungi, large animals (cattle, horses, etc.) birds, man

E. Slope and drainage

1. Hillsides

a. Thin topsoil due to soil loss by erosion

b. Reduced plant growth

c. Low organic matter

d. Less leaching (due to runoff)

2. Flat lands

a. Deeper topsoil

b. More vegetation

c. High organic matter

d. Greater leaching

VI. Physical properties of soil

A. Soil texture

B. Soil structure

C. Soil depth

D. Soil color

VII. Soil particles (Transparencies 6, 7, 8, 9)

A. Sand

1. Diameter--2.00 to 0.05 mm

2. Coarse and gritty

3. When moist, individual grains can be seen

4. Its presence decreases water-holding capacity

5. Its presence decreases nutrient holding capacity

B. Silt

1. Diameter--.05 to .002 mm

2. Its presence increases water-holding capacity

3. Its presence increases nutrient holding capacity

4. Moderate to high exchange capacity

5. Feels smooth and velvety

C. Clay

1. Diameter--less than .002 mm

2. Its presence increases water-holding capacity

3. Its presence increases nutrient holding capacity

4. High to very high exchange capacity

VIII. Methods used to determine soil texture

A. Mechanical analysis (Transparency 10)

1. A mechanical analysis of a soil reports the percentage of each of the soil particles (sand, silt and clay)

2. Percentages can be applied to the texture triangle to determine the texture of a soil

B. Feel method

1. Texture is determined by moistening the soil and rubbing between thumb and fingers

a. The wet sample is worked into a ball and placed between thumb and index finger; the thumb is pushed gradually forward in an attempt to form the soil into a ribbon (clayey soil)

b. If the wet sample will not form a ribbon, evaluate for grittiness (sandy soil)

c. Evaluate wet sample to determine if it feels velvety and slick, but will not ribbon (silty soil)

2. Descriptions of soils of different texture using the feel method (Laboratory Exercise #4)

   a. Sandy soil

      (1) Coarse and gritty

      (2) When moist, individual grains can be seen

      (3) Called a "light" soil

   b. Silty soil

      (1) Feels smooth, flowing when dry

      (2) Feels velvety or slick when wet

   c. Clayey soil

      (1) Sticky and will form a ribbon when wet

      (2) Very hard when dry

      (3) Called a "heavy" soil

IX. Types of soil structure (Transparency 11)

A. Granular (sphere shaped)--Ideal for plant growth

B. Blocky (sharp and angular faces)

   1. Water storage good

   2. Circulation of air and water is poor

C. Platy (flat, horizontal, plate-like)--Poor permeability

D. Prismatic and columnar (column-like)--Poor air-water relationship

E. Single grain

F. Massive

X. Soil depth (Transparency 12)

A. Depth refers to the total thickness of a soil from the topsoil to the parent material

B. Common measurements are

1. Very deep--over 60" deep

2. Deep--40" to 60" deep

3. Moderately deep--20" to 40" deep

4. Shallow--10" to 20" deep

5. Very shallow--less than 10" deep

(Note: The productive ability of land largely depends upon its depth of soil. Deep soils are necessary to provide the needed water and nutrients for favorable plant production. Shallow soils have a limited capacity for plant nutrients, water and root development.)

XI. Soil color

A. Color is an important characteristic used in the identification of soil conditions that affect the value of land for agricultural uses

B. Influenced mainly by organic matter content; benefits of organic matter include

1. Makes soil porous

2. Supplies nitrogen and other nutrients to the plant

3. Holds water in the soil

4. Reduces leaching

5. Improves soil structure

C. Soil colors

1. Dark brown to black--Regarded as the most productive; usually contains a higher organic matter content

2. Red or reddish brown--Usually less fertile than black or dark brown soils; may contain a high iron content

3. Yellow or gray--Usually caused by imperfect drainage

XII. Soil profile (Transparency 13)

A. Components of the soil profile

1. The "A" horizon

2. The "B" horizon

3. The "C" horizon

B. Characteristics of the soil horizons

1. The "A" horizon

a. It includes the upper part of the profile in which life is most active; generally called the topsoil

b. It is the most productive horizon because of its normally high organic matter content and is usually dark colored

c. May be from a few inches to a foot or more deep

d. Lighter in texture than the "B" or "C" horizons

e. More likely to have granular structure than the other horizons

2. The "B" horizon

a. Generally called the subsoil

b. Usually lower in organic matter and lighter in color than "A" horizon

c. Usually red or yellowish in color

d. Structure is less desirable than the "A" horizon; it may have a blocky or prismatic structure

e. Frequently heavier texture than "A" horizon

3. The "C" horizon

a. Generally called parent material

b. It is the deepest of the three major horizons

c. Usually very low in organic matter

d. Usually no structure

XIII. Acidity or alkalinity (Transparencies 14, 15, 16, 17, 18, 19, 20, 21)

A. The acidity or alkalinity of the soil solution is determined by the relative number of hydrogen (H^+) ions and hydroxyl (OH^-) ions

B. When a soil solution contains more H^+ ions than OH^- ions, it is acidic. When the OH^- ions are more abundant, the solution is alkaline. A neutral solution has an equal amount of H^+ and OH^- ions

C. The acidity or alkalinity is expressed in pH values

D. pH ranges on a scale from 1 to 14

1. 1 to 7--Acidic soil

2. 7--Neutral soil

3. 7 to 14--Alkaline soil

(Note: Acidity or alkalinity exert a great influence on the availability of plant nutrients. Plants grow best in pH range 6.0 to 7.5. Poor plant growth is the usual result at pH less than 5.2 or greater than 8.3.)

XIV. Liming soils

A. Soil acidity can be corrected by adding lime to the soil. The function of lime is to neutralize the hydrogen (H^+) ions that cause soil acidity

B. Amount of lime to apply depends on

1. The degree of acidity of the soil

2. The crops to be grown

3. The grade or purity of the lime materials

4. The frequency of application

5. Soil texture

6. Soil exchange capacity

XV. Types of alkali soils

A. Saline--Soils in which there has been an accumulation of soluble salts, for example: NaCl (table salt); these are referred to as "white alkali" soils

B. Sodic--Soils in which there has been an accumulation of sodium (Na); sodium affected soils have low permeability to water

(Note: Sodium can solubilize organic matter in the soil. In some instances this happens and the solubilized organic matter is carried to the surface. When dry, this leaves a dark crust on surface of soil. This is called "black alkali" soil.)

C. Saline-sodic--Both salty and sodic affected

(Note: The presence of either salt or sodium greatly affects the potential of a soil for crop production purposes. Their presence affects the water and nutrient uptake by the plant.)

XVI. Reclamation of alkali soils

A. Saline

1. Flood with water and leach out salts

2. Install drainage tiles to remove accumulated salts

3. Grow salt tolerant crops

B. Sodic

1. Apply gypsum ($CaSO_4$)

2. Grow sodic tolerant crops

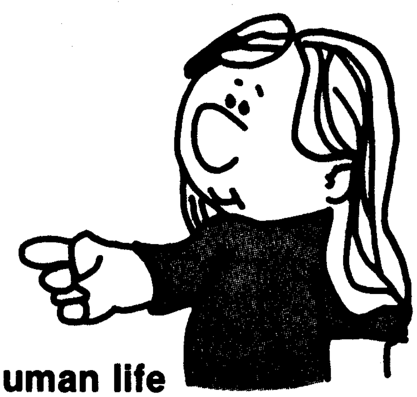
C. Saline-sodic

1. First correct sodic

(Note: This should be done first because of the poor permeability effect of sodium on the soil. This makes leaching of the salts difficult.)

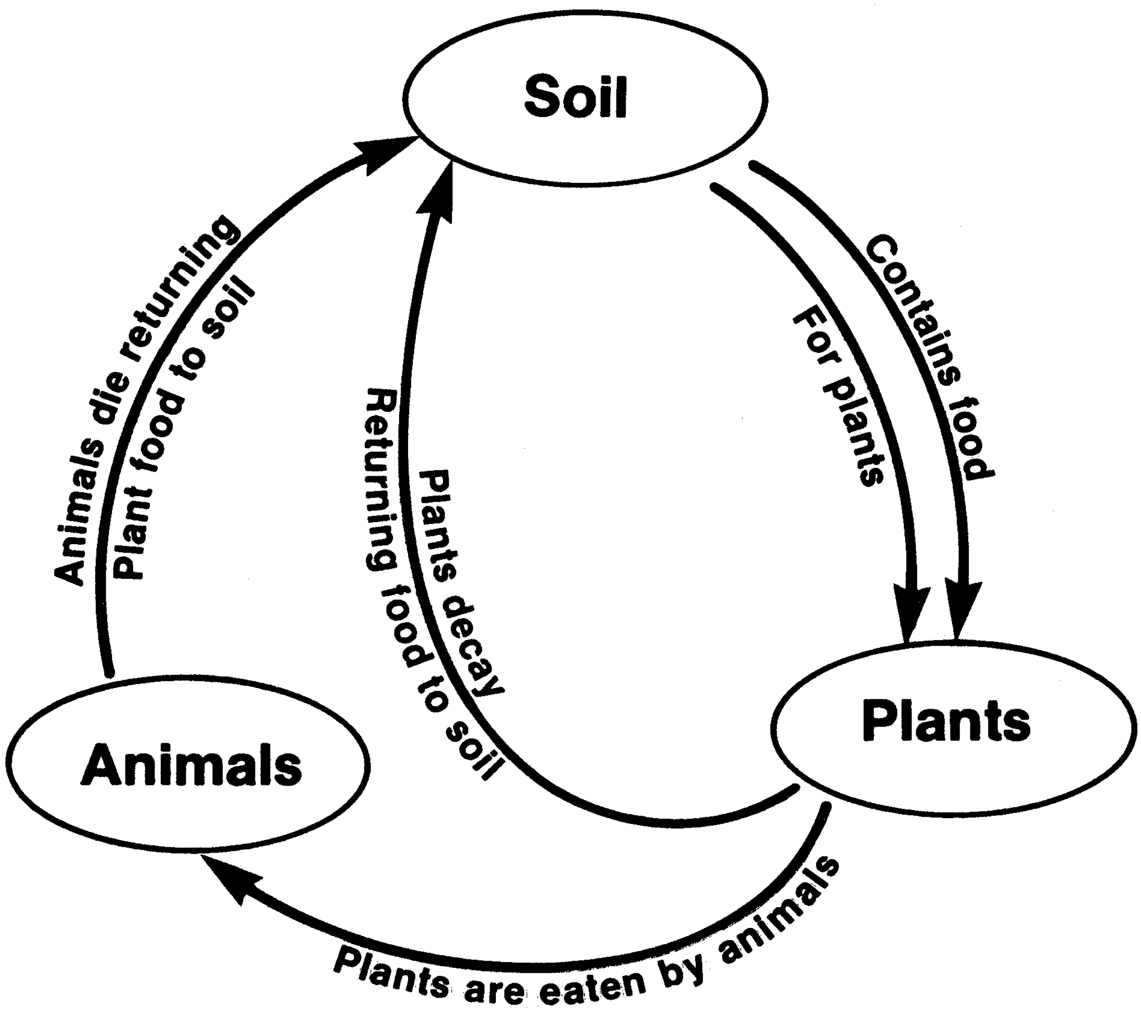
2. Then correct salt problem

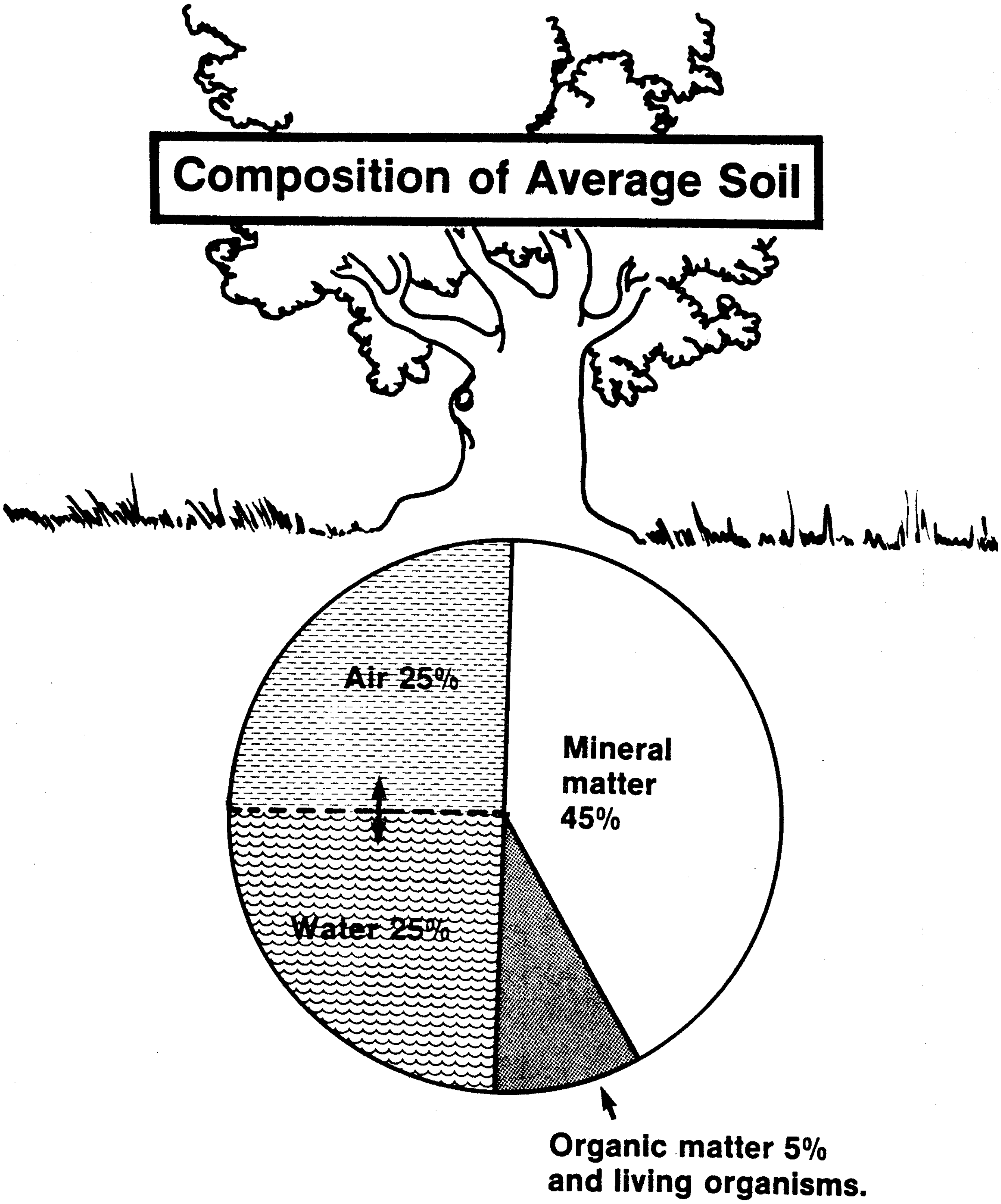
Why Soils Are Important

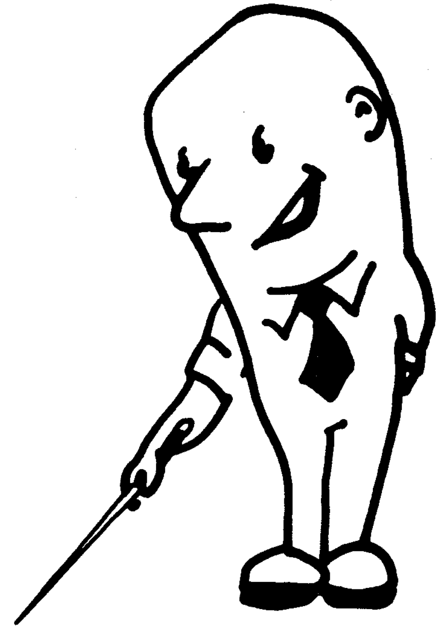


1. Plants grow in and on soil
2. Plants support animal life
3. Plants and animals support human life
4. World population is rapidly increasing and/or has inadequate nutrition
5. Supply of productive soil is limited
6. Improved soil management could feed more people

Soil-Plant-Animal-Cycle




Composition of Average Soil
Air 25%
Mineral matter 45%
Water 25%
Organic matter 5% and living organisms.



Soil Origins

1. Residual

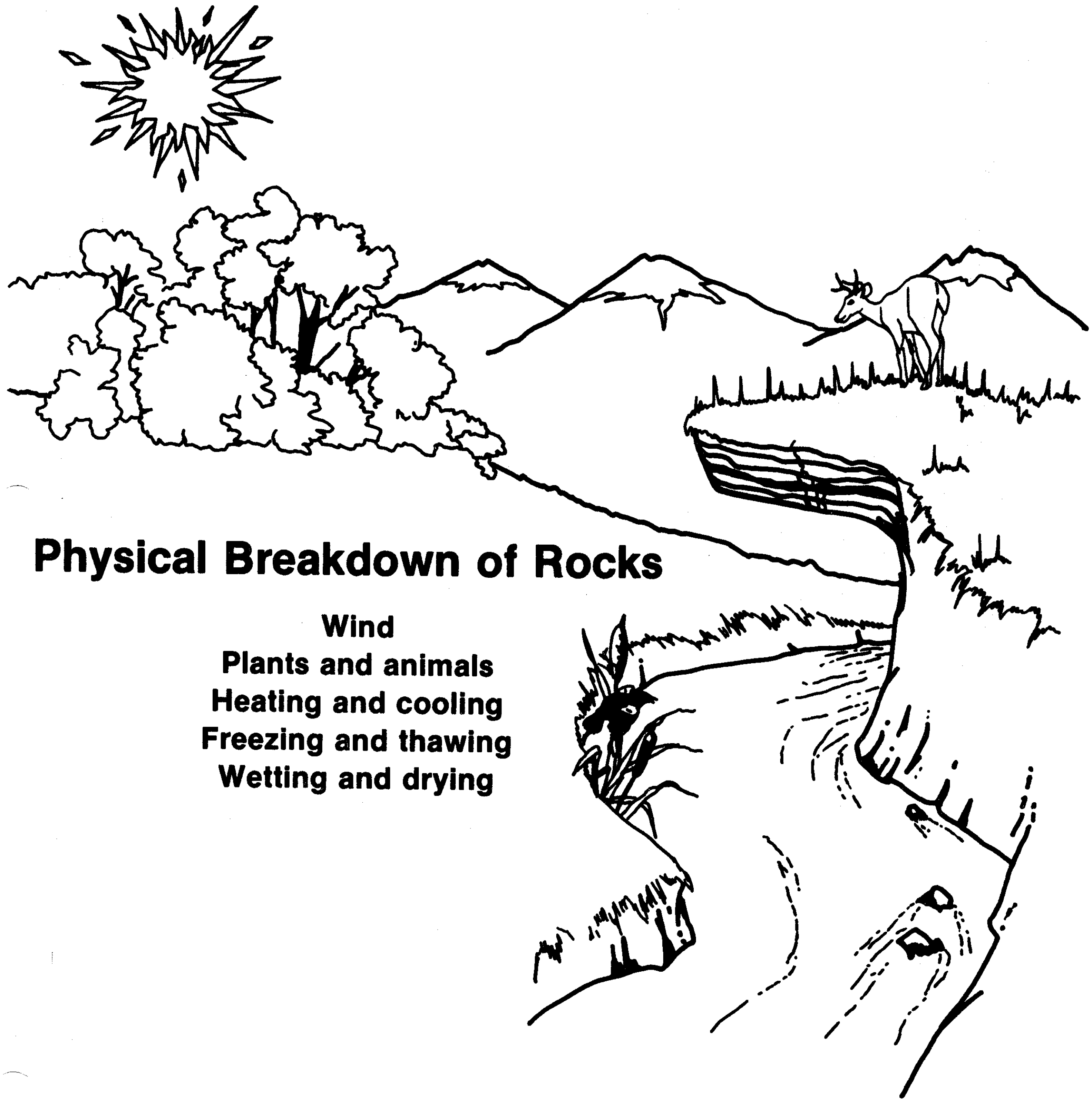
a. Igneous
b. Sedimentary
c. Metamorphic

} From rock

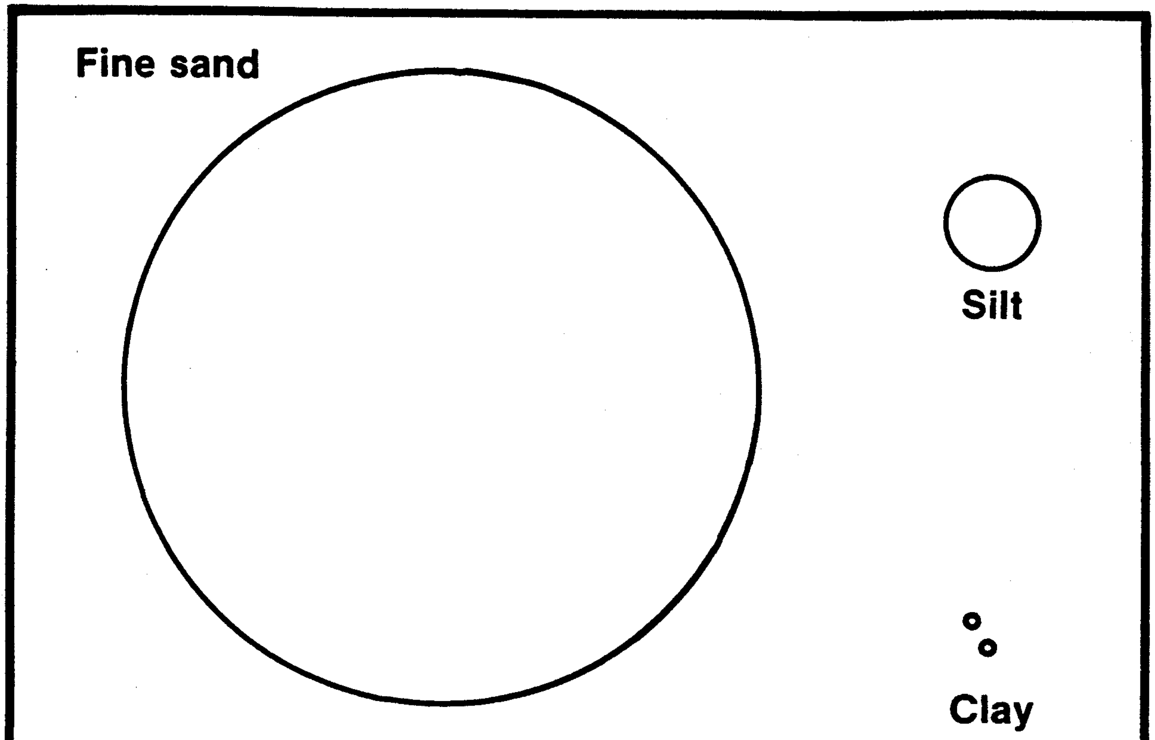
d. Organic - peat (from plant life)

2. Transported

a. Wind (loess)
b. Water (alluvial)
c. Ice (glacial till)

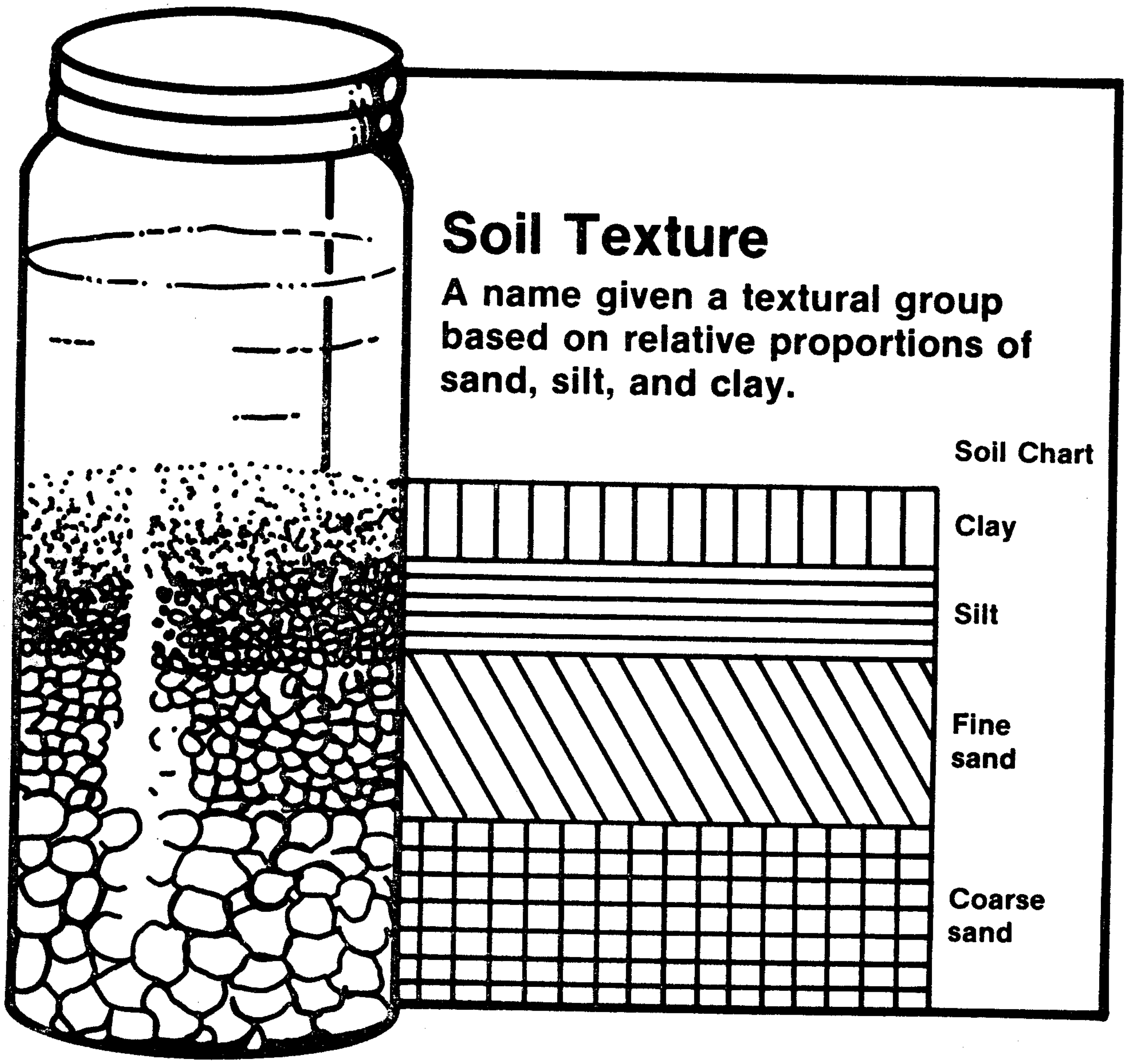

Physical Breakdown of Rocks
Wind
Plants and animals
Heating and cooling
Freezing and thawing
Wetting and drying

The Relative Sizes of Sand, Silt, and Clay Particles



Size of soil particles

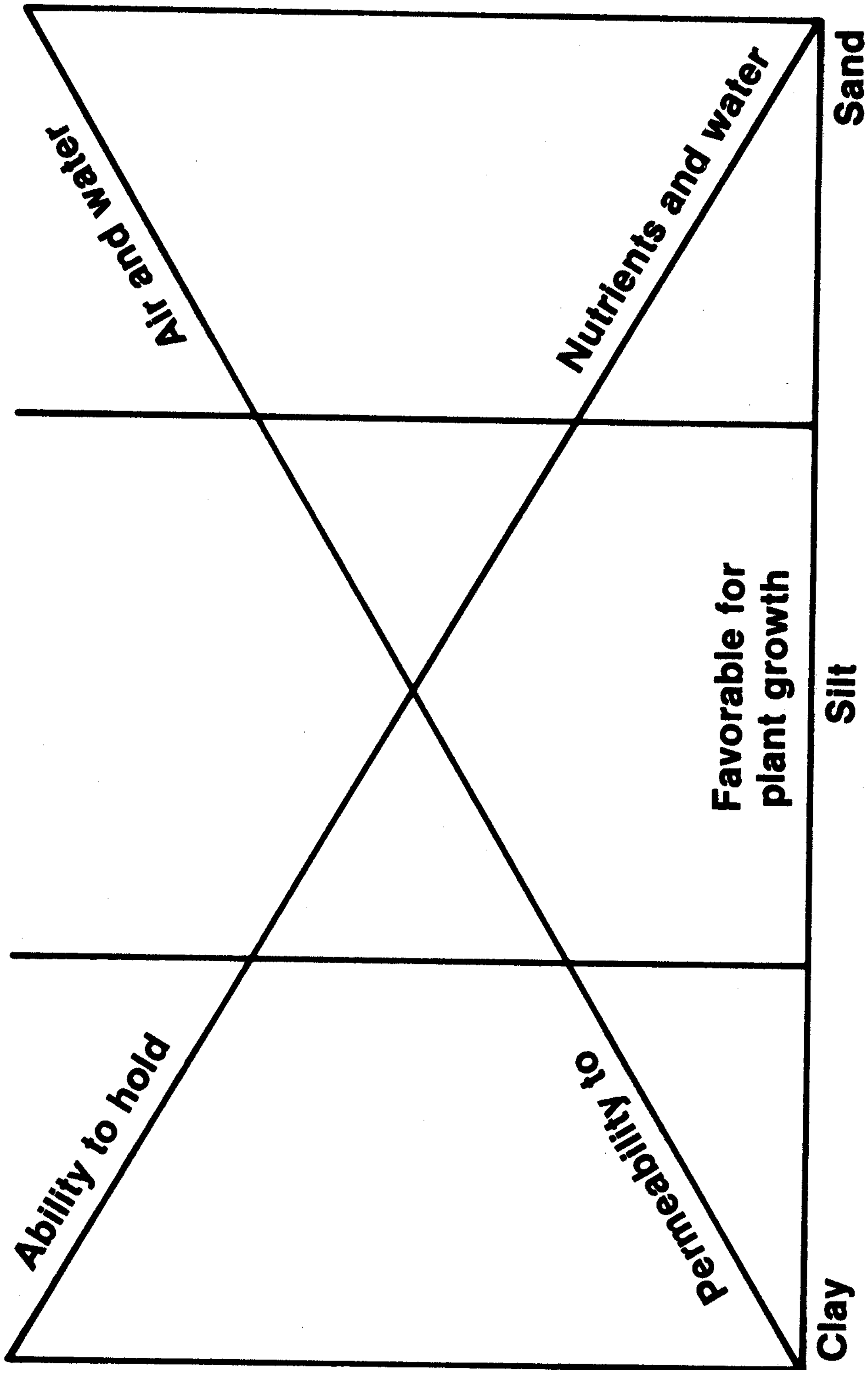
Name	Size, diameter in millimeters
Fine gravel	2 - 1
Coarse sand	1.00 - 0.50
Medium sand	0.50 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	Less than 0.002


Soil Texture
A name given a textural group based on relative proportions of sand, silt, and clay.
Soil Chart
Clay
Silt
Fine sand
Coarse sand

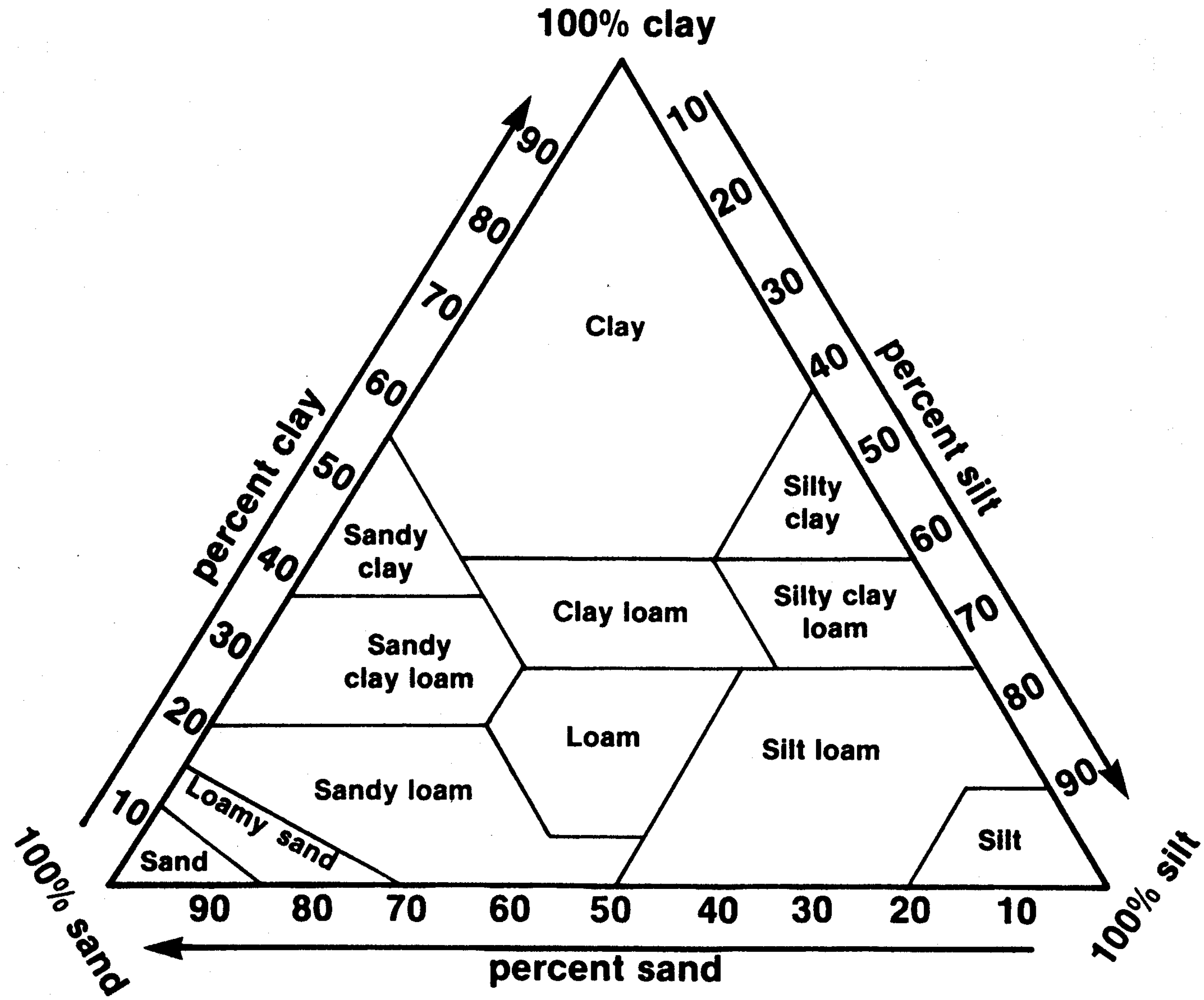
Characteristics of the Various Soil Classes

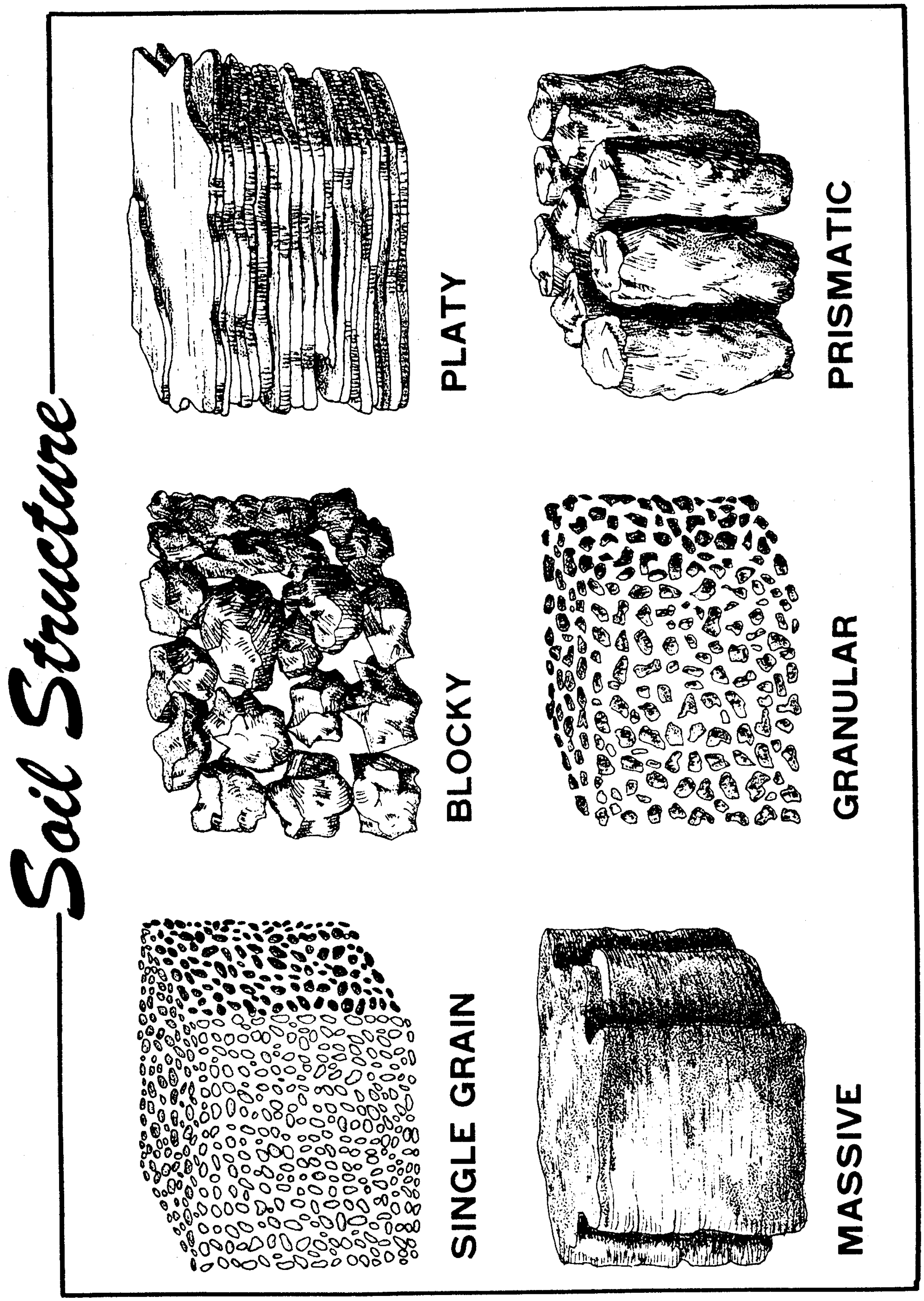
Characteristics	Sand	Silt	Clay
Looseness	Good	Fair	Poor
Air space	Good	Fair to Good	Poor
Drainage	Good	Fair to Good	Poor
Tendency to form clods	Poor	Fair	Good
Ease of working	Good	Fair to Good	Poor
Moisture holding capacity	Poor	Fair to Good	Good
Fertility	Poor	Fair to Good	Fair to Good

Permeability Related to Nutrient Capacity

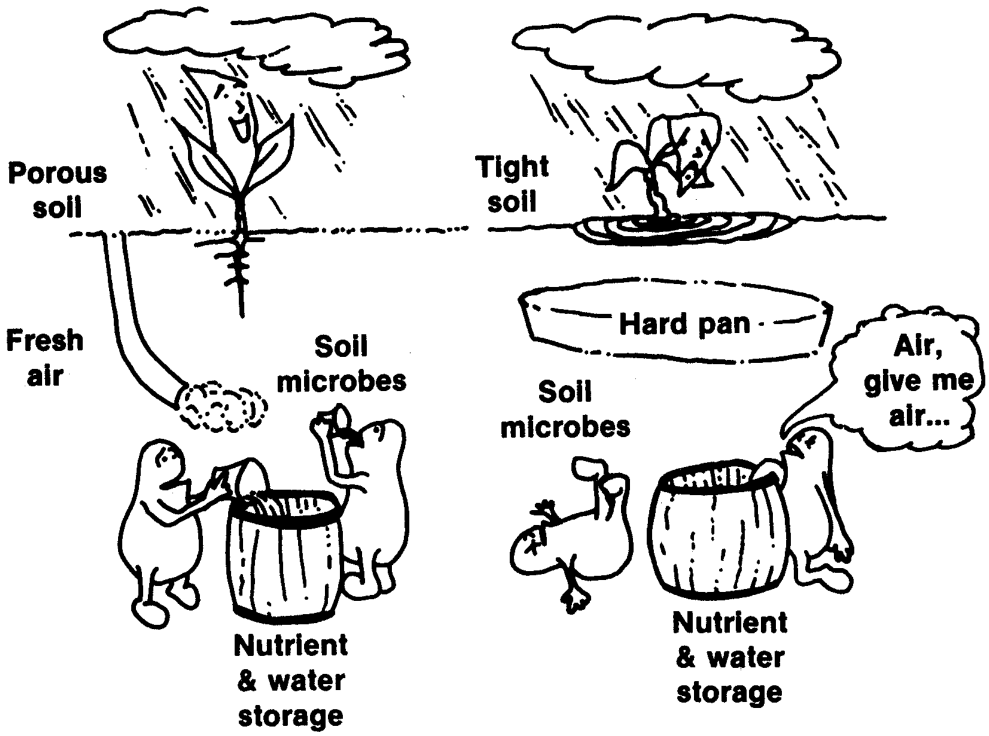


The Texture Triangle




Soil Structure
PLATY
PRISMATIC
BLOCKY
GRANULAR
SINGLE GRAIN
MASSIVE

Hard Pans Effect On Soil Depth



A hardened layer of soil is called a hard pan. A hard pan can prevent water, air and nutrients from moving through the soil, and will limit root growth to that part of the soil profile above the restrictive layer.

Soil Profile

01 Undecomposed organic matter

02 Decomposed organic matter

A Horizon

Accumulated decomposed organic matter and mineral materials - usually dark in color

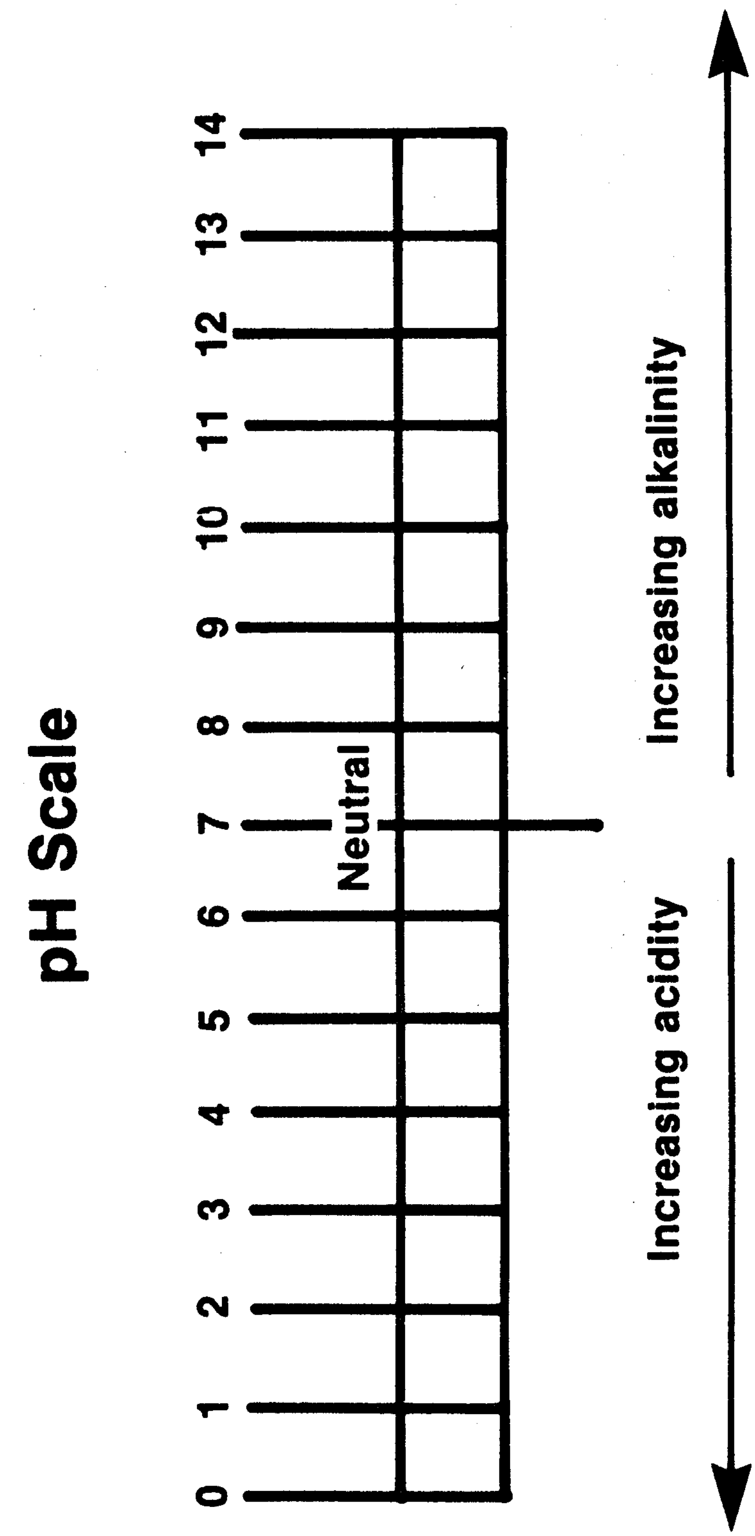
B Horizon

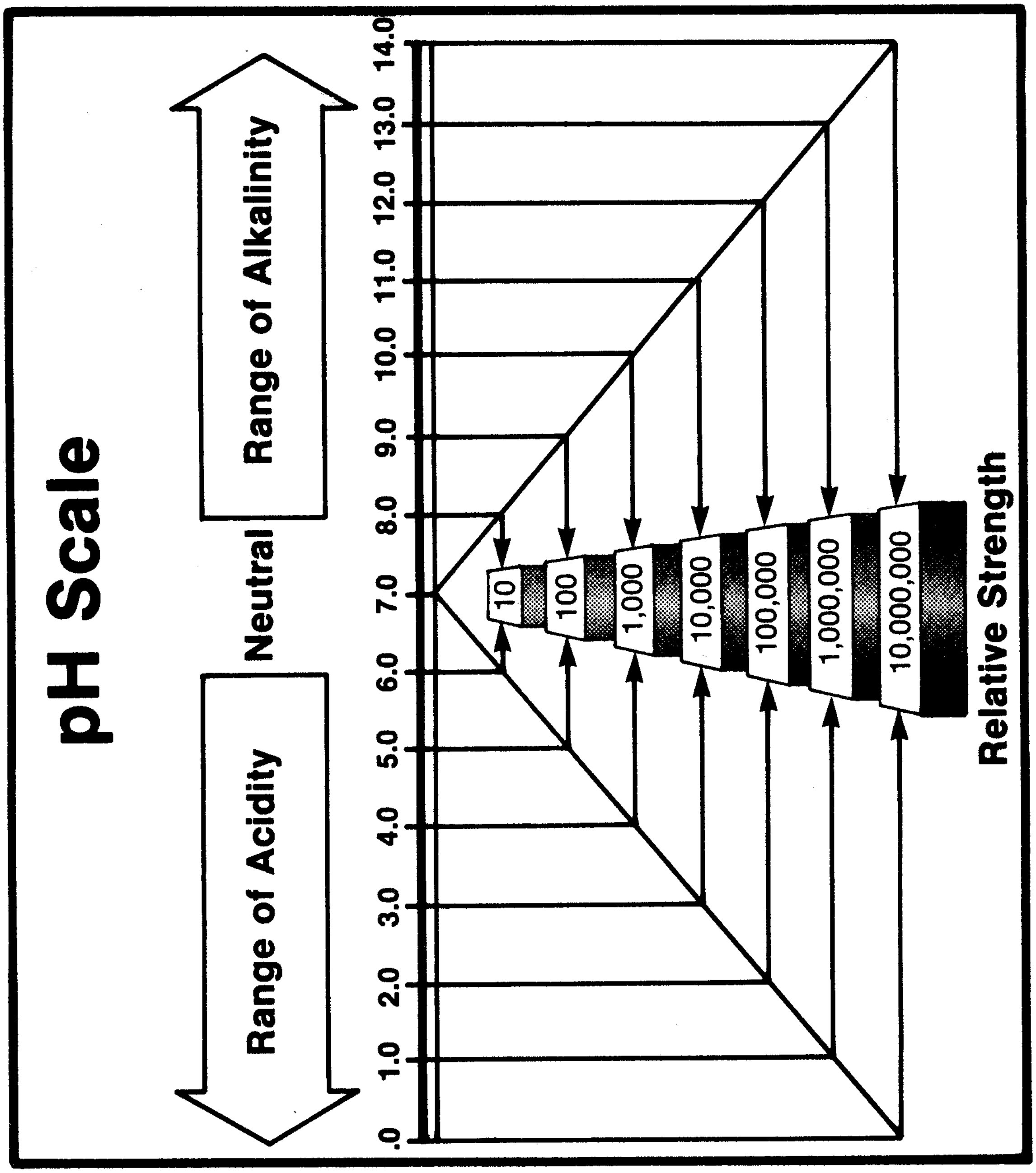
Mineral materials which accumulate organic matter, clay, iron, aluminum, etc. from layer above

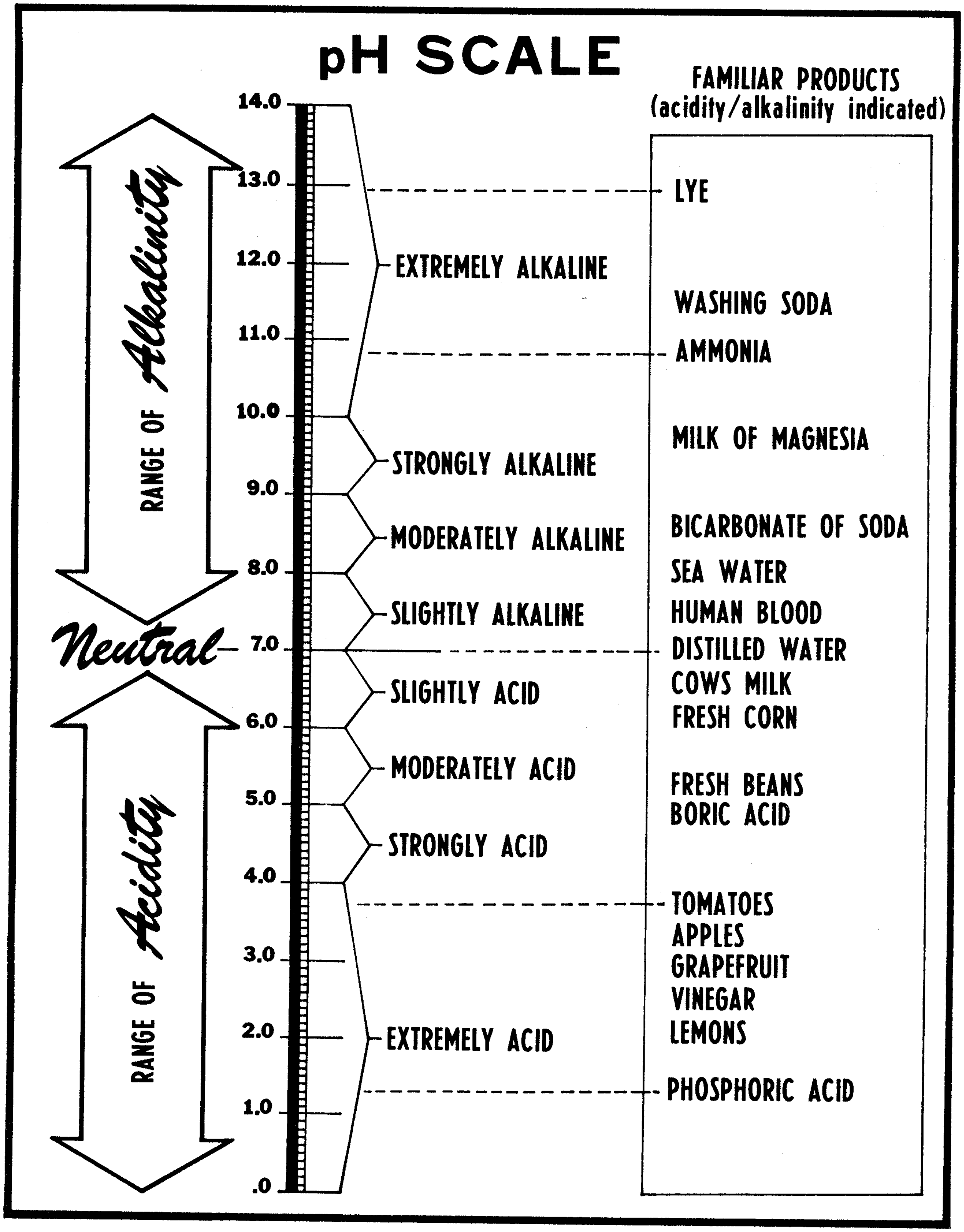
C Horizon

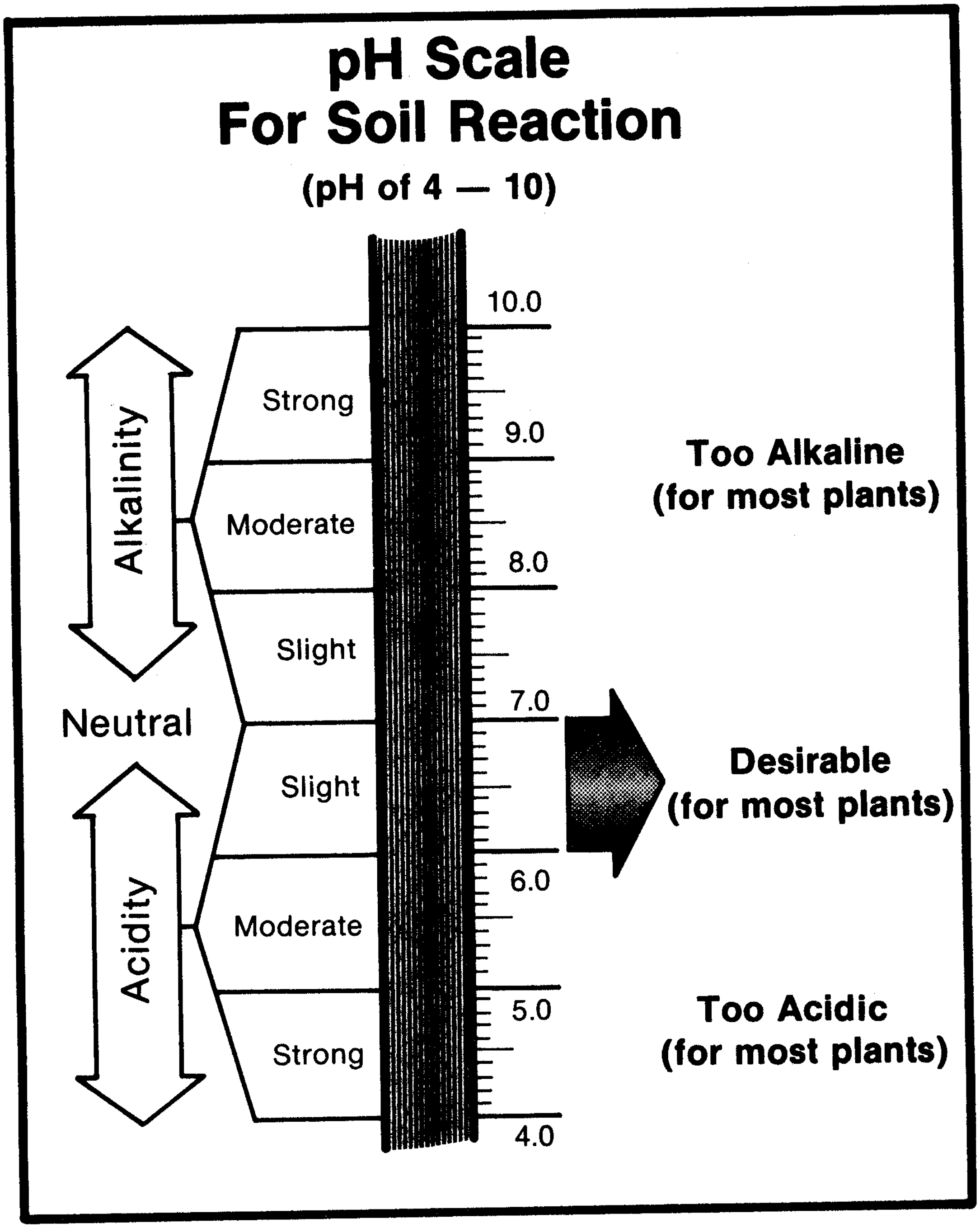
Mineral material of weathered rock or other unconsolidated material

TM 13

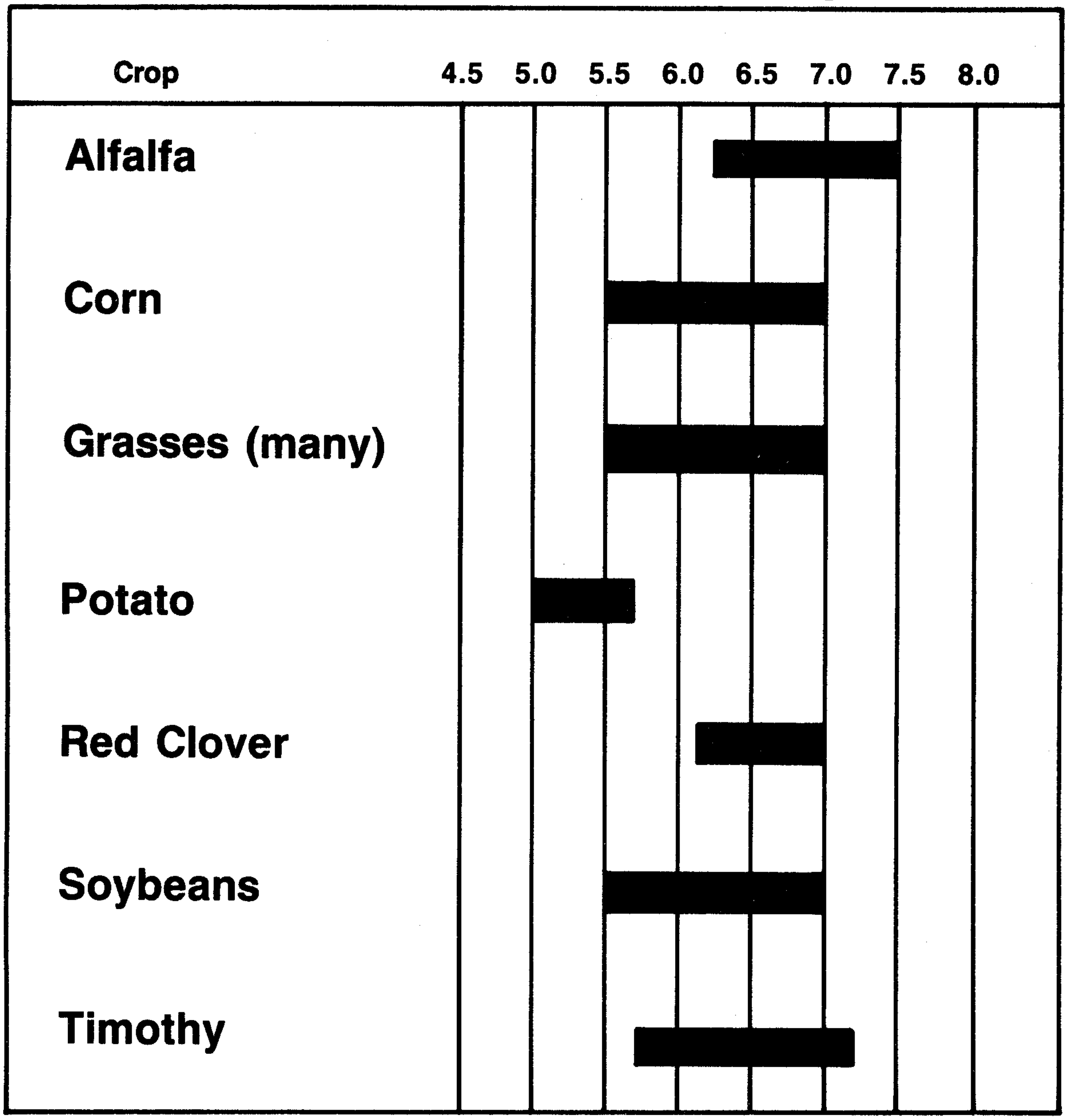

pH Scale
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Neutral
Increasing acidity
Increasing alkalinity


pH Scale
Range of Acidity
Neutral
Range of Alkalinity
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
10
100
1,000
10,000
100,000
1,000,000
10,000,000
Relative Strength

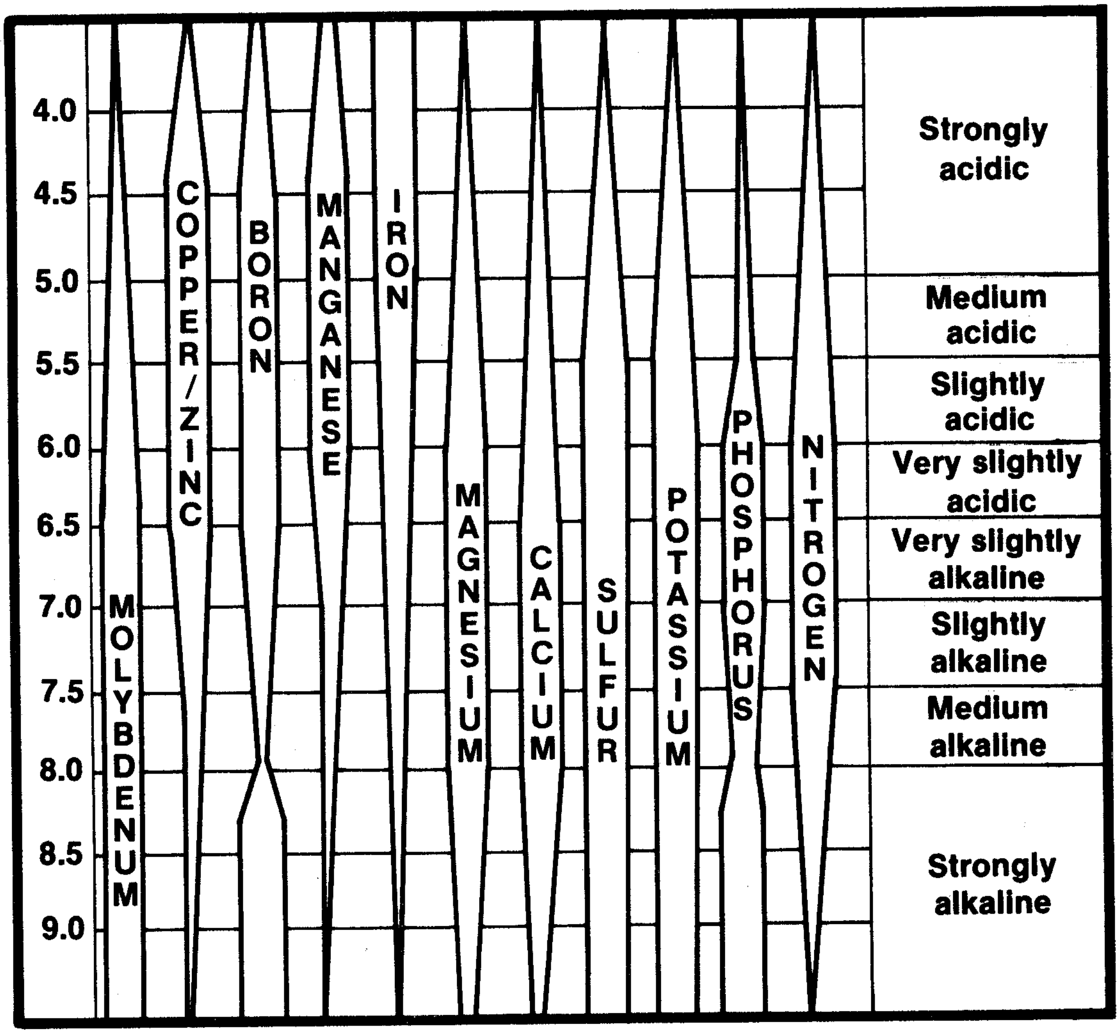

pH SCALE
FAMILIAR PRODUCTS
(acidity/alkalinity indicated)
RANGE OF Alkalinity
Neutral
RANGE OF Acidity
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
.0
EXTREMELY ALKALINE
STRONGLY ALKALINE
MODERATELY ALKALINE
SLIGHTLY ALKALINE
SLIGHTLY ACID
MODERATELY ACID
STRONGLY ACID
EXTREMELY ACID
LYE
WASHING SODA
AMMONIA
MILK OF MAGNESIA
BICARBONATE OF SODA
SEA WATER
HUMAN BLOOD
DISTILLED WATER
COWS MILK
FRESH CORN
FRESH BEANS
BORIC ACID
TOMATOES
APPLES
GRAPEFRUIT
VINEGAR
LEMONS
PHOSPHORIC ACID


pH Scale
For Soil Reaction
(pH of 4 — 10)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
Alkalinity
Strong
Moderate
Slight
Neutral
Slight
Moderate
Strong
Acidity
Too Alkaline
(for most plants)
Desirable
(for most plants)
Too Acidic
(for most plants)

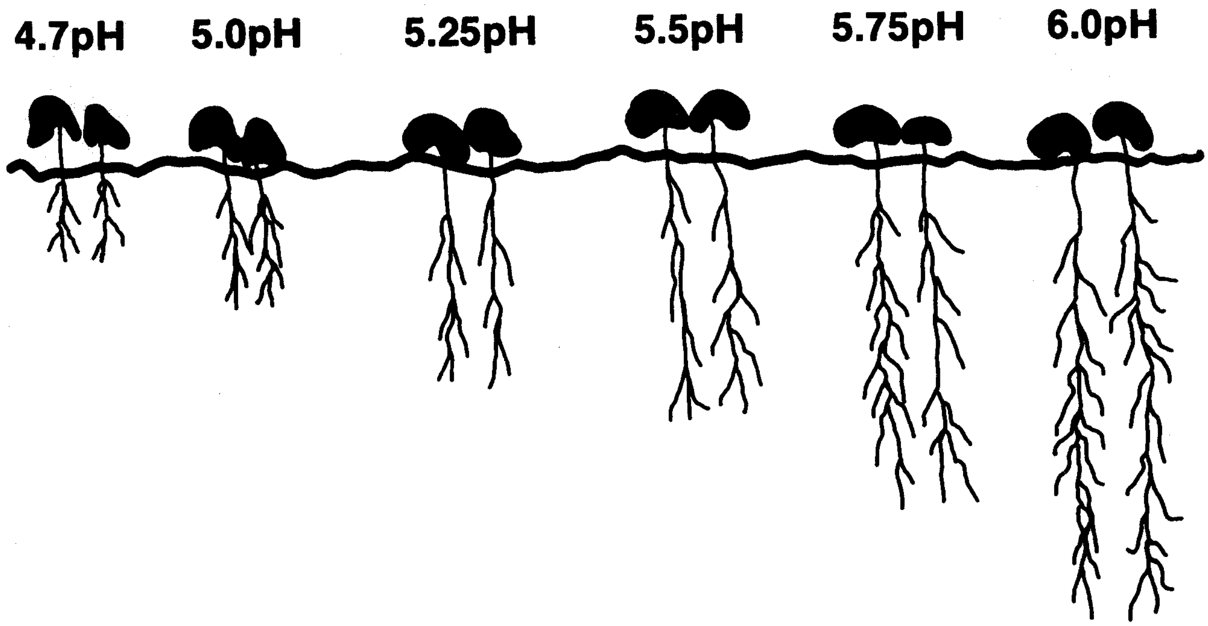
pH Requirements of Crops



Soil pH Governs Nutrient Release
Acidity or alkalinity (pH) controls relative nutrient availability.



Low pH Limits Root Growth



Ion Exchange of Soil Particles

Figures 1:

Mineral nutrients held on the surface of a soil particle are absorbed

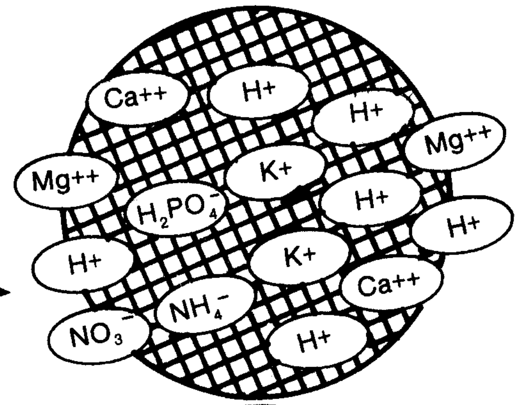


Figure 2:

A soil particle with mostly hydrogen ions tests ACID

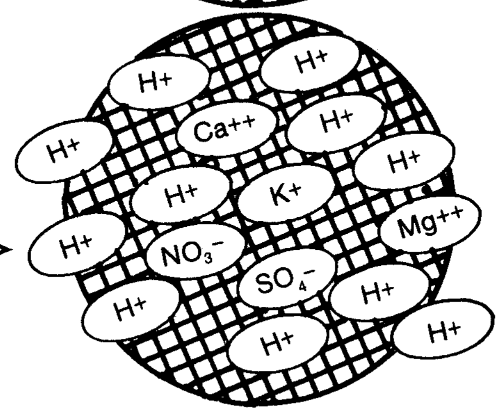
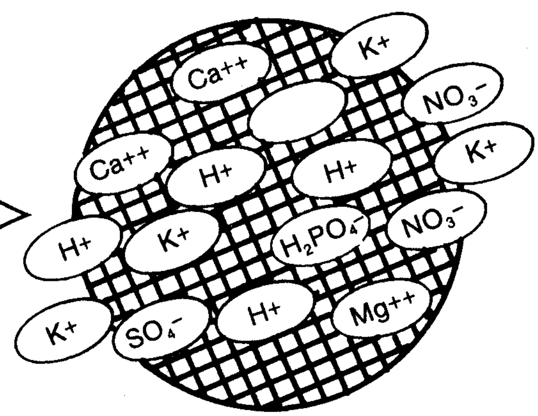


Figure 3:

A soil particle with mostly basic ions tests ALKALINE



ELEMENTARY STUDY OF SOILS

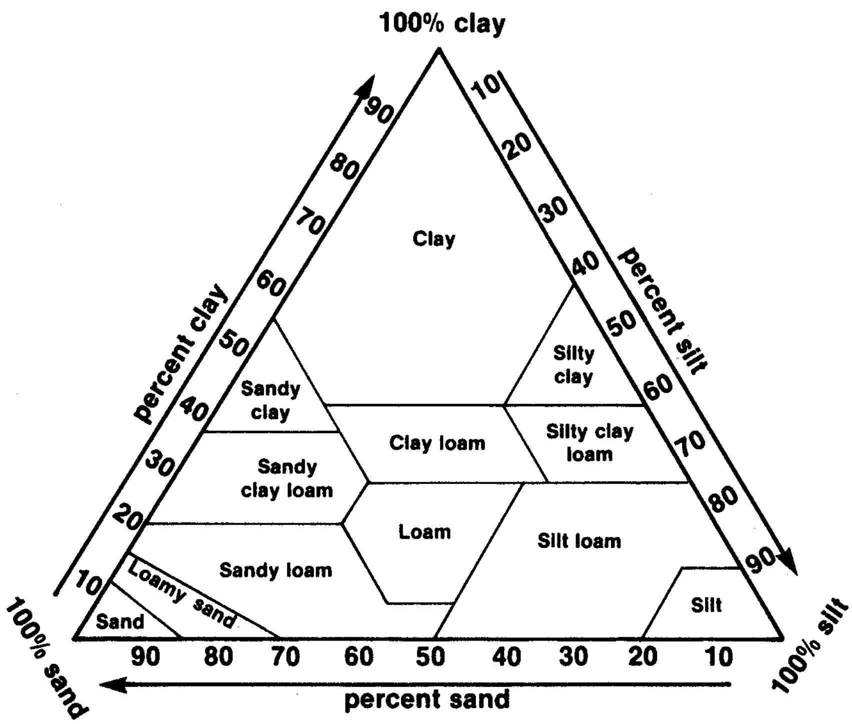
AG 510 - A

ASSIGNMENT SHEET #1--USING THE TEXTURAL TRIANGLE

Name______________________________________score_________________________________

Part I

The textural triangle (Figure 1) can be used to determine the textural class of a soil sample. The percentage of sand, silt and clay can be calculated by mechanical analysis.



To use the triangle, locate the percent sand along the bottom of the triangle. From this point move upward and to the left. The percent sand is the same along this line. Next locate the percent clay on the left side of the triangle and move horizontally to the right. The textural class is located where the clay and sand percents meet. This textural class can be checked by locating the silt percentage on the right side of the triangle and moving downward to the left. All points should intersect. If all lines intersect on a division line between classes, move towards the finer textured soil.

Part II

A. How much sand must a soil contain before it is called a

1.	Sandy clay loam	________	3.	Sand	_______
2.	Loamy sand	________	4.	Sandy clay	_______

B. How much clay must a soil contain before it is called a

1. Clay ________ 3. Sandy clay loam _______

2. Clay loam ________ 4. Sandy clay _______

C. Given the relative amounts of sand, clay and silt, find the textural classes of the following:

1. 20% sand
   20% clay ____________________________
   60% silt

2. 55% sand
   40% clay ____________________________
   5% silt

3. 30% sand
   40% clay ____________________________
   30% silt

4. 20% sand
   70% clay ____________________________
   10% silt

5. 85% sand
   10% clay ____________________________
   5% silt

ELEMENTARY STUDY OF SOILS

AG 510 - A

ANSWERS TO ASSIGNMENT SHEET

1. **Part I**--Evaluated to satisfaction of instructor.

2. **Part II**

A. 1. 45% 2. 70% 3. 85% 4. 45%

B. 1. 40% 2. 27% 3. 20% 4. 35%

C.
1. Silt loam
2. Sandy clay
3. Clay
4. Clay
5. Loamy sand

ELEMENTARY STUDY OF SOILS

AG 510 - A

INSTRUCTOR NOTES FOR LABORATORY EXERCISES

Lab #2

Allow approximately 80 minutes for activity
Have students read *Anatomy of the Microscope* before class, and then make the changes that are necessary to fit the microscopes being used.

Part IV:

Demonstrate the procedure for high power focusing.

Remind students that fine adjustments should be approximately 1/4 of a turn.

Looking at the letter "a" under low power, image will be upside down.

Under high power, you cannot view the entire "a", only a small portion can be seen. It appears very rough and coarse.

Lab #3

Procedure A can be completed in one laboratory period. Procedure B can be completed in a second laboratory period.

Allow approximately 80 minutes for completion of this laboratory.

Recommended Student Grouping: Groups of Four

Students will need several minutes each day for about two weeks to make continuing observations of the soil samples.

A dark loam and a light sandy soil are good samples to compare for this laboratory.

If possible allow students to collect soil samples. Provide each student with a trowel and a plastic bag to collect samples.

Part I:

To observe proportion of soil particles of different types, half fill a jar with soil. Then, fill the remaining portion of the jar with water. Cover the jar with its lid and shake the jar vigorously for several minutes until the large particles break apart. Let the mixture stand overnight. The soil will separate into layers of floating organic matter, water, settled organic matter, clay, silt, fine sand, coarse sand and gravel.

You will need to dry soil samples in an oven at low heat for several hours before students can measure moisture-holding capacity of the soil.

To find the mass of the water in the saturated soil, students should subtract the mass of the dried soil and the mass of the wet cloth from the mass of the saturated soil in the cloth.

Part II:

You may wish to set up two Baermann funnels for each soil sample before the class period to increase time spent on observations. Have each student examine nematodes found in both cultures.

You may need to add extra water to the funnel if the soil is highly absorbant.

You can preserve the nematodes by adding several ml of isopropyl alcohol to the nematodes in the beaker.

Minerals and other nutrients in pasteurized spring water are necessary for the culturing of fungi.

Part III:

The action of decomposers causes carbon dioxide to be released into the soil. Carbon dioxide forms a mild acid when it dissolves in water in the soil. Ask students to answer these questions based on the pH of their two soil samples. Which soil sample should have the larger population of decomposers? Explain. Is your explanation confirmed by other tests performed in this laboratory? Explain.

ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #1--GENERAL LABORATORY PROCEDURES, EQUIPMENT AND REPORT WRITING

Name____ Score________________________________

Part I: General Laboratory Procedures

The following is a list of general laboratory procedures. You will be required to write at least ten of these on a quiz.

1. Never "horse around" in the laboratory.

2. Never play with laboratory equipment or materials.

3. Always follow instructions and wait until you are told to begin before starting any investigation.

4. Never carry out unassigned experiments.

5. Never eat or taste anything in the laboratory. This includes food, drinks and gum, as well as chemicals found in the laboratory.

6. Wash your hands after *every* experiment.

7. Keep all books and other nonessential items away from the work area.

8. Keep your work area clean. Dispose of waste materials in appropriate containers.

9. Turn off any gas jets or any electrically operated equipment when you have completed the laboratory investigation.

10. Report all injuries or accidents to your teacher immediately.

11. Never use broken or cracked glassware.

12. Always wear shoes in the laboratory. Sandals are not suggested.

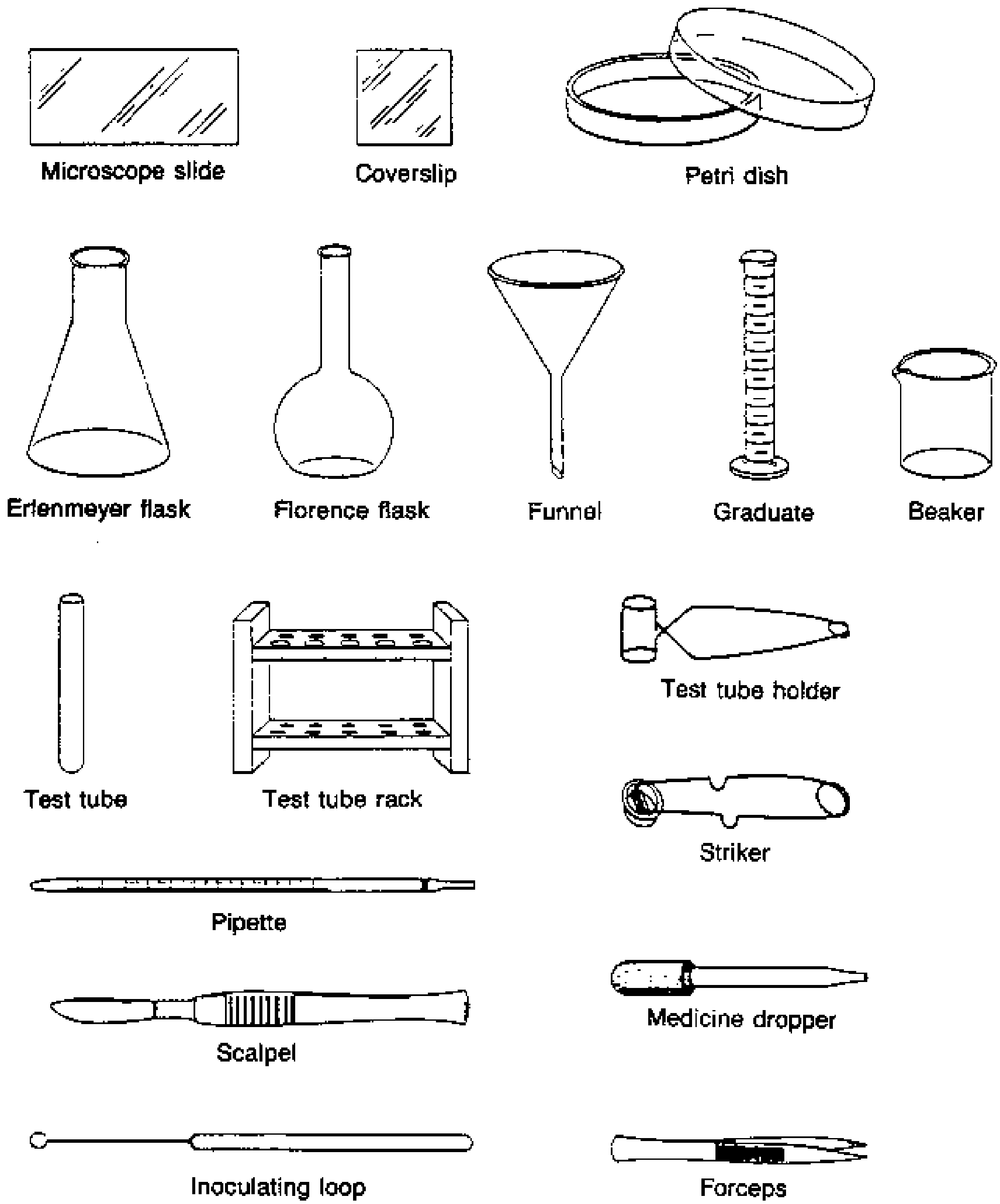
13. Tie back long hair and restrict any loose clothing.

14. Wear safety goggles, laboratory aprons and gloves when instructed to do so.

Part II: Laboratory Equipment

Various types of laboratory equipment are identified and illustrated on the following page. Ask your teacher to show you examples of each. You will be required to identify all the illustrations on a quiz.

Laboratory Equipment



<u>Part III: How to Write a Laboratory Report</u>

The following information explains how to write laboratory reports. You will be asked to outline and explain these procedures on a quiz.

There are two different types of laboratory reports that you may be asked to write. The first is a report of a laboratory investigation in which the results and your interpretation of the results are the most important items required by your teacher. This type of investigation is usually found in a laboratory manual, where the procedure is already outlined for you. Such reports would contain the following parts.

Title This is the name of the laboratory investigation you are doing. In an investigation from a laboratory manual, the title will be the same as the title of the investigation.

Hypothesis The hypothesis is what you think will happen during the investigation. It is often posed as an "If...then" statement. For example: If sulfuric acid is added to sugar, then the sugar will be broken down into its chemical components.

Materials This is a list of all the equipment and other supplies you will need to complete the investigation. In investigations taken from a laboratory manual, the materials are generally listed for you.

Procedure The procedure is a step-by-step explanation of exactly what you did in the investigation. Investigations from laboratory manuals will have the procedure carefully written out for you, all you need to do is to read it very carefully. Often, in laboratory manuals, there will be questions in the procedure section that will help you understand what is happening in the investigation.

Data Your data is what you have observed. It is often recorded in the form of tables, graphs and drawings.

Analyses and Conclusions This is the most important and difficult part of the investigation. It explains what you have learned. You should include everything you have learned; you should explain any errors you made in the investigation; and you should evaluate your hypothesis. Keep in mind that not all hypotheses will be correct. That is normal. You just need to explain why things did not work out the way you thought they would. In laboratory manual investigations, there will be questions to guide you in analyzing your data. You should use these questions as a basis for your conclusions.

In some cases, you might be required to do an independent project. You may design your own investigation for a science fair project, or your teacher may have you design an investigation to perform in class.

The report for this type of investigation should include two sections not included in the previous type of report. In order for a laboratory report on an independently designed experiment to be complete, you must now include an introduction and a reference section. They should be included in your report in the following order:

Title

Introduction The introduction should include a clear, simple statement of your purpose. In addition, the introduction should include a discussion of the important ideas that led you to design and perform the experiment. For example, you could include such things as why you are doing this investigation, what is interesting about the topic to be investigated, and what information you have already gathered about the topic. In order to prepare a good introduction, you will need to do library research on the topic. Be sure to use proper citation methods when you use ideas from any reference source.

Hypothesis

Materials

Procedure

Data

Analyses and Conclusions

References List all the reference materials used to originate and to complete the project. Be sure to use complete citations, including author, title, date of publication and place of publication. Your teacher will give you the format preferred for the type of investigation you are doing.

Remember that a good laboratory report takes time. Do not wait until the night before the report is due to begin work on it.

Part IV: Quiz

1. List ten general laboratory procedures.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

   f. ____________________

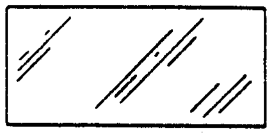
   g. ____________________

   h. ____________________

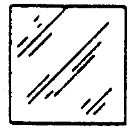
   i. ____________________

   j. ____________________

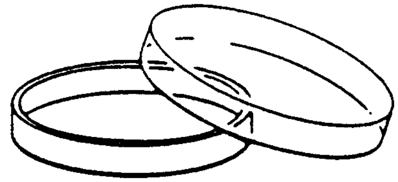
2. Identify the following types of laboratory equipment.



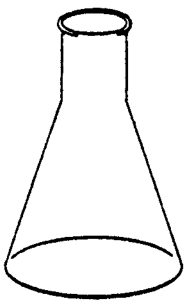
a. ____________



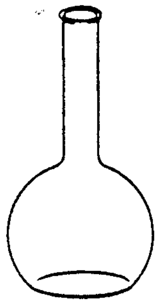
b. ____________



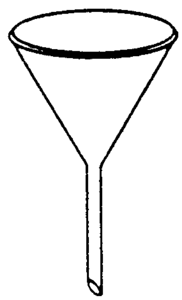
c. ____________



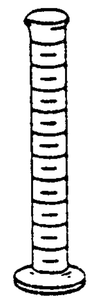
d. ____________



e. ____________

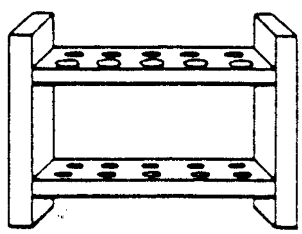


f. ____________



g. ____________

h. ____________

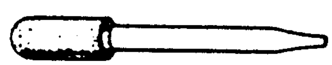


i. ____________

j. ____________

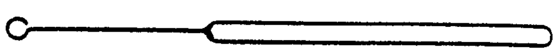
l. ____________

k. ____________



n. ____________

m. ____________



o. ____________

p. ____

3. Outline and explain the procedures used in writing the two different types of laboratory reports.

ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #2--USING A COMPOUND MICROSCOPE

Name___________________________________ Score___________________________________

Materials needed

Compound microscope	Scissors
Lens paper	Droppers
Microscope slides and coverslips	Thread of two different colors
Newspaper	

Part I: Procedure--Anatomy of a Microscope

1. When removing a microscope from the cabinet, always hold one hand under the *base* and firmly grasp the *arm* with the other hand. Hold the microscope upright and treat it like the precision instrument it is. Place the microscope on your desk with the arm away from you so that you can observe the parts more easily.

   Using the diagram below, identify the parts of the microscope starting at the top. As you read about each of the parts, memorize its name and function.

2. At the top of the microscope is the first lens that is called the *eyepiece*. Most compound microscopes have numbers, such as 5, 10, or 15 written near the eyepiece. The numbers refer to the total magnification of the lens. The symbol "X" means times or magnification power. For example, if you are looking at a piece of wool using only a 10X eyepiece, it would be seen ten times larger than its natural size.

3. The *body tube*, which extends below the eyepiece, helps in focusing the lenses properly.

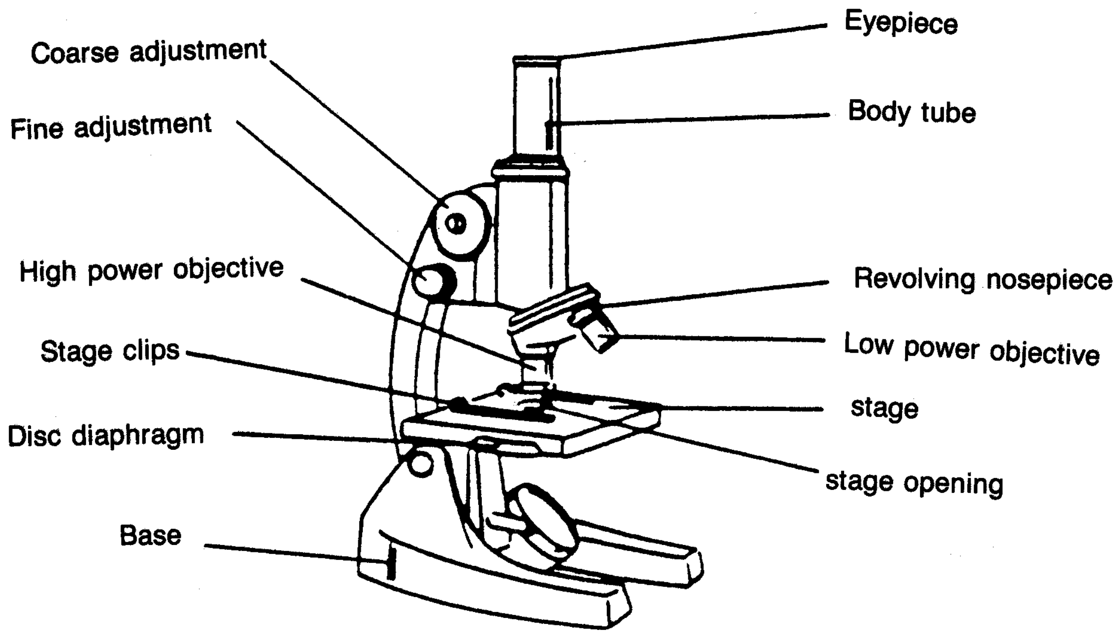
4. The body tube ends in a part known as the *revolving nosepiece*, under which are lenses called *objectives*. By turning the nosepiece, the objectives will turn and click into place. The objectives are *low power* or *high power* lenses. Low power usually consists of 5X or 10X, while high power consists of 43X to 100X magnification power.

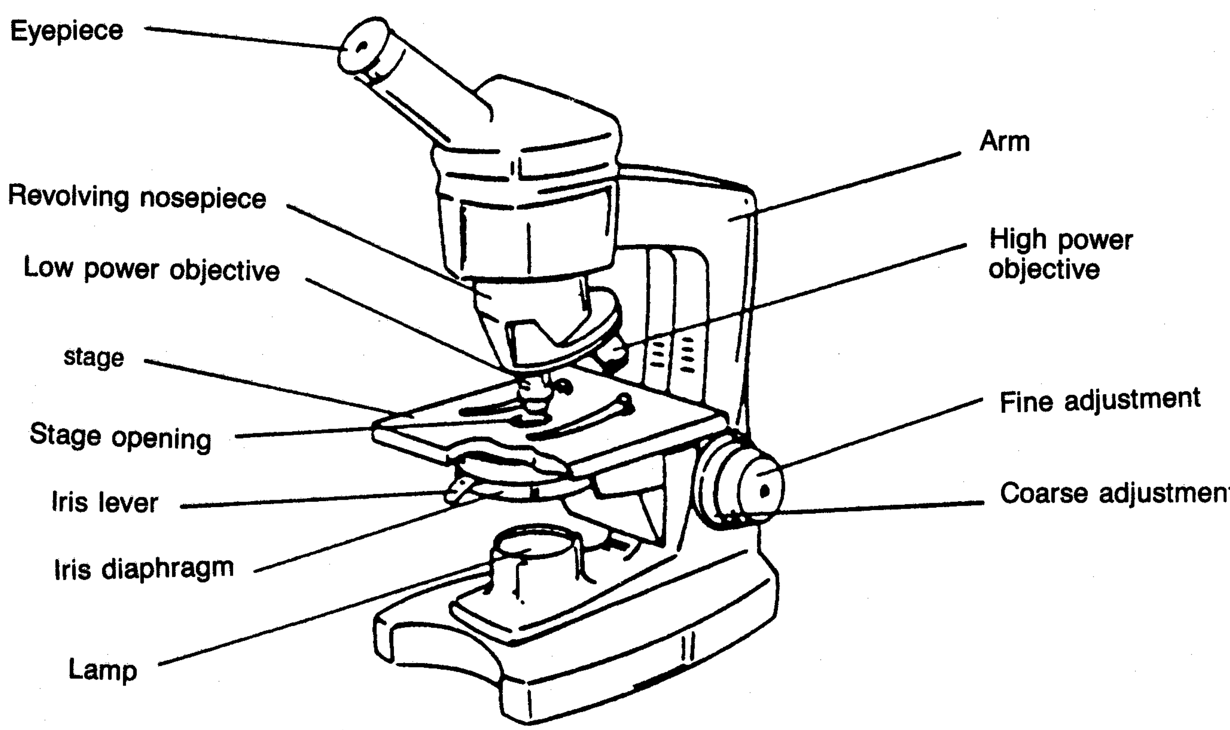
   Extreme care must be exercised when using these lenses; they must not hit the microscope slide when lowering the body tube. The objectives should be cleaned only with lens paper so that dirt and dust will not scratch them.

5. When a microscope has a double set of lenses (eyepiece and objective), it is called a *compound microscope*.

   If you multiply the number on the eyepiece by the number on the objective, the total magnification of the microscope will be known. For example, if the magnification of the eyepiece is 5X, and the magnification of the objective is 10X, then by multiplying, you get a total magnification of 50X.

6. The objectives overlook a flat platform called the *stage*. The stage has an opening in its center that allows light to enter the microscope. A slide is placed on this stage and kept from moving by the use of *stage clips*.


Eyepiece
Coarse adjustment
Body tube
Fine adjustment
High power objective
Revolving nosepiece
Stage clips
Low power objective
stage
Disc diaphragm
stage opening
Base


Eyepiece
Arm
Revolving nosepiece
Low power objective
High power objective
stage
Fine adjustment
Stage opening
Iris lever
Coarse adjustment
Iris diaphragm
Lamp

7. Underneath the stage is a *diaphragm*. The diaphragm regulates the amount of light entering the microscope. The diaphragm is adjustable for the type of lighting conditions used.

   On a microscope with an *iris diaphragm*, a lever controls the size of the opening through which light passes. A microscope with a *disc diaphragm* is operated by rotating a disc containing various sized openings. *Important: Adjusting the diaphragm is as important as correctly focusing a microscope.*

8. Your microscope may have a *lamp* or a *mirror* for a light source. If the microscope is equipped with a mirror, it can be turned toward the source of light so that the rays are diverted upwards through the body tube. *Caution*: Never use direct sunlight as a source of light; it can damage your eyes.

9. There are usually two pairs of adjustment wheels on a microscope. One large pair, when turned, move the body tube up or down rather rapidly. This will produce a *coarse adjustment* that is used for initial or first focusing. The second, smaller pair, is used to fine focus the image. This is called the *fine adjustment* and is for final focusing.

10. The bottom part of the microscope is the *base*. Make sure that the base is resting securely wherever it is placed for viewing.

11. Now place the microscope in its normal position for use, with the arm facing you. Before observing anything under the microscope, you should get it ready for viewing by following these simple steps:

    --Make sure the microscope is resting on a secure foundation.

    --Clean the eyepiece and all objectives by wiping them with a piece of lens paper.

    --Open the diaphragm all the way.

    --Turn the nosepiece until the low power objective (4X, 5X or 10X) clicks into place.

    --Look through the eyepiece with *both eyes open*. Doing this will reduce eyestrain.

    --Turn on the lamp or turn the mirror towards a light source until an evenly illuminated white light field is seen.

    --If the light is too bright or too dark, regulate it with the diaphragm.

    --If any tiny specks of dust appear, clean the lenses with fresh lens paper.

Part II: Analysis

1. Briefly describe the function of the following microscope parts:

   a. eyepiece ____

   ____

   b. objectives ____

   ____

   c. mirror or lamp ____

   ____

   d. revolving nose piece ____

   ____

   e. stage ____

   f. stage clips ____

   g. diaphragm ____

   h. coarse adjustment ____

   ____

   i. fine adjustment ____

   ____

2. Why is the microscope called a compound microscope?

   ____

   ____

3. What would the magnification of your microscope be if you used:

   a. a 5X eyepiece and a 10X objective? ____________________________

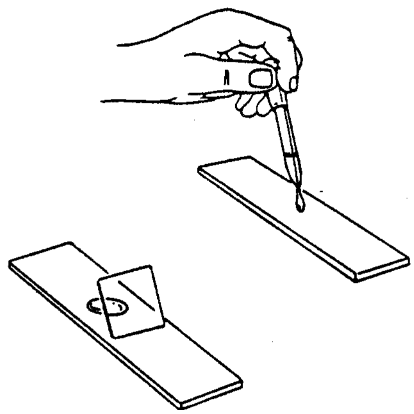
   b. a 10X eyepiece and a 40X objective ____________________________

   c. a 10X eyepiece and a 100X objective ____________________________

Part III: Making a Wet Mount

1. Cut out a small letter "a" from a newspaper column.

2. Carefully position it so that the letter "a" is in the center of a clean microscope slide and is right-side up. Using a dropper, place a drop or two of tap water over the specimen.



3. Holding a coverslip at a 45^o angle, slowly lower it into the drop of water containing the letter. Preparing a slide in this manner is known as a *wet mount*. If properly done, there should be no air bubbles trapped under the coverslip. If this is not the case, start over again.

   Why must all wet mount preparations be cut very thin?

   ___

   ___

Part IV: Low Power and High Power

When observing a specimen under *low power,* the following steps should be taken:

--Obtain a compound microscope and adjust the light as instructed at the beginning of this activity.

--Turn the nosepiece until the low power (10X) objective clicks into place. If the objective is not in place, the entire field will not be seen.

--Place the microscope slide on the stage under the stage clips with the letter "a" facing you in the center of the stage opening.

--Fasten the stage clips to the slide and lower the body tube until it stops. Most microscopes have an automatic stop on low power.

--Looking through the eyepiece, *slowly* raise the body tube with the coarse adjustment until the letter "a" comes into focus. Center the letter and use the fine adjustment to bring it into better focus. Look at the distance between the slide and the objective. This is called the *working distance*.

--At this point, adjust the diaphragm to control the amount of light.

While observing under low power, move the slide to the right and to the left. Then move it towards you and away from you. When you move the slide from left to right, in what direction does the letter move?

a. ____

When you move the slide away from you, in what direction does the letter seem to move?

b. ____

In order to see the entire field, the objective must be in place. (True or False)

c. ____

The distance between the slide and the objective is called the d. ______________________________

When observing a specimen *under high power,* these steps should be taken:

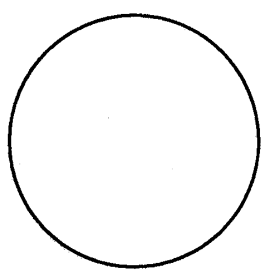
--Always position the specimen in the center of the field of view and fine focus under low power first.

--Open the diaphragm all the way. This is done because as you increase magnification, it becomes necessary for light rays to travel through additional lenses, producing a darker field.

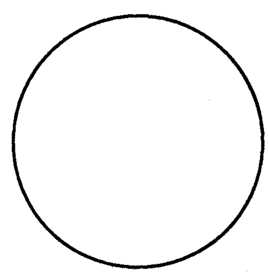
--Turn the nosepiece until the high power objective clicks into place. Most microscopes are *parfocal.* This means that an object focused under low power will be approximately focused under high power.

--All focusing is done *only* with the fine adjustment. Not more than one turn either way should be needed for a sharp focus. Look at how small the working distance is on high power. Using the coarse adjustment knob might crack the slide or damage the objective lens.

Sketch the "a" as you see it under low and high powers. Try to sketch your specimens as accurately as you can.



Low Power



High Power

When you changed from low to high power, how did the change affect the working distance of the lens?

e. ____

____

brightness of the field of view?

f. ____

size of the field of view?

g. ____

Part V: Depth of Field and Resolution

Depth of field is the vertical amount of the specimen that will be in focus at one time while *resolution* is the ability of a microscope to show fine details clearly. Actually, resolution is just as important as magnification. To merely magnify a blur does not tell one anymore about it. The ability of a microscope to resolve very closely spaced objects depends on the quality of the lenses and the wavelength of the light being used.

1. Make a wet mount of two different colored threads that cross each other. Add a coverslip and observe under *low* and *high* power.

   a. Which diaphragm setting provides the clearest view on each power?

   ____

   b. How can the microscope be used to determine which thread is on the bottom?

   ____

   ____

   c. Are both threads in focus at once under low power? ______________________

   d. High power? ____

   e. Under which power is the depth of field greater? __________________________

Part VI: Analysis

1. Given a prepared slide of a one-cell organism, briefly list the steps from the beginning that must be taken to locate the organism under high power (430X).

   ____

   ____

   ____

2. You are searching a slide for an object that is in the lower right-hand side of the field of view. In which direction would you move the slide on the stage in order to center the object?

   ____

3. The largest opening on the diaphragm is always best. (True or False) ____________

   Explain ____

   ____

4. When searching a slide for a small object, with which objective is it best to begin?

   ____

5. Microscope A has a 20X eyepiece and a 30X objective; microscope B has a 5X eyepiece and a 40X objective.

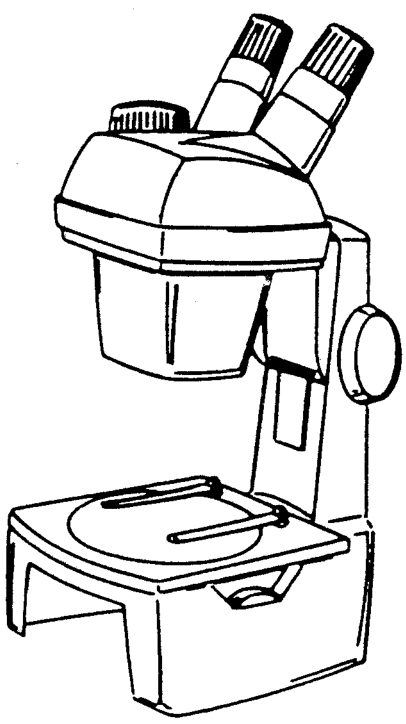
   a. Which microscope has the greatest magnification?

      ____

   b. Which requires the most light? ______________________

   c. Which has the greatest depth of field? ______________________

Part VII: The Stereoscopic Dissecting Microscope



In some cases, it is better to work with less magnification. This is true when the objects are opaque and too large to be seen whole under the lowest power of the compound microscope. Because the working distance is much greater, it is also possible to handle objects while they are being viewed with this microscope. Specimens are usually viewed by reflected light, and since there are two objectives and two eyepieces, a 3-dimensional effect is achieved.

1. Place the dissecting scope on a table and light its stage with a lamp. Adjust the eyepieces to fit the distance between your eyes. Use the focusing knob to move the objective as far down as it will go.

2. Focus on a plastic ruler by turning the focusing knob slowly toward you.

   a. What is the magnification with this objective? ____________________

   b. What is the field size in millimeters? ____________________

   c. in micrometers? ____________________

   d. How does the field size compare with the compound microscope low power field?

   ____

3. Magnification with this type of microscope can be increased by changing the eyepieces or objectives. If your microscope is so equipped, change to a higher magnification. What is the high power magnification?

   a. ____________________

   How does the field size compare with the low power field?

   b. ____________________

4. Select an object such as a leaf or insect to view. Focus the object under both low and high power. While looking through the microscope, move the specimen to the right. Which way did the image move?

   a. ____________________

   Move the specimen toward you. Which way did the image move?

   b. ____________________

   How does this movement compare with observation of movement when using the compound microscope?

   c. ____________________

   ____

5. Examine other objects under the dissecting microscope. If possible, practice moving the objects about with forceps or dissecting needles as you view them.

Part VIII: Analysis

1. List several advantages to using a stereoscopic dissecting microscope.

2. When searching a slide for even small objects, it is best to start with low power. Explain.

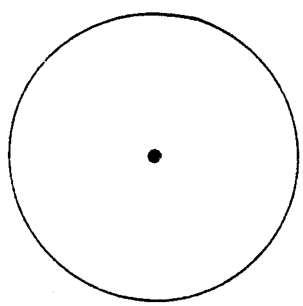
3. A microscope has a 10X field measuring 6 mm. What is the size of the field at 10X in micrometers? a. ____________

   b. at 20X? ____________

   c. at 45X? ____________

   d. What is the total magnification when using a 5X eyepiece with a 45X objective?

4. The circle below represents the field of view when using the 10X objective. Using the same center point, draw a circle that would approximate the field of view at 43X.



5. Why are objects frequently lost when switching to high power?

ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #3--DETERMINE SOIL TEXTURAL CLASS BY MECHANICAL ANALYSIS

Name____ Score________________________________

I. Equipment needed

A. Quart fruit jars with lids

B. 8% calgon solution

C. Ruler, pencil and paper

D. Tablespoon

E. A variety of soil samples

II. Procedure

A. Fill the quart fruit jar 1/2 full of soil

B. Add 5-6 tablespoons of calgon solution and neatly fill the quart jar with water

C. Put the lid on the jar and shake for 5 minutes. Let the jar stand for 24 hours

D. Measure the depth of the settled soil at the end of 24 hours. This is the total depth

E. Thoroughly shake for 5 minutes. Let the jar set

F. Measure the depth of the settled soil at the end of 40 seconds. This is the sand layer

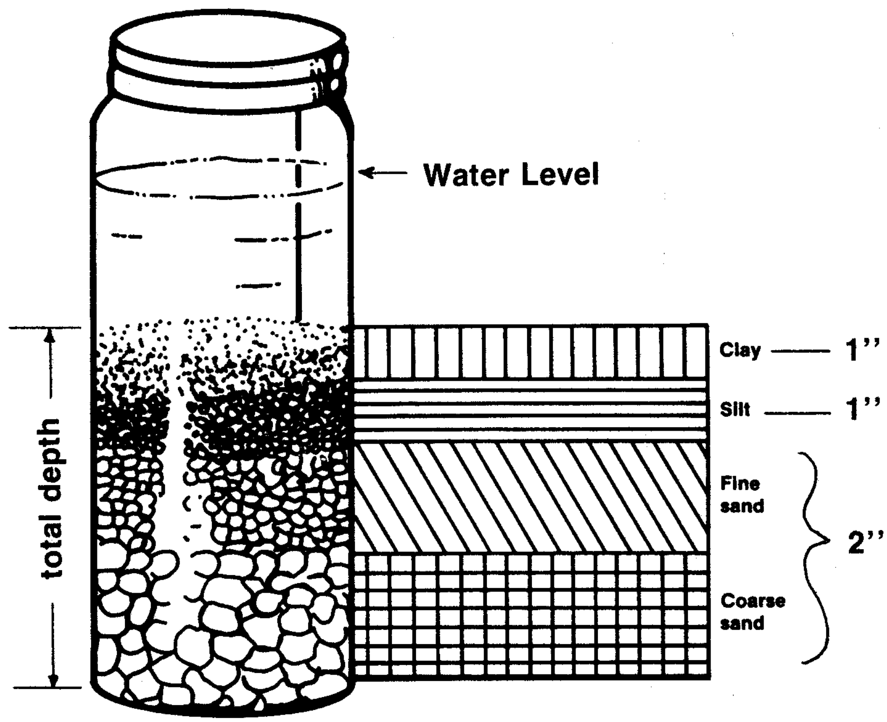
G. Measure the depth of the settled soil at the end of 30 minutes

H. Subtract the first depth (sand) from this new depth of soil. This is the depth of the silt layer

I. Subtract the depth of sand and silt from the original total depth to determine the amount of clay

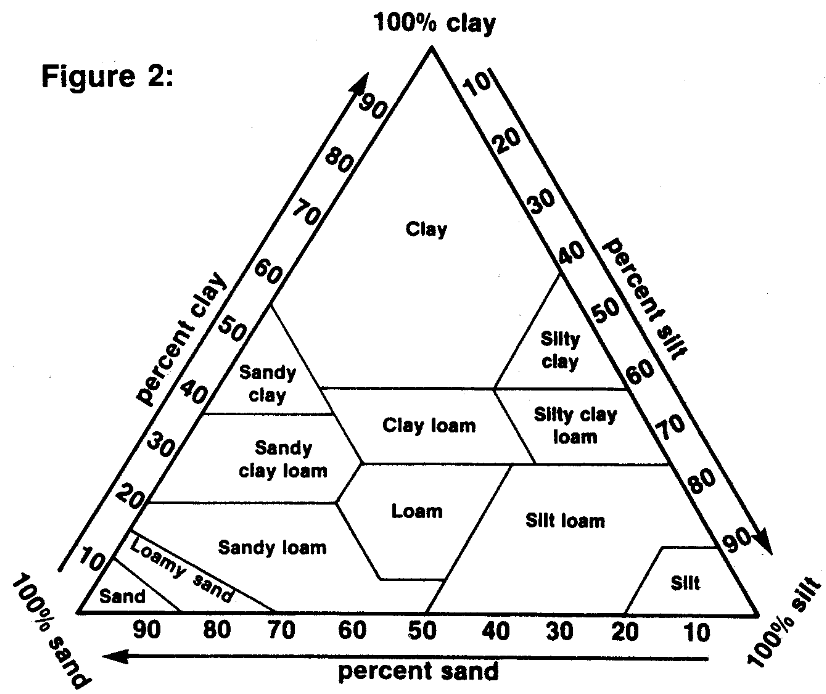
J. Calculate the percentage of each soil separately by dividing the depth of each soil separately by the original total depth (Figure 1)

Figure 1:



K. Determine the soil textural classification by using the soil textural triangle (Figure 2)

Figure 2:



ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #4--DETERMINE SOIL TEXTURAL CLASS BY FEEL

Name____ Score__________________________

I. Equipment needed

A. Spray bottle filled with water

B. Sink (to wash hands)

C. Paper towels

D. A variety of soil samples

II. Procedure

A. Review soil textural class characteristics

1. Sand or loamy sand: Dry--loose, single grained; gritty; no or very weak clods; Moist--gritty; forms easily crumbled ball; does not ribbon; Wet--lacks stickiness, but may show faint clay stainings (loamy sand especially); Individual grains can be both seen and felt under all moisture conditions

2. Sandy loam: Dry--clods break easily; Moist--moderately gritty to gritty; forms balls that stands careful handling; ribbons very poorly; Wet--definitely stains fingers; may have faint smoothness or stickiness, but grittiness dominates; Individual grains can be seen and felt under nearly all conditions

3. Loam: This is the most difficult texture to place since characteristics of sand, silt and clay are all present but none predominates; Suggests other textures; Dry--clods slightly difficult to break; somewhat gritty; Moist--forms firm ball; ribbons poorly; may show poor fingerprint; Wet--gritty, smooth and sticky all at same time; Stains fingers

4. Silt or silt loam: Dry--clods moderately difficult to break and rupture suddenly to a floury powder that clings to fingers; shows fingerprint; Moist--has smooth, slick, velvety or buttery feel; forms firm ball; may ribbon slightly before breaking; shows good fingerprint; Wet--smooth with some stickiness from clay; stains fingers; Grittiness of sand is well masked by other separates; (Texture most like silt loam; there are few silt soils)

5. Sandy clay loam: Dry--clods break with some difficulty; Moist--forms firm ball that dries moderately hard; forms 1/2" ribbons that hardly sustain own weight; may show poor to good fingerprint; Wet--grittiness of sand and stickiness of clay about equal, masking smoothness of silt; stains fingers

6. Clay loam: Dry--clods break with difficulty; Moist--forms firm ball that dries moderately hard; ribbons fairly well, but ribbons barely support own weight; shows fair to good fingerprint; Wet--moderately sticky with stickiness dominating over grittiness and smoothness; stains finger

7. Silty clay loam: Resembles silt loam but with more stickiness of clay; Dry--clods break with difficulty; Moist--shows a good fingerprint; forms a firm ball drying moderately hard; ribbons 1/2" that can be fairly thin; Wet--stains fingers; has sticky-smooth feel with little grittiness of sand

8. Sandy clay: Dry--often cloddy, clods broken only with extreme pressure; Moist--forms very firm ball, drying quite hard; shows fingerprint; squeezes to thin, long, somewhat gritty ribbon; Wet--stains fingers; clouds water; usually quite sticky and plastic, but has some grittiness present

9. Silty clay: Dry--see sandy clay; Moist--forms very firm ball becoming quite hard on drying; shows fingerprint; squeezes out to a thin, long, smooth ribbon; Wet--stains fingers; clouds water; stickiness dominates over smoothness, grittiness is virtually absent

10. Clay: Dry--cloddy, clods often cannot be broken even with extreme pressure; Moist--forms firm, easily molded ball drying very hard; squeezes out to a very thin ribbon 2 to 3 inches long; Wet--stains fingers, clouds water; usually very sticky with stickiness masking both smoothness and grittiness; wets slowly

B. Examine the dry soil sample

(Note: Look for clods and ease of crumbling them between your fingers. Remember soils high in sand are seldom cloddy. Soils high in silt may be cloddy but usually break easily. Clay soils are usually cloddy and are often hard to break.)

C. Take a quantity of soil about the size of a golf ball. Moisten it with water from the spray bottle to the consistency of putty

D. Try to form a ball with the moistened soil sample; then try to form a "ribbon" by working the soil between the thumb and forefinger

(Note: Soils high in sand feel gritty and ribbon poorly unless also high in clay. Soils high in silt feel smooth or floury. They may also form a short ribbon in varying length depending on the clay content. Soils high in clay can be rolled out into very thin ribbons.)

E. Saturate the soil sample and note staining on the fingers

(Note: Clay or loam soil is indicated if the moist soil ball stains your fingers.)

F. Compare several soil samples of different textures

(Note: Compare the amount of grittiness of sand to the smoothness of silt and the stickiness of clay. Sand gives a grinding sound when held close to the ear. Grittiness indicates a sandy soil. Silt is smooth and velvety. Clay is sticky.)

ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #5--STUDYING SOIL SAMPLES

Name______________________________________ Score__________________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

No one knows how many organisms exist on the earth. But probably as many organisms can be found below the earth's surface as above it. Where? In the soil. Familiar organisms, such as plants, fungi and earthworms can be found in many soil samples. Microscopic organisms live in tiny air spaces between the soil particles. Abiotic factors such as the size of soil particles, the amount of moisture the soil can hold, and the acidity or alkalinity of the soil help determine the kinds of organisms that will live in a particular soil. In this laboratory you will examine two different types of soil. First, you will study some physical features of the soil samples. Then, you will look for living organisms in the soils.

Materials needed

Newspaper
2 soil samples, each about 1 L in volume
Hand lens or stereoscopic microscope
Beaker
Metric balance
Tap water
Cheesecloth square, about 30 cm long
Rubber band
Strainer or wire screen
Coverslip
20 ml distilled water
Test paper for Ph
Stirring rod or spoon
Ring stand with hoop that will support a large funnel
Large glass funnel
Rubber tubing, about 12 cm long
Pinch clamp
Medicine dropper
Microscope slide
Compound microscope
Filter paper
Scissors
2 test tubes
2 corks to fit test tubes
2 thumbtacks
200 ml pasteurized spring water
Grease pencil
Test-tube rack
Optional: Field guide to soil organisms

Part I: Physical Factors of Soil

1. The composition of soil helps determine the kinds of organisms that can exist in the soil. Cover your desk or work surface with newspapers. Observe the texture and color of one of the soil samples. Squeeze the soil in your hand to observe its texture and water content. Observe the sizes of the soil particles. Try to find clay particles, silt, sand, gravel and organic matter in your sample. Which type of soil particles are most closely packed?

   (a) First soil sample:____

   Second soil sample: ____

Use a hand lens or stereoscopic microscope to make further observations. Write the identification number or a brief description of the soil sample in the first column of Table I on the following page, and record your observations. CAUTION: *Whenever you finish handling a soil sample, wash your hands thoroughly*.

2. Repeat step 1 with the other soil sample.

Moisture-Holding Capacity

3. How well soil can hold moisture affects the kinds of organisms that can live in a particular soil. The moisture-holding capacity tells how much water is retained by soil when it is completely saturated. First, find the mass of an oven-dried sample of your soil. Record this mass in Table I. Then, wet and find the mass of a piece of cloth. Record the wet cloth's mass. Wrap the dried soil in the wet cloth and secure the cloth with a rubber band. Immerse the cloth in a beaker of water overnight.

4. Repeat step 3 for the second soil sample.

5. Remove the wrapped soil samples from the beaker. Place the samples on a screen or in a strainer, and allow the soil and the cloth to drain into the beaker for about 20 minutes. Then, find the mass of each wrapped soil sample, and record these masses in the table. Use the formula below to calculate the moisture-holding capacity for each soil sample. Record this calculation in Table I.

Moisture-holding capacity

$$\text{Moisture-holding capacity} = \frac{\text{Mass of water (gain in mass)}}{\text{Mass of dried soil}} \times 100$$

Measuring pH

6. The acidity or alkalinity of soil determines the kinds of organisms that can live in the soil. Mix 10 g of soil with about 10 ml of distilled water. Stir this mixture vigorously and allow it to stand for about 10 minutes. Use pH test paper to find the pH of the soil. Record the color of the test paper in Table I. Interpret your results according to information on the test-paper package or provided by your teacher.

7. Repeat step 6 with the second soil sample. When you are finished, clean your equipment and return it to its proper place. Wash your hands thoroughly.

Table I. Physical factors of soil

Soil sample number or description	Observations (color, texture, particle size, plasticity, moisture, composition)	Moisture-holding capacity					pH	
		Mass of dried soil	Mass of wet cloth	Mass of wet soil and cloth	Mass of water	Moisture-holding capacity	Color	Reading

Part II: Living Organisms in Soil

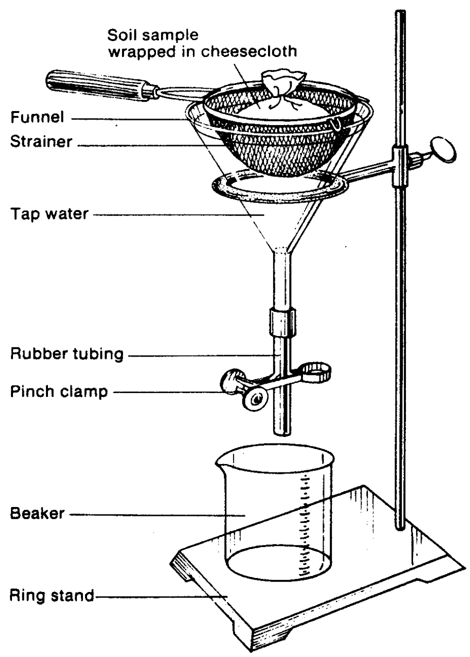
1. On a separate piece of paper, make a table similar to Table II on the following page for recording your observations.

2. Obtain a soil sample. Write the identification number or a brief description of the soil in your Table II. Then, record the types and numbers of organisms you observe. Next, examine the soil with a hand lens, and record in your table any additional observations. If you do not know the name of a type of organism, draw the organism in your table or use a field guide to identify the organism. CAUTION: *Whenever you finish handling a soil sample, wash your hands thoroughly.*

3. Obtain a second soil sample, and repeat step 2 with that soil sample.

Isolating Nematodes

4. A nematode is a type of worm common to almost all environments on earth. Different types of nematodes inhabit different environments. Most soil nematodes are microscopic. Set up a Baermann funnel to isolate nematodes from your soil sample. Using a as your guide, set up a ring stand with a funnel. Attach rubber tubing to the end of the funnel, and clamp the tubing closed with a pinch clamp. Place a beaker below the rubber tubing to catch any drips. Half fill the funnel with water. Place a strainer or wire screen in the funnel. Wrap a small amount of soil in a cheesecloth square, securing it with a rubber band. Place the wrapped soil in the Baermann funnel, as shown. Let the soil remain in the funnel overnight. The nematodes in the soil will crawl through the holes in the cheesecloth into the water. Being heavier than water, they will sink to a position just above the pinch clamp.



a. Baermann funnel You may need to add extra water to the funnel if the soil is highly absorbent.

You can preserve the nematodes by adding several mL of isopropyl alcohol to the nematodes in the beaker.

5. After 24 hours, release a small volume of water into the beaker by quickly opening and closing the pinch clamp. Make a wet mount slide of the liquid, and examine your slide under low and high power. Nematodes look like short pieces of white thread. Record in your Table II the number of nematodes you observe in one field. How many different types of nematodes do you observe?

   (b) ____

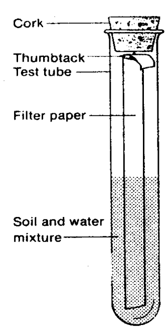
6. Repeat steps 4 and 5 with the second soil sample.

Table II. Organisms in soil

Soil sample	Organisms observed in soil		Number of nematodes	Populations of decomposers										Description of decomposers		
	Kinds of organisms	Numbers of organisms		1	2	3	4	5	6	7	8	9	10			
	Answers will depend on soil types being studied.															

Isolating Decomposers

7. Soil contains many decomposers--bacteria and fungi that break down complex chemicals into simpler materials that can be reused by other organisms. You can isolate decomposers that break down cellulose from plant tissue in paper. Cut a strip of filter paper so that it will fit into a test tube, as shown in b. Tack the filter paper to a cork that will plug the test tube. In a beaker mix about 5 ml soil with about 100 ml of pasteurized spring water. Stir the mixture vigorously with a stirring rod or spoon. Half fill the test tube with the soil and water mixture. Plug the test tube with the cork, making sure that the attached filter paper is partially immersed in the water. Use a grease pencil to label your test tube with the type of soil contained in the mixture. Place the test tube in a test-tube rack, and allow the test tube to stand at room temperature for 24 hours.



b. Setup for isolating decomposers

8. Repeat step 7 with the second soil sample.

9. After the test tubes have stood for 24 hours, examine the filter paper strips for evidence of decomposers. (Note: Do not remove the strips from the test tube. Removal will expose the paper to airborne decomposers.) Record your observations in your Table II. Replace the test tubes in the rack.

10. Repeat step 9 each day for the next two weeks, recording your observations in your table. After two weeks, remove the filter paper strips from the test tubes and observe them under a stereoscopic or compound microscope. Use space in your Table II to describe the decomposers you examined.

Part III: Analysis

1. How do the two soil samples you tested differ physically?

____

____

2. How do the populations of organisms in the two soil samples differ?

____

____

3. How do physical features of soil affect the population of organisms that inhabit the soil? Explain using data from this laboratory.

____

____

4. Which soil particles packed most tightly? How does the degree of particle packing affect organisms in the soil?

____

____

5. Which soil sample do you think would support the most living organism? What soil conditions favor the support of life?

____

____

ELEMENTARY STUDY OF SOILS

AG 510 - A

LABORATORY EXERCISE #6--THE ORIGIN AND MEANING OF COLOR IN SOIL

Name____ Score_________________________

Introduction

By looking at the color of a soil, even when it is dry, you can tell how well or how poorly its drainage will be in the wet season. Wet soggy soil is usually black or grey. Look at the soil in bogs, swamps, low spots in the fields, bottoms of drainage ditches, etc. Well drained soil is usually tan, brown, yellow or red. The black comes from humus and will burn off. The grey comes from iron oxides with the iron in the Fe^{2+} (reduced) form. The tan to reds come from iron oxides with the iron in the Fe^{3+} (oxidized) form.

Let us observe how soil organisms and anaerobic conditions will turn a soil grey (reduce the iron from Fe^{2+} to Fe^{3+}).

Materials needed

3 bottles or flasks
Red, brown or tan subsoil
Poorly drained soil
Surface soils containing humus
2 balloons
Sugar or ground alfalfa meal
Bunsen burner

Part I: Procedure

1. Place about an inch of red, brown or tan subsoil into each of two bottles or flasks. Add water to one inch above the soil.

2. Seal the first flask by snapping a balloon over the bottle top. This soil has been made anaerobic but it has no energy source for the anaerobic organisms so nothing should happen.

3. Add 1/4 teaspoon sugar to the second flask (you might try to substitute a teaspoon of finely ground alfalfa meal) as energy and carbon supply for the microorganisms. Also add a small pinch of a poorly drained soil (this serves to inoculate the system with plenty of anaerobic organisms). Seal it with a balloon snapped over the bottle top and set both bottles in a warm place.

Part II: What We Will See

1. The anaerobic microbes begin to work in bottle 2. After a few days you can see the bubbles of CO2 rising in the water. Also the balloon may fill a little with gas.

2. After 10 days the soil should have turned grey (reduced) or at least begun to do so. This is what happens in water logged soils especially when there is enough food for the organisms. It is why the subsoil of "poorly drained" soils is grey and why "somewhat poorly drained" soils have grey mottles.

3. Open the flask with the grey soil. It will smell badly from the organic acids formed by anaerobic decomposition. Pour the water off into a bottle and leave it stand in the room air with a lid on loosely so it won't evaporate dry, yet so oxygen can enter. The reduced iron is very soluble in

water but the oxidized iron is not. After a few days the Fe^{2+} in the water as FeO should form Fe^{3+} as Fe_2O_3 which is red and is insoluble. Red and brown iron concretions in soil form when reduced (Fe^{2+}). Iron in solution moves and becomes insoluble. It collects in a zone with more oxygen and becomes Fe_2O_3.

4. The black color in surface soils is mostly from humus. Burn the humus off of several soils by heating them red hot over a Bunsen burner or on a stove. After the humus is gone you will see the iron color (tan, yellow, brown or red) that was hidden by the humus.

ELEMENTARY STUDY OF SOILS

AG 510 - A

ANSWERS TO LABORATORY EXERCISES

Lab #1

Part IV--Quiz

1. Answer should include ten of the following:

   Never "horse around" in the laboratory.
   Never play with laboratory equipment or materials.
   Always follow instructions and wait until you are told to begin before starting any investigation.
   Never carry out unassigned experiments.
   Never eat or taste anything in the laboratory. This includes food, drinks and gum, as well as chemicals found in the laboratory.
   Wash your hands after *every* experiment.
   Keep all books and other nonessential items away from the work area.
   Keep your work area clean. Dispose of waste materials in appropriate containers.
   Turn off any gas jets or any electrically operated equipment when you have completed the laboratory investigation.
   Report all injuries or accidents to your teacher immediately.
   Never use broken or cracked glassware.
   Always wear shoes in the laboratory. Sandals are not suggested.
   Tie back long hair and restrict any loose clothing.
   Wear safety goggles, laboratory aprons, and gloves when instructed to do so.

2.

a.	Microscope slide	b.	Coverslip
c.	Petri dish	d.	Erlenmeyer flask
e.	Florence flask	f.	Funnel
g.	Graduate	h.	Test tube
i.	Test tube rack	j.	Test tube holder
k.	Pipette	l.	Striker
m.	Scalpel	n.	Medicine dropper
o.	Inoculating loop	p.	Forceps

3. Answer should include the following information:

Laboratory Investigation Report:

Title This is the name of the laboratory investigation you are doing. In an investigation from a laboratory manual, the title will be the same as the title of the investigation.

Hypothesis The hypothesis is what you think will happen during the investigation. It is often posed as an "If...then" statement. For example: If sulfuric acid is added to sugar, then the sugar will be broken down into its chemical components.

Materials This is a list of all the equipment and other supplies you will need to complete the investigation. In investigations taken from a laboratory manual, the materials are generally listed for you.

Procedure The procedure is a step-by-step explanation of exactly what you did in the investigation. Investigations from laboratory manuals will have the procedure carefully written out for you, all you need to do is to read it very carefully. Often, in laboratory manuals, there will be questions in the procedure section that will help you understand what is happening in the investigation.

Data Your data is what you have observed. It is often recorded in the form of tables, graphs and drawings.

Analyses and Conclusions This is the most important and difficult part of the investigation. It explains what you have learned. You should include everything you have learned; you should explain any errors you made in the investigation; and you should evaluate your hypothesis. Keep in mind that not all hypotheses will be correct. That is normal. You just need to explain why things did not work out the way you thought they would. In laboratory manual investigations, there will be questions to guide you in analyzing your data. You should use these questions as a basis for your conclusions.

<u>Independent Project Report</u>

Title

Introduction The introduction should include a clear, simple statement of your purpose. In addition, the introduction should include a discussion of the important ideas that led you to design and perform the experiment. For example, you could include such things as why you are doing this investigation, what is interesting about the topic to be investigated, and what information you have already gathered about the topic. In order to prepare a good introduction, you will need to do library research on the topic. Be sure to use proper citation methods when you use ideas from any reference source.

Hypothesis

Materials

Procedure

Data

Analyses and Conclusions

References List all the reference materials used to originate and to complete the project. Be sure to use complete citations, including author, title, date of publication and place of publication. Your teacher will give you the format preferred for the type of investigation you are doing.

<u>Lab #2</u>

Part II:

1.
   a. Lens closest to the eye that has 5X or 10X magnification power.
   b. Lens closest to the object being observed. These lenses usually have 5X, 10X, 43X or 100X magnification power.
   c. Provides an adequate light source for viewing.
   d. Allows observer to change from low (10X magnification) to high power (43X magnification).
   e. Supports the slide.
   f. Secures the slide.
   g. Regulates the amount of light entering the microscope.
   h. Brings objects into rapid but approximate focus.
   i. Brings objects into a more exact focus.

2. Because a double set of lenses (eyepiece and objective) is used

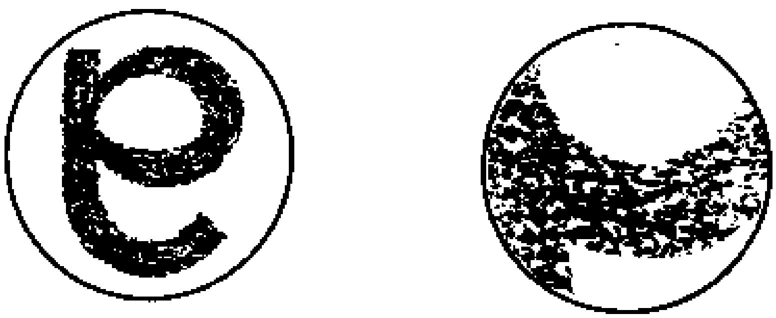
3. a. 50X b. 400X c. 1000X

Part III:

3. So that light can be transmitted through the object for viewing.

Part IV:

a. The letter will move from right to left.
b. Toward you.
c. True
d. Working distance



e. Working distance is much smaller with the high power
f. Brightness is decreased on high power
g. Field of view is restricted on high power

Part V:

1. a. Less light is desirable on low power
   b. Use the fine adjustment to focus up and down. The bottom thread will come into view as the scope is focused down.
   c. Probably
   d. No
   e. Low power

Part VI:

1. See steps outlined in procedure under high power
2. Down and to the right
3. False. At low power the excessive light does not allow the eye to see detail.
4. Low power; a greater area can be seen at once
5. a. Microscope A b. Microscope A c. Microscope B

Part VII:

2. a. Answers variable
   b. Answers may vary
   c. Answers variable, should be 1000X answer above
   d. Field size is larger

3. a. Variable
   b. Field size is smaller

4. a. Movement of image is the same as movement of object
   b. The specimen moves toward you
   c. Not reversed as with compound microscope

5. Students can practice dissecting objects, such as insects, leaves or presoaked seeds, just to get the feel of working with a stereoscope.

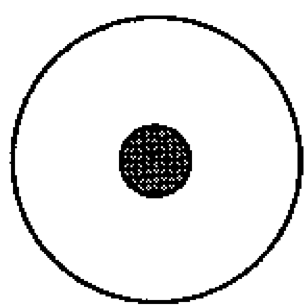
Part VIII:

1. Opaque objects can be viewed. Larger objects can be studied. Specimens can be dissected under the scope.

2. A larger field of view is available to find the objects.

3. a. 6000pm
   b. 3000pm
   c approximately 1300pm+
   d. 225X

4. Students should draw a circle having an area approximately 1/4 the original circle



5. The object is not centered in the portion of the low power field that will be seen under high power.

Lab #5

Part I:

(a) Answers depend on soil composition
    Answers depend on soil composition

Table I: Answers will depend on soil types being studied.

Part II:

(b) Answers depend on soil sample, but five genera of soil nematodes are commonly distinguished.

Table II: Answers will depend on soil types being studied.

Part III:

1. Answers depend on samples studied but should compare such factors as color, texture, particle types, water content, moisture-holding capacity and pH.

2. Answers depend on samples studied, but should compare populations visible to the naked eye, and populations of nematodes and decomposers.

3. Answers depend on samples, but students should discuss how populations are affected by soil composition, water content, moisture-holding capacity and pH.

4. Clay. Degree of packing determines the amount of air space for gas exchange between the organism and the soil.

5. Answers depend on samples studied, but students should discuss how moisture, gas exchange, and nutrients in soil affect life in the soil.

ELEMENTARY STUDY OF SOILS

AG 510 - A

UNIT TEST

Name____________________________________ Score__________________________________

1. Match terms associated with elementary study of soils to the correct definition. Write the correct numbers in the blanks.

_____a. A mixture of particles of rock, organic materials, living organisms, air and water

_____b. Removal of water soluble soil components from the downward action of water

_____c. Total thickness of a soil from the topsoil to the parent material

_____d. Dark colored upper layer of soil that may vary from several inches to 2 or more feet thick

_____e. A vertical cross-section of the soil from the surface through all its horizons

_____f. Mass or cluster of soil particles such as a clod, crumb or granule

_____g. Soil having a pH value greater than 7.0

_____h. General term for inorganic elements in the soil

_____i. A name given a textural group based on the relative proportions of the various soil separates

_____j. A layer of soil approximately parallel to the land surface, differing from other layers in color, structure, texture, pH, etc.

_____k. The layer of soil directly beneath the topsoil

_____l. General term for plant and animal material in or on the soil in all stages of decomposition

_____m. Indication of the amount of organic matter and moisture of the soil

_____n. Soil with a pH of less than 7.0
capacity

1. Soil
2. Mineral matter
3. Organic matter
4. Parent material
5. Soil texture
6. Soil structure
7. Aggregate
8. Soil depth
9. Soil color
10. Soil profile
11. Soil horizon
12. Topsoil
13. Subsoil
14. Acid soil
15. Alkaline soil
16. Leaching
17. Reclamation
18. Cation
19. Anion
20. Exchange

_____o. An ion that has lost an electron and has a positive (+) charge

_____p. The ability of a soil to absorb ions to the surface of the soil particle

_____q. Restoration to a better or useful stage, as of wasteland, desert, alkali, etc.

_____r. The combination or arrangement of soil particles into aggregates

_____s. The rock or other unconsolidated material from which the soil has developed

_____t. An ion that has gained an electron and has a negative (-) charge

2. Select from the following list reasons that soils are important. Write an "X" in the blank before each correct answer.

   _____a. Holds the earth together

   _____b. Provides food

   _____c. Population is increasing

   _____d. Productive soil is limited

   _____e. Provides insulation

3. Discuss the function of soil as related to plant growth, development and maintenance.

   ____

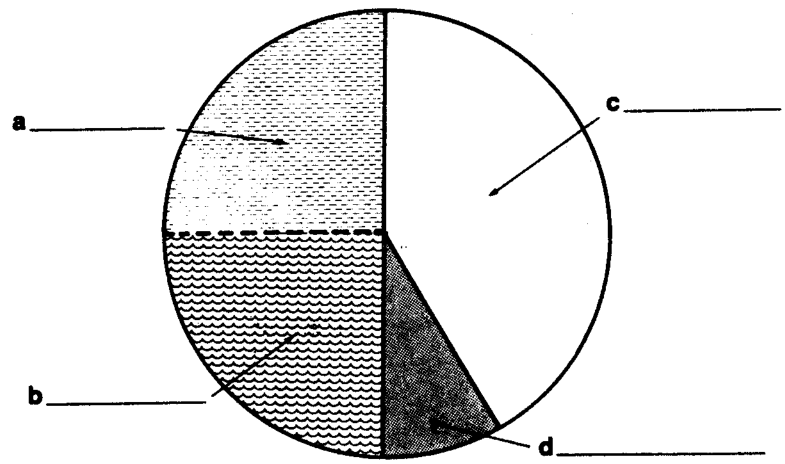
   ____

   ____

   ____

   ____

4. Label the drawing below showing the composition of an average soil. Write the correct names in the blanks.



5. Select from the following list factors that are important in soil formation. Write an "X" in the blank before each correct answer.

_____a. Freezing and thawing of parent material

_____b. The amount of rainfall

_____c. The type of soil structure

_____d. The steepness or flatness of the landscape

_____e. The presence of clay in the "B" horizon

_____f. The amount of vegetation present

6. Name the four physical properties of soil.

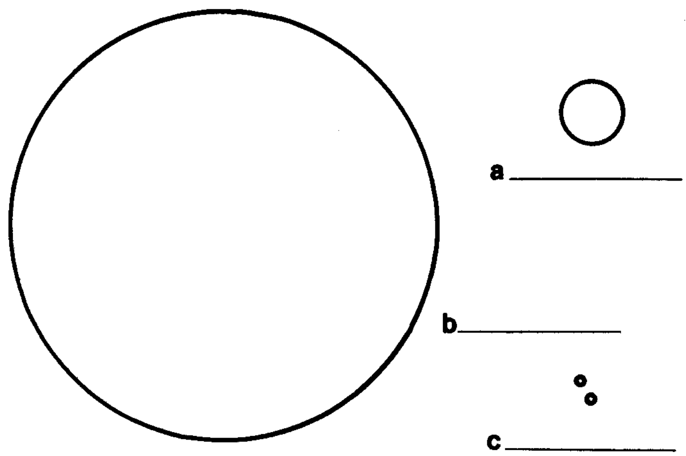
a. ______________________________

b. ______________________________

c. ______________________________

d______________________________

7. Identify the soil particles according to size.

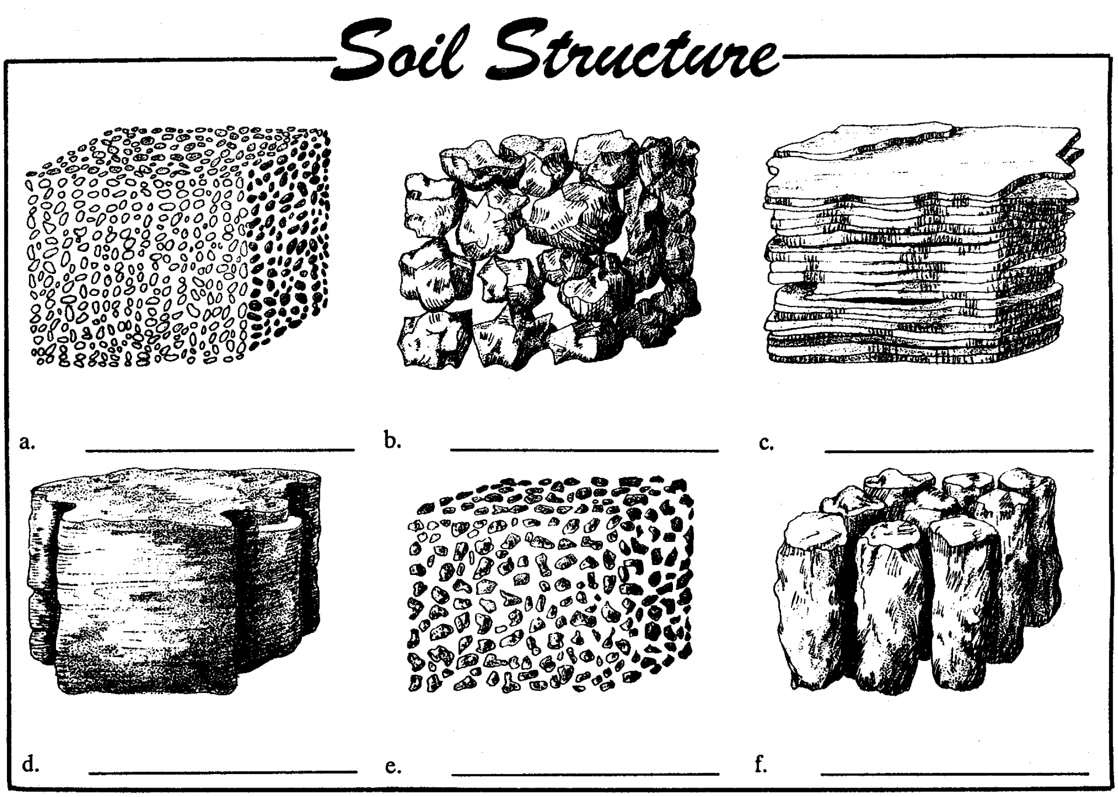


8. List two methods used to determine soil texture.

a____

b____

9. Identify the six kinds of soil structure in the illustrations below.



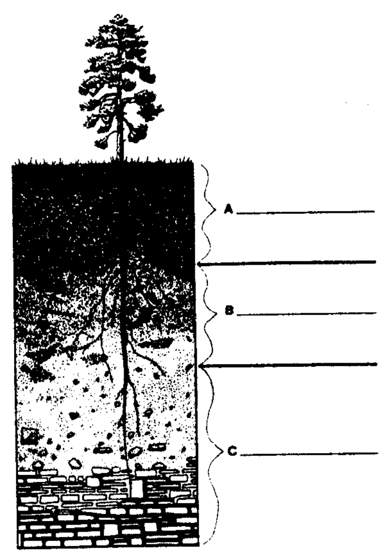
10. Match terms indicating soil depth to their correct description. Write the correct numbers in the blanks.

_____a.	40 to 60 inches deep	1.	Shallow
_____b.	20 to 40 inches deep	2.	Moderately deep
_____c.	10 to 20 inches deep	3.	Deep
_____d.	Less than 10 inches deep	4.	Very shallow
_____e.	Over 60 inches deep	5.	Very deep

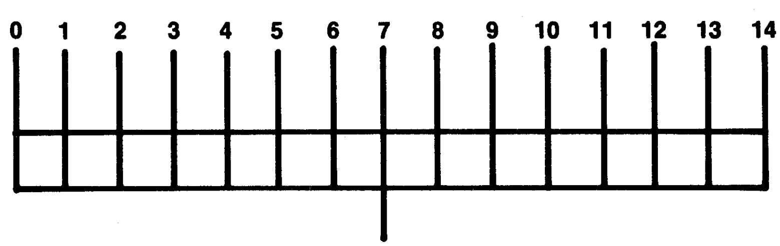
11. Match the colors of the soil to their correct description. Write the correct numbers in the blanks.

_____a.	High iron content	1.	Dark brown to black
_____b.	Caused by imperfect drainage	2.	Red or reddish-brown
_____c.	High organic matter content	3.	Yellow or gray

12. Label the illustration showing the layers of a soil profile. Write the correct names in the blanks.



13. Identify on the pH scale the area of acidity and the area of alkalinity.



14. Discuss the liming of soils to correct soil acidity.

____

____

____

____

____

____

____

15. Name three types of alkali soils.

a____

b. ____

c____

16. Discuss reclamation of alkali soils.

____

____

____

____

____

____

ELEMENTARY STUDY OF SOILS

AG 510 - A

ANSWERS TO TEST

1.

a.	1	h.	2	o.	18
b.	16	i.	5	p.	20
c.	8	j.	11	q.	17
d.	12	k.	13	r.	6
e.	0	l.	3	s.	4
f.	7	m.	9	t.	19
g.	15	n.	14		

2. b, c, d

3. Answer should include the following information:

   Media for seed germination; Media for support of plants; Storehouse of plant nutrients; Storehouse of water for the plant

4. a. Air
   b. Water
   c. Mineral matter
   d. Organic matter and living organisms

5. a, b, d, f

6. Soil structure; Soil texture; Soil depth; Soil color

7. a. Silt
   b. Sand
   c. Clay

8. Mechanical analysis; Feel method

9. a. Single grain
   b. Blocky
   c. Platy
   d. Massive
   e. Granular
   f. Prismatic

10. a. 3 b. 2 c. 1 d. 4 e. 5

11. a. 2 b. 3 c. 1

12. a. "A" horizon
    b. "B" horizon
    c. "C" horizon

13. Acid--pH values less than 7.0
    Alkaline--pH values greater than 7.0

14. Answer should include the following information: The function of lime is to neutralize hydrogen (H^+) ions that cause soil acidity; Amount of lime to apply depends on the degree of acidity of the soil, crops to be grown, grade or purity of lime materials, frequency of application, soil texture and soil exchange capacity

15. Saline; Sodic; Saline-sodic

16. Discussion should include the following information:

    <u>Saline</u>: Flood with water and leach out salts; Install drainage tiles to remove accumulated salts; Grow salt tolerant crops
    <u>Sodic:</u> Apply gypsum; Grow sodic tolerant crops
    <u>Saline-</u>sodic: Correct sodic problem first, then salt problem

SOIL FERTILITY

AG 510 - B

UNIT OBJECTIVE

After completion of this unit, students should be able to classify essential nutrients as primary, secondary or micronutrient, and match function and deficiency symptoms to the correct nutrient. Students should also be able to interpret soil test information, determine the amount of fertilizer to apply and calculate nutrient cost. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with soil fertility to the correct definitions.
2. Classify the essential nutrients for plant growth as being primary, secondary or micronutrient.
3. Match the functions of nutrients for crop growth to the correct nutrient.
4. Match nutrients to their correct deficiency symptoms.
5. Select factors that influence the use of fertilizers.
6. Discuss major points in collecting and handling a representative soil sample.
7. Calculate amounts of fertilizer required per acre using soil test and fertilizer guide information.
8. Discuss major points in collecting and handling a representative plant tissue sample.
9. List four sources of nutrients.
10. Select the information that must be stamped on fertilizer bags according to state law.
11. Match types of fertilizer analyses to their correct description.
12. Match types of fertilizers to their correct description.
13. Calculate problems comparing cost per pound of nutrient.
14. Formulate a fertilizer blend.
15. List three methods of fertilizer application.
16. Complete a soil test report form.

SOIL FERTILITY

AG 510 - B

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Crop Management Series--No-Till and Minimum Tillage Farming: Fertilizer Band Location for Cereal Root Access,* available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.50; order no. PNW 283.

b. *Fertilizer Placement,* available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.35; order no. CIS 757.

c. *Fertilizer Primer: Terminology, Calculations and Application*, available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.35; order no. CIS 863.

d. *How to Calculate Manure Application Rates in the Pacific Northwest,* available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.25; order no. PNW 239.

e. *Making Soil Fertility Decisions*, 120-page instructional unit; available from IAVIM Center, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $7.50; order no. 226.

f. Pamphlets on fertilizer use; available from Potash and Phosphate Institute, 2801 Buford Hwy., N.E., Suite 401, Atlanta, Georgia 30329; approximate cost 25› each.

g. *Principles of Soil Sampling*, available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.50; order no. WREP 9.

h. *Soil Sampling*, available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.50; order no. EXT 704.

i. *Taking Soil Samples*, 25-page instructional manual; available from IAVIM Center, ATTN: Thomas A. Hoerner, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $2.50; order no. 212.

j. *University of Idaho Soils Handbook*, includes basic soils information and soils-related Current Information Series (CIS) publications published by the College of Agriculture; available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $27.

k. *Using the Soil Test Report Form*, available from Agricultural Communications Center, Building J40, University of Idaho, Moscow, Idaho 83843-4196, (885-7982); approximate cost $.25; order no. CIS 363.

2. Filmstrips, slideshows, etc.

a. *Fertilizer Purchase*, 1 disk and worksheet; available from Teaching Aids, Inc., P.O. Box 1789, Costa Mesa, California 92626; approximate cost $22.00; order no. ACS-9.

b. *Fertilizer Quarterly*, 1 disk and worksheet; available from Teaching Aids, Inc., P.O. Box 1789, Costa Mesa, California 92626; approximate cost $22.00; order no. ACS-10.

c. *Fertilizers and Soil Fertility*, 3 cassettes, 3 filmstrips, program guide and reproducible masters; available from Teaching Aids, Inc., P.O. Box 1789, Costa Mesa, California 92626; approximate cost $105.00; order no. P1321.

d. *Soil pH and Limestone*, 7 slides, cassette and 1 film loop, 24 minutes; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $31.20; order no. D21.

e. *Soil Sampling and Soil Testing*, 63-frame filmstrip and script; availablefrom IAVIM Center, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $8.75; order no. 314.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet.

D. Provide students with information and assignment sheets.

E. Discuss unit and specific objectives.

F. Discuss information and assignment sheets.

G. Take soil sample from schoolyard or school farm for analysis.

H. Have students bring a soil sample from home farm for analysis.

I. Develop a fertilizer test plot for students to observe different fertilizing methods, rates and results.

J. Contact local fertilizer dealer for samples of different fertilizers.

K. Review and give test.

L. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Chemical Elements Essential to Plant Growth
2. TM 2--Ten Essential Elements
3. TM 3--Profits Can Fall if Any Nutrient is Short
4. TM 4--Nitrogen Deficiency in Corn
5. TM 5--Phosphate Deficiency in Corn
6. TM 6--Potash Deficiency in Corn
7. TM 7--Factors That Influence Fertilizer Use
8. TM 8--Soil Sampling (A-B)
9. TM 9--Soil Sampling (C-D)
10. TM 10--Soil Sampling (E-F)
11. TM 11--Soil Sampling (G-H)
12. TM 12--Soil Sampling
13. TM 13--Soil Sample Bag
14. TM 14--Soil Test Report
15. TM 15--Nutrient Sources
16. TM 16--Information Commonly Found on a Fertilizer Bag
17. TM 17--Fertilizer Analysis
18. TM 18--Plant Nutrient Blends

19. TM 19--Compare Cost Per Pound of Nutrient, NOT Cost Per Pound of Fertilizer

20. TM 20--Calculate Amount of Fertilizer to Apply

E. Assignment sheets

1. AS 1--Calculate Number of Pounds of Actual Nitrogen, Phosphorus and Potassium Available From Different Fertilizer Analyses

2. AS 2--Calculate Cost Per Pound of Nitrogen for Different Fertilizer Analyses

3. AS 3--Calculate Application Rates of Fertilizers

4. AS 4--Formulate a Fertilizer Blend, Calculate Total Cost and Cost Per Acre

5. AS 5--Complete a Soil Test Report Form

F. Answers to assignment sheets

G. Test

H. Answers to test

III. Unit references

A. *Agronomy Curriculum Workshop*, Iowa State University, Department of Agricultural Education, Ames, Iowa, 1980.

B. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

C. *Crops, Soils, and Fertilizer Resource Manual*, Vo Ed No. 73, University of Idaho, Department of Agricultural Education, Moscow, Idaho, 1978.

D. Donahue, Roy L., Follett, Roy H., Tulloch, Rodney W., *Our Soils and Their Management*, 5th edition, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1983.

E. Fridline, Clarence R., *Field Crop Nutrition*, Ohio Agricultural Curriculum Materials Service, Ohio State University, Columbus, Ohio.

F. Hartmann, Hudson T., Kofranek, Anton M., Rubatzky, Vincent E., Flocker, William J., *Plant Science: Growth, Development and Utilization of Cultivated Plants*, 2nd edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

G. Knuti, Williams and Hide, *Profitable Soil Management, 3rd edition*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

H. *Oklahoma Curriculum Guide*, Oklahoma State University and the Oklahoma State Board for Vocational-Technical Education, Stillwater, Oklahoma.

I. *Soils Handbook*, Cooperative Extension Service, College of Agriculture, University of Idaho, Moscow, Idaho.

J. *Texas Curriculum Guide*, Vocational Instruction Services, Texas State Board for Vocational Education.

K. Tisdale and Nelson, *Soil Fertility and Fertilizers*, 2nd edition, The MacMillan Co., Toronto, Canada, 1969.

L. *Western Fertilizer Handbook*, Soil Improvement Committee, California Fertilizer Association, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1980.

SOIL FERTILITY

AG 510 - B

INFORMATION SHEET

I. Terms and definitions

A. Essential nutrient--Element necessary for plant growth and reproduction, for example: nitrogen, phosphorus and potassium

B. Deficiency--Plant condition where an essential nutrient is not sufficiently available

C. Symptom--A visual sign or condition that results from a deficiency; symptoms aid in diagnosing a deficiency

D. Fertilizer--Natural, manufactured or processed material or mixture of materials that contains one or more of the essential nutrients; available in dry, liquid or gaseous form

E. Analysis--Percentage water soluble content of nitrogen (N), phosphorus (P) expressed as P_2O_5, and potassium (K) expressed as K_2O in the fertilizer

F. Brand--Trademark of the company which produced the fertilizer

G. Complete fertilizer--Fertilizer which supplies all three of the primary nutrients (N, P, K)

II. Essential nutrients for plant growth (Transparencies 1, 2, 3)

(Note: Plants require 16 nutrients for healthy growth. These nutrients are obtained from either air, water or soil. From these basic nutrients, plants can put together all of the necessary substances needed for growth and storage of food.)

A. Non-mineral--From air and water

1. Hydrogen (H)--from water

2. Oxygen (O)--from water and air

3. Carbon (C)--from air

B. Mineral--From the soil

1. Primary nutrients--Needed in large amounts

a. Nitrogen (N)

b. Phosphorus (P)

c. Potassium (K)

2. Secondary nutrients--Needed in moderate amounts

   a. Sulphur (S)

   b. Calcium (Ca)

   c. Magnesium (Mg)

3. Micronutrients--Needed in small amounts

   a. Boron (B)

   b. Manganese (Mn)

   c. Zinc (Zn)

   d. Copper (Cu)

   e. Iron (Fe)

   f. Chlorine (Cl)

   g. Molybdenum (Mo)

III. Functions of nutrients for crop growth

A. Carbon, hydrogen and oxygen are needed in the plant processes of photosynthesis and respiration

(Note: Importance of photosynthesis to net gain in weight should be emphasized. Approximately 95% of weight of crop plants comes from products of photosynthesis.)

B. Primary nutrient functions

1. Nitrogen (N)

   a. Gives green color to plant

   b. Induces vigorous, rapid growth in plants

   c. Increases protein and yield

   d. Aids and promotes seed and fruit development

   (Note: Excess nitrogen causes vegetative growth and poor seed and fruit production. Nitrogen constitutes 80% of the atmosphere, yet it is one of the most critical elements for plant growth. The reason is that plants cannot utilize nitrogen as a gas; it must be combined with other elements into a plant available form.)

2. Phosphorus (P)
   a. Important to germinating seedlings
   b. Contributes to early maturing crops
   c. Necessary for seed and fruit formation
   d. Stimulates root growth
3. Potassium (K)
   a. Necessary for production and translocation of carbohydrates
   b. Produces plumper seeds
   c. Controls water intake and respiration
   d. Stiffens straw and stalks

C. Secondary nutrient functions

1. Sulphur (S)
   a. Necessary for nodule formation on legumes
   b. Associated with plant enzyme systems
   c. Stimulates seed production
   d. Affects protein and crop quality
2. Calcium (Ca)
   a. Speeds decay of organic matter
   b. Stimulates formation of nitrates
   c. Promotes root and leaf growth
   d. Necessary for nodulation of legumes
3. Magnesium (Mg)
   a. Necessary for chlorophyll or green plant color
   b. Increases absorption of phosphorus
   c. Aids in formation of fats and oils
   d. Important in plant enzyme system

IV. Symptoms of nutrient deficiencies

A. Primary nutrient deficiency symptoms

1. Nitrogen (N) (Transparency 4)

a. Stunted and spindly

b. Yellow, yellowish-green or light green color in foliage (chlorosis)

c. Older leaves affected first

(Note: Yellowing or browning starts at the tip and moves along the middle of the leaf. This occurs first on the lowest leaves of the plant.)

2. Phosphorus (P) (Transparency 5)

a. Stunted growth

b. Very dark green color

c. Purple leaves or portions of leaves in advanced stages

d. Older leaves affected first

3. Potassium (K) (Transparency 6)

a. Shorter plants

b. Bronzing or browning of leaf color

c. Lodging (bending of the stem) occurs

(Note: Leaves show yellow to brown coloring along leaf margins followed by complete browning.)

B. Secondary nutrient deficiency symptoms

1. Sulphur (S)

a. Young plants have stunted appearance

b. Leaves have a light-green to yellow coloring

c. Stems are thin and spindly

(Note: Sulphur deficiency symptoms are similar in appearance to nitrogen deficiency symptoms.)

2. Magnesium (Mg)

   a. Leaf parts between veins show a whitish color

   b. Leaf tissue becomes yellow, veins remain green (interveinal chlorosis)

   c. Leaves curl upward along the margins

   (Note: It is important to note that other conditions besides nutrient shortages may cause abnormal plant growth. Cold, wet weather, lack of sunlight, disease, insect damage and improperly applied chemicals are examples.)

V. Factors that influence fertilizer use (Transparency 7)

A. Fertility of the soil

(Note: The fertility of the soil is dependent on the availability of total nutrients in the soil, soil organic matter and can be determined by soil test.)

B. Physical condition of the soil

(Note: Moisture content, soil texture, soil structure and the ability to prevent leaching are important physical conditions to consider in fertilizer use.)

C. Crop to be grown

(Note: Nutrient needs vary between crop plants. The cost of the type of fertilizer compared to the value of the crop is an important consideration.)

D. Climatic conditions, such as temperature and moisture

E. Time of application--fall, spring or during season

VI. Soil testing to determine nutrient needs (Transparencies 8, 9, 10, 11, 12, 13, 14)

(Note: If you apply fertilizer that is not needed, you are wasting money. On the other hand, you will lower crop yields if you don't apply enough. Confusing? Sure. That's why soil testing is so highly recommended. A soil test is a guide to fertilizer needed for your farm. Consult your cooperative extension agent or refer to the "Soils Handbook" published by the College of Agriculture, University of Idaho, for more information on procedure and cost.)

A. Five main steps involved in taking a good soil sample

1. Obtain needed materials for the sample

2. Select a good time to take the sample

3. Select good sampling areas

4. Collect representative samples

5. Send the sample to a soil testing laboratory

   (Note: Soil tests are only as good as the samples taken.)

B. Materials needed for sampling

1. Soil auger or shovel to take soil cores

   (Note: Always use clean tools so sample will not be contaminated.)

2. Plastic pail for mixing core samples

   (Note: Mix sample well so sample will be representative of soil cores.)

3. Soil sample bags and information sheet

4. Map of your fields

C. When to take sample

1. After harvest, before fall fertilization

2. Spring, before spring fertilization

   (Note: Do not sample after a lime, fertilizer or manure application or when soil is excessively wet. Sampling at other times such as in winter or in a growing crop can be satisfactory if you can divide the field into uniform sampling areas and take soil samples at the proper depth.)

D. Choosing good sampling areas

1. Sampling areas depend on field size and soil types in field

2. Sampling area should represent an area with similar past management and soil types

   (Note: Soil survey maps from local SCS may be helpful in determining areas with common soil type, slope and erosion. If a recent soil survey map is not available, sampling areas should be separated on the basis of visual differences, such as texture, color and slope. Avoid areas not representative of the uniform field area, such as old fence lines, eroded areas, etc.)

E. Collecting representative samples

1. Take 8 to 12 separate cores in a zig-zag pattern from a ten-acre sampling area

1		3		5		7		9	
	2		4		6		8		10

2. Take 10 to 15 cores if the area is variable

3. Take core samples by 12 inch increments

   (Note: For nitrogen, sulphur and other mobile nutrients, sample to rooting depth. For phosphorus, potassium and the micronutrients, sample to 12 inches.)

4. Place cores in a clean, plastic pail and mix cores thoroughly

   (Note: Be sure to clear away any plant material or surface trash where core is to be taken. Plastic pail is recommended because the sample can absorb nutrients (especially zinc) from the metal coating on the bucket and give you erroneous results on the soil test.)

F. Sending sample to be tested

1. Each soil sample bag should be identified and numbered before filling

   (Note: Label all samples correctly and identify area on farm map where sample was taken.)

2. Fill soil sample bag one-half to two-thirds full with thoroughly mixed soil from pail

3. Securely close the bag

4. Complete the soil test report

   (Note: Information on cropping history and the crop to be grown is usually required on information sheet for accurate fertilizer recommendations.)

5. Send samples and the completed soil test report to the desired soil testing laboratory

   (Note: Be sure to indicate type of soil test desired. Some of the more common tests are the following: phosphorus, potassium, nitrogen, organic matter, zinc, sulphur and soil pH. Consult county agent or soil specialist in your area for the soil tests you need.)

   Note: In Idaho, take samples to local county agent, or mail to:

   Analytical Services Laboratory
   College of Agriculture
   University of Idaho
   Moscow, ID 83843-4196
   Phone: (208) 885-6201

G. How often to test soil

1. Each field should be sampled every 3 to 5 years or once in a crop rotation; nitrogen should be run each year

   (Note: If fertilizer applications do not appear to be beneficial, resampling should be done.)

VII. Completing a soil test report form--Interpreting soil test results

(Note: Numbers are meaningless without interpretation. Interpretations are based on research on response of the crop at various soil test levels. Fertilizer guides are available for most agronomic crops raised in Idaho. These guides are used in conjunction with the University of Idaho soil test results, but may also be used with soil test results from private laboratories. Each guide is specific to a crop and an area of the state. The fertilizer guides are accurate if: (1) the soil sample submitted was properly taken and represents the area to be fertilized, (2) the crop to be grown and previous history are known, and (3) reasonable management occurs.)

VIII. Plant tissue analysis to determine nutrient needs

(Note: Plant tissue analysis is an excellent tool for diagnosing nutrient status and needs for plants. It generally involves collecting a certain portion of the plant, for example: petiole, root, stem or leaf, to be analyzed. Nutrient levels vary from one part of the plant to another and change with age or maturity. Consequently, the part of the plant taken and time of sampling will depend on research that has been done on that specific crop.)

A. Collecting plant tissue sample

1. Determine part of plant to sample

   (Note: Petioles are collected for tissue sampling of potatoes and sugarbeets.)

2. Collect enough samples to be representative of a field

   (Note: 40 petioles per 160-acre field is recommended for potatoes and sugarbeets.)

3. Do not collect samples from areas that are obviously different from the rest of the field

   (Note: Do not sample edges of field or near tire tracks on center pivot irrigation systems.)

4. Follow sampling pattern

   (Note: Sampling pattern will be determined by the shape and uniformity of the field; following a pattern will help ensure the sample is representative of the field.)

5. For crops sampled periodically during the season, they should be sampled at the same time of day

   (Note: This is especially important when monitoring nitrate levels in the samples. Nitrates accumulate in plant tissue at night and are utilized by plants during the day. Nitrate levels may vary 10%-15%.)

B. Handling plant tissue sample

1. Obtain representative sample from the field

2. Partially air-dry sample

3. Fill in required information on sample form

   (Note: Consult your cooperative extension agent or refer to the "Soils Handbook" published by the University of Idaho, College of Agriculture, for more information on procedure, forms and cost.)

4. Mail to testing lab in white paper bag

   (Note: Brown bags have contamination in the glue. Either white or brown bag may be used if testing only for nitrate-nitrogen (N-NO3). Do not use plastic bag as samples will mold.)

C. Interpretation of results--Crop logging: Crop is sampled periodically throughout the growing season; the data is plotted on a graph and trends are considered deciding whether additional fertilizer is required

   (Note: Consult your extension crop specialist or management consultant for interpretation of data you have logged on your field.)

IX. Nutrient sources (Transparency 15)

A. Animal manure--The liquid and solid excrement of animals mixed with bedding material; used to supply nutrients for plant growth; helps add organic matter to the soil

   (Note: Organic matter is the soil's storehouse for nitrogen. Almost all of the N in the soil is part of the organic matter. When organic matter decomposes, N is released and changes to available forms for plant use. The nutrient content of animal manure may vary considerably under different livestock production systems, amount and type of bedding and methods of handling the manure produced.)

B. Crop residues--Leaves, stems, roots and other parts of plants remaining in the field after harvest, for example: wheat stubble, corn stover, potato vines, sugarbeet tops, etc.

C. Green manure crops--A crop grown to be plowed under in a green, succulent condition for soil improvement purposes; usually a legume crop which fixes atmospheric nitrogen, such as black peas, clover or vetch

D. Commercial fertilizers--Commercially prepared plant nutrients are applied to soils to increase their productivity by supplying additional essential nutrients

X. Information on fertilizer (bulk or bags) (Transparency 16)

A. The net weight

B. Name and address of manufacturer or distributor

C. The guaranteed analysis of the material

D. Name, brand or trademark

(Note: Fertilizer materials are sold by the bag, gallon or tank truck, pressure tank and dry bulk in trucks. It is important to remember that state laws require the seller of fertilizer to guarantee the nutrient content to the buyer. This information is listed on a tag or on the bag. Bulk fertilizer sales must have the same information on the invoice. If problems arise, contact the State Department of Agriculture, Boise, Idaho.)

XI. Fertilizer analysis (Transparency 17)

(Note: A fertilizer analysis consists of three numbers. These three figures indicate the water soluble plant nutrient content of the material. The first figure represents the actual pounds of nitrogen in 100 pounds of fertilizer. The second figure represents the actual pounds of phosphorus expressed as P2O5. The third figure represents the actual pounds of water soluble potassium expressed as K2O. The fourth number, if present, represents the actual pounds of sulfur.)

A. Ordinary analysis--Less than 20% plant nutrients

Example: 5-5-5

B. High analysis--20% to 30% plant nutrients

Example: 5-10-5

C. Concentrated analysis--Over 30% plant nutrients

Example: 20-20-20 or 83-0-0

XII. Types of fertilizers

A. Liquid--Fertilizer made by dissolving the correct proportion of the solid plant nutrient carriers into water; may be in solution or suspension

B. Dry mixed--Granulated fertilizer made by combining selected plant nutrient materials to obtain certain ratios and quantities of plant nutrients

C. Gas--Liquid fertilizer containing solid fertilizer materials which is dispensed under pressure and usually contains a higher analysis than clear liquid mixes

XIII. Comparing costs of fertilizer materials (Transparencies 18, 19)

(Note: Compare fertilizer prices on the basis of cost per pound of nutrient, not on the cost per pound of fertilizer material.)

A. Calculating cost per pound of nutrients:

$$\frac{\text{Price of Fertilizer Per Pound of Material}}{\text{Guaranteed Percentage}}$$

Example: Fertilizer analysis -- 20 - 10 - 10
Fertilizer cost -- $150.00/ton or 7.5¢/lb

$$\frac{7.5¢/\text{lb}}{40\%} = 18.75¢/\text{lb of nutrient}$$

B. Calculating cost of materials that contain only one nutrient

(Note: The same formula is used.)

Example: Fertilizer analysis -- 45 - 0 - 0 (Urea)
Fertilizer cost -- $240.00/ton or 12¢/lb

$$\frac{12¢/\text{lb}}{0.45} = 26.6¢/\text{lb of N}$$

XIV. Formulate a fertilizer blend (Transparency 20)

A. Needed information

1. Amount of nutrients to be applied

(Note: This refers to amount of nutrients and not to amount of fertilizer. Usually determined from a soil test report, past experience or field man recommendation.)

2. Available fertilizers

3. Method of application

EXAMPLE:

a. Want to apply 40 lbs of nitrogen/acre, 40 lbs P_2O_5/acre and 20 lbs of K_2O/acre

b. Available fertilizers

(1) 34 - 0 - 0 (ammonium nitrate)

(2) 18 - 46 - 0 (diammonium phosphate)

(3) 0 - 0 - 60 (potassium chloride)

c. Formula for calculating fertilizer amount

$$\frac{\text{Amount of Nutrient to Apply/Acre}}{\text{\% Nutrient in Fertilizer Used}} = \text{Amount of Fertilizer To Apply Per Acre}$$

d. Steps to follow:

(1) Potash requirements from potassium chloride

$$\frac{20 \text{ lbs/acre}}{.60} = 33 \text{ lbs/acre of 0-0-60}$$

(2) Phosphate requirements from diammonium phosphate

$$\frac{40 \text{ lbs/acre}}{.46} = 87 \text{ lbs/acre of 18-46-0}$$

(3) How much nitrogen would 87 lbs of 18-46-0 supply?

87 lbs/acre x .18 = 16 lbs N/acre

(4) How much additional nitrogen is needed?

40 lbs N/acre - 16 = 24 lbs N needed

(5) Additional nitrogen requirements from ammonium nitrate

$$\frac{24 \text{ lbs/acre}}{.34} = 71 \text{ lbs/acre of 34-0-0}$$

(6) Results:

87 lbs/acre of 18-46-0
71 lbs/acre of 34-0-0
<u>33 lbs/acre of 0-0-60</u>
191 lbs/acre total

XV. Methods of fertilizer application

A. Broadcast

1. Truck mounted fertilizer spreader
2. Trailer mounted fertilizer spreader
3. Truck mounted liquid fertilizer applicator
4. Field sprayer
5. Aerial application

B. Soil injection

1. Anhydrous ammonia

2. Nitrogen liquid solution under pressure

C. Banding

1. Dry fertilizer with planter

2. Liquid or suspension fertilizer with planter

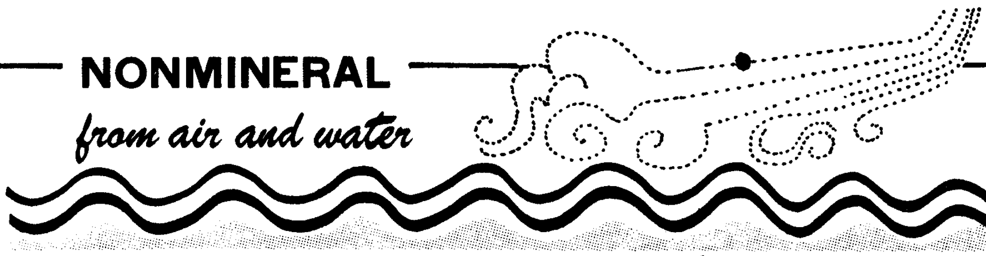
3. Liquid or suspension with side dress application

D. With irrigation water

CHEMICAL ELEMENTS ESSENTIAL TO PLANT GROWTH

NONMINERAL

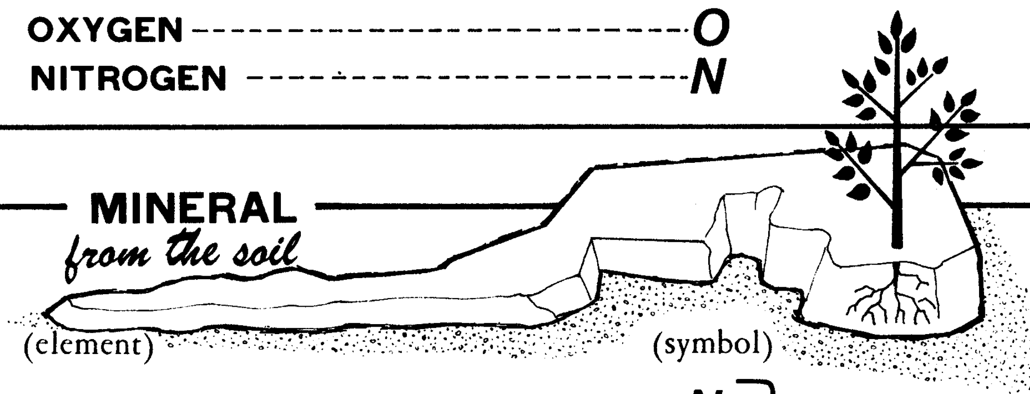
from air and water



(element)	(symbol)
CARBON	C
HYDROGEN	H
OXYGEN	O
NITROGEN	N

MINERAL

from the soil

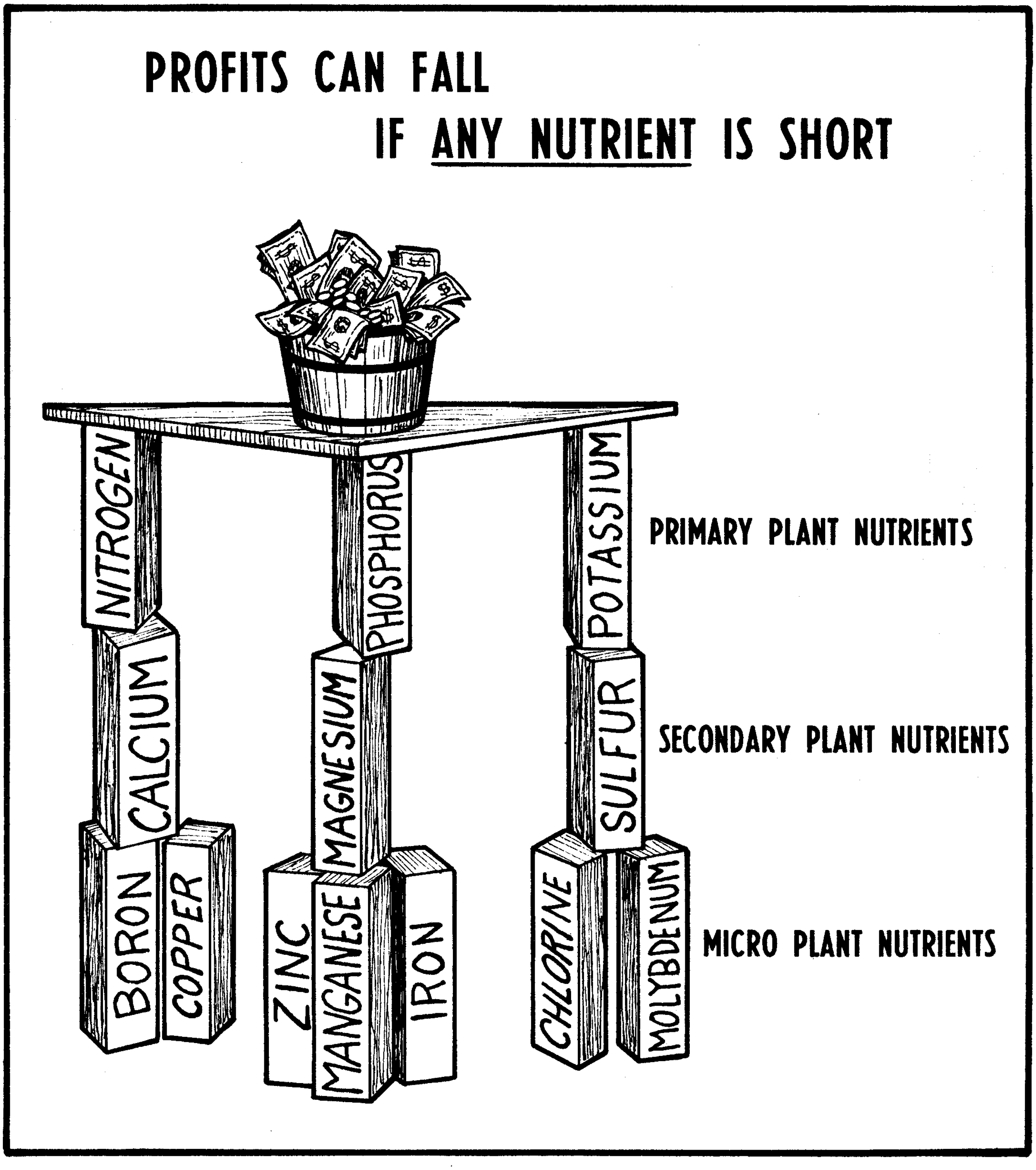


(element)	(symbol)	
NITROGEN	N	PRIMARY NUTRIENTS
PHOSPHORUS	P	
POTASSIUM	K	
CALCIUM	Ca	SECONDARY NUTRIENTS
MAGNESIUM	Mg	
SULFUR	S	
IRON	Fe	MICRO-NUTRIENTS
BORON	B	
MANGANESE	Mn	
COPPER	Cu	
ZINC	Zn	
MOLYBDENUM	Mo	
CHLORINE	Cl	

TEN ESSENTIAL ELEMENTS

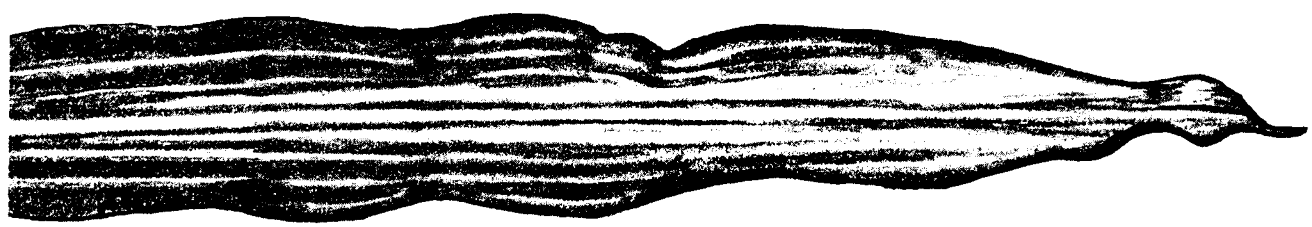
ESSENTIAL ELEMENT	SIMPLE SAYING
Carbon (C)	C.
Hydrogen (H)	H
Oxygen (O)	O
Phosphorus (P)	P
Potash (K)	K
Nitrogen (N)	N
Sulphur (S)	S
Calcium (Ca)	CA
Iron (Fe)	FE
Magnesium (Mg)	Mighty Good

C. HOPKNS CAFE Mighty Good


PROFITS CAN FALL
IF ANY NUTRIENT IS SHORT
NITROGEN
PHOSPHORUS
POTASSIUM
PRIMARY PLANT NUTRIENTS
CALCIUM
MAGNESIUM
SULFUR
SECONDARY PLANT NUTRIENTS
BORON
COPPER
ZINC
MANGANESE
IRON
CHLORINE
MOLYBDENUM
MICRO PLANT NUTRIENTS

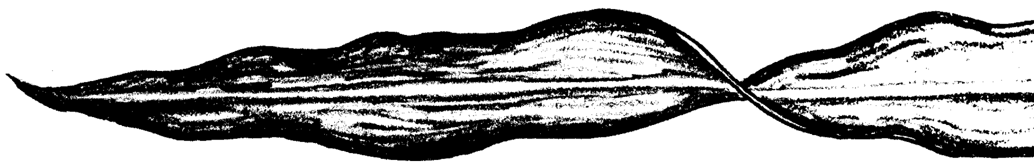
NITROGEN deficiency in corn

SMALL EARS AND LOW PROTEIN CONTENT
RESULT FROM N DEFICIENCY

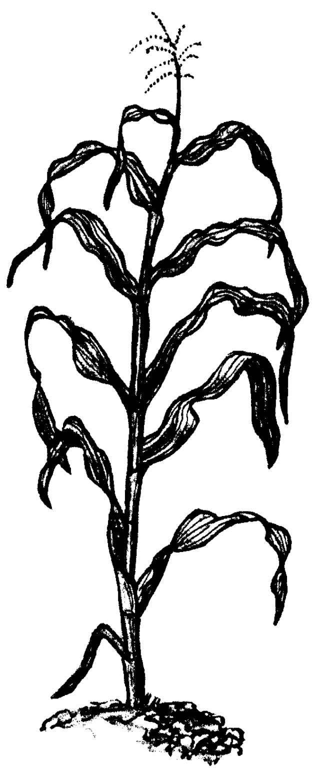


YELLOWING STARTS AT TIP AND MOVES
ALONG MIDDLE OF LEAF

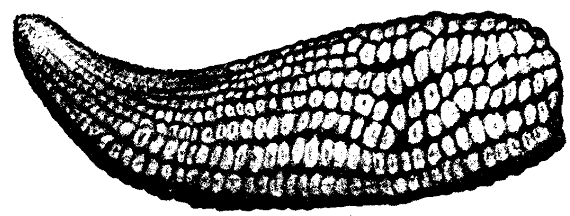
PHOSPHATE deficiency in corn



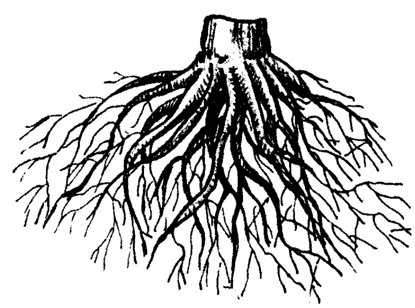
P SHORTAGE MARKS LEAVES WITH REDDISH-PURPLE COLOR



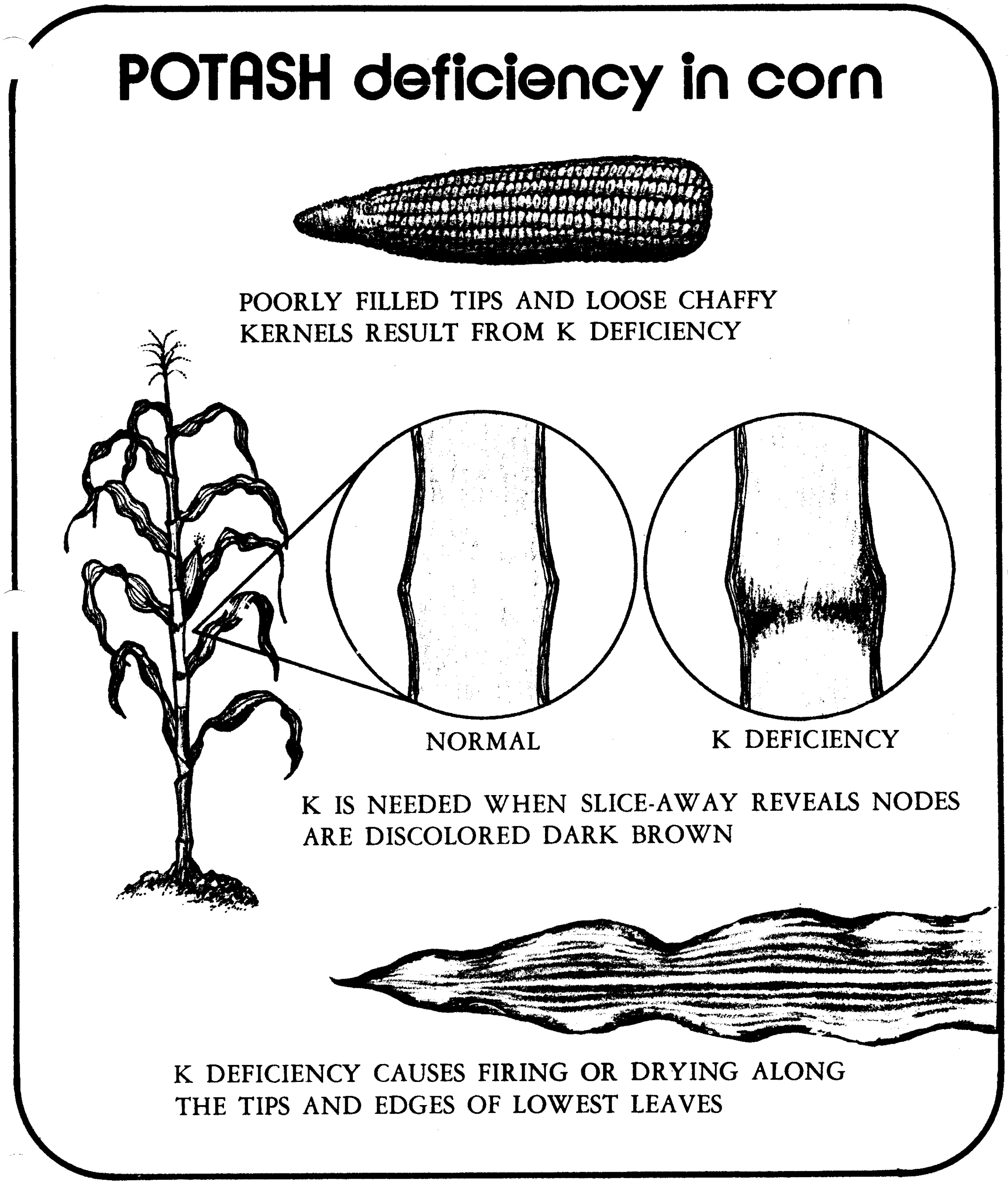
P CONTROLS STALK SIZE AND EAR SET; WHEN THERE'S A SHORTAGE, STALKS ARE WEAK, SPINDLY AND OFTEN BARREN OF EARS



P IS NEEDED WHEN EARS ARE SMALL AND TWISTED AND KERNELS ARE UNDEVELOPED



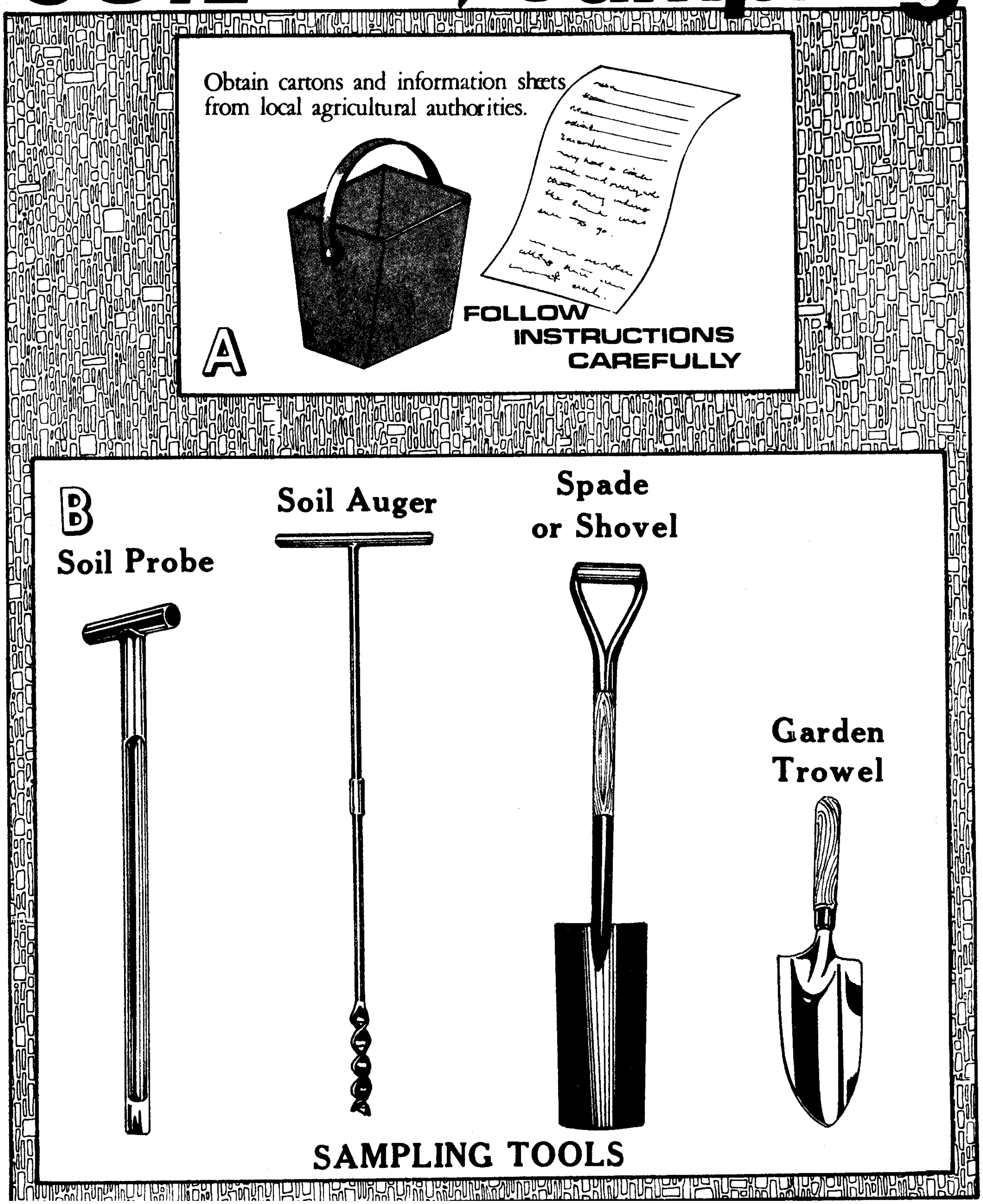
P SHORTAGE DURING EARLY WEEKS CAUSES A SHALLOW ROOT SYSTEM WITH LITTLE SPREAD

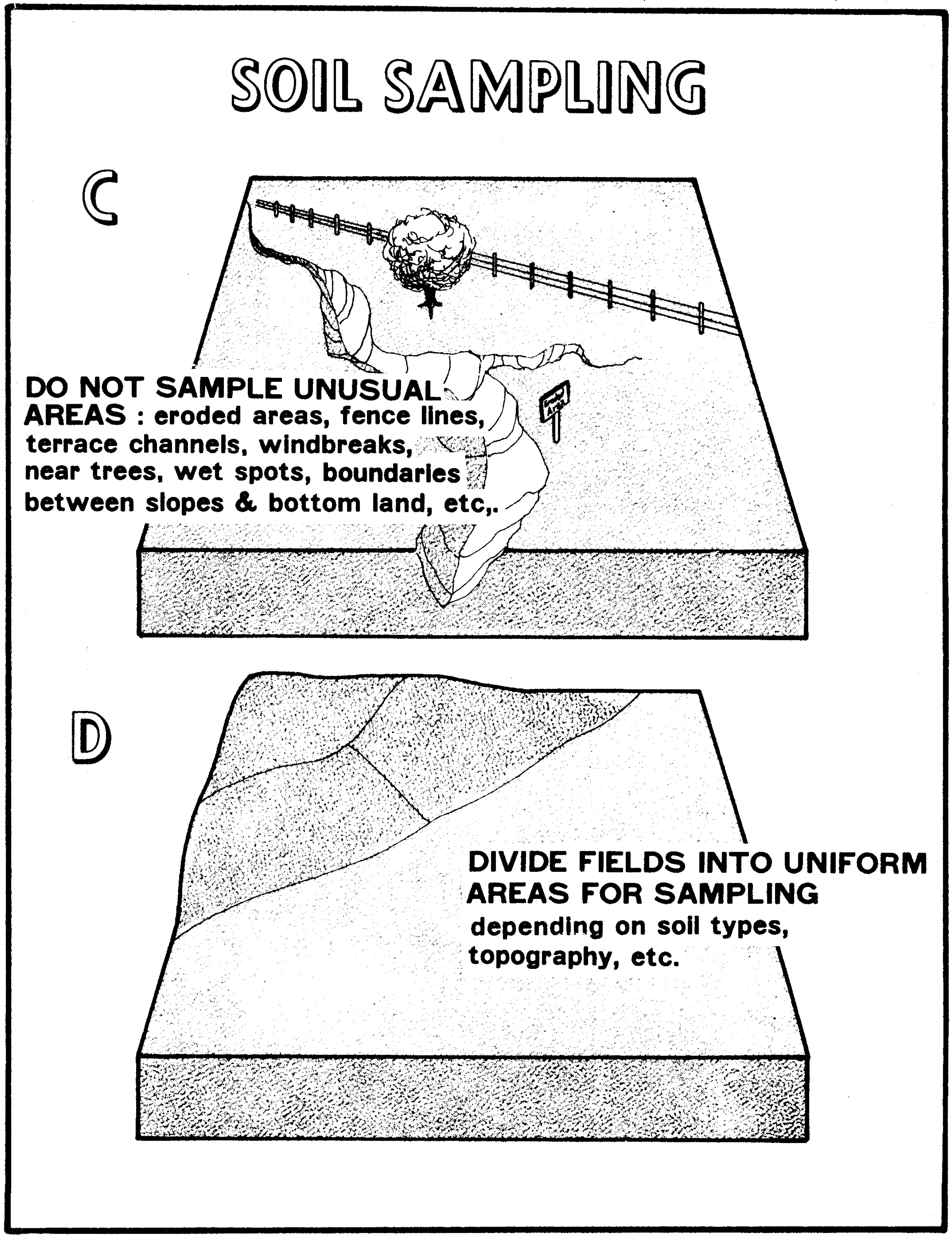

POTASH deficiency in corn
POORLY FILLED TIPS AND LOOSE CHAFFY KERNELS RESULT FROM K DEFICIENCY
NORMAL
K DEFICIENCY
K IS NEEDED WHEN SLICE-AWAY REVEALS NODES ARE DISCOLORED DARK BROWN
K DEFICIENCY CAUSES FIRING OR DRYING ALONG THE TIPS AND EDGES OF LOWEST LEAVES

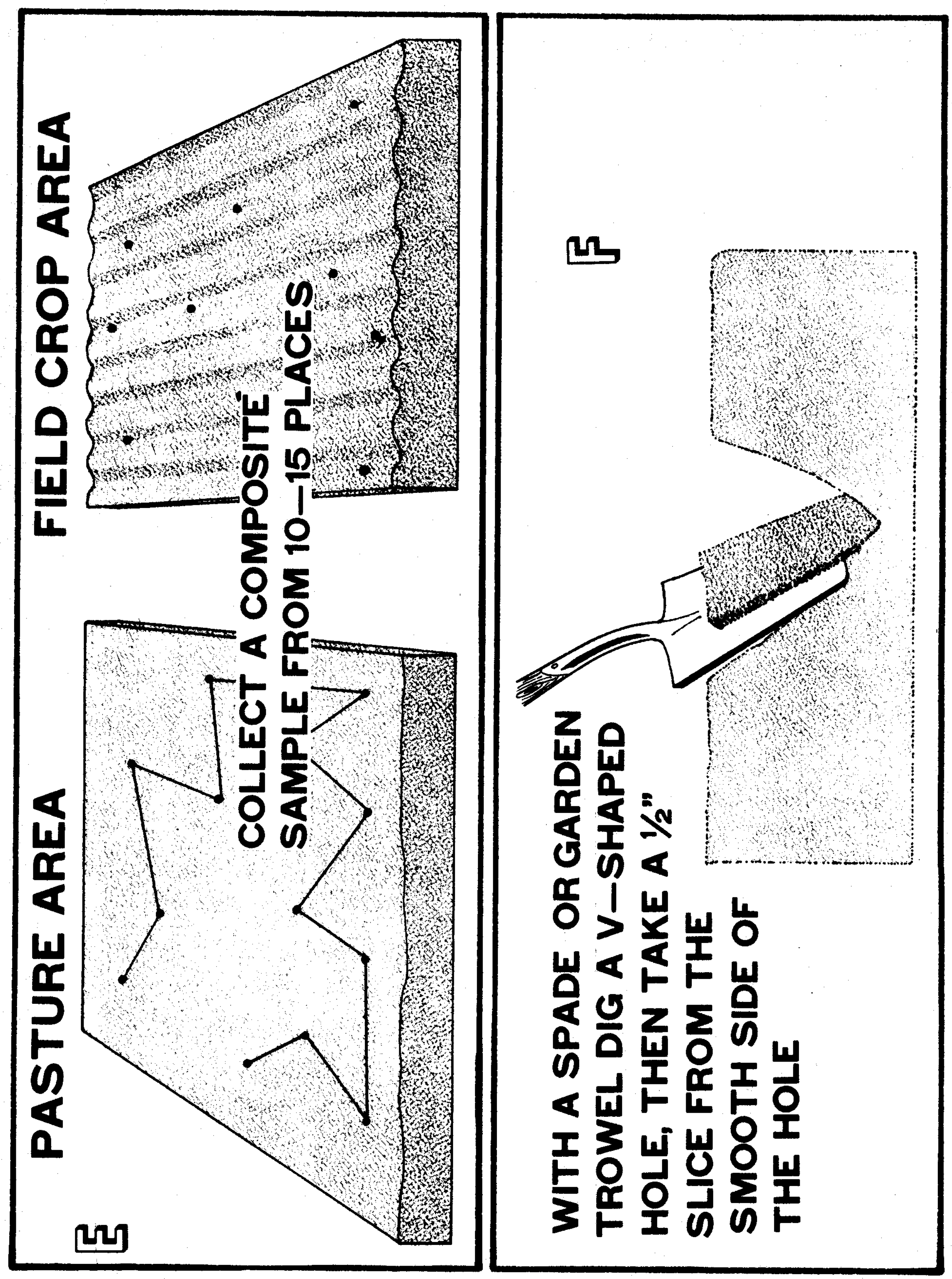
Factors That Influence Fertilizer Use

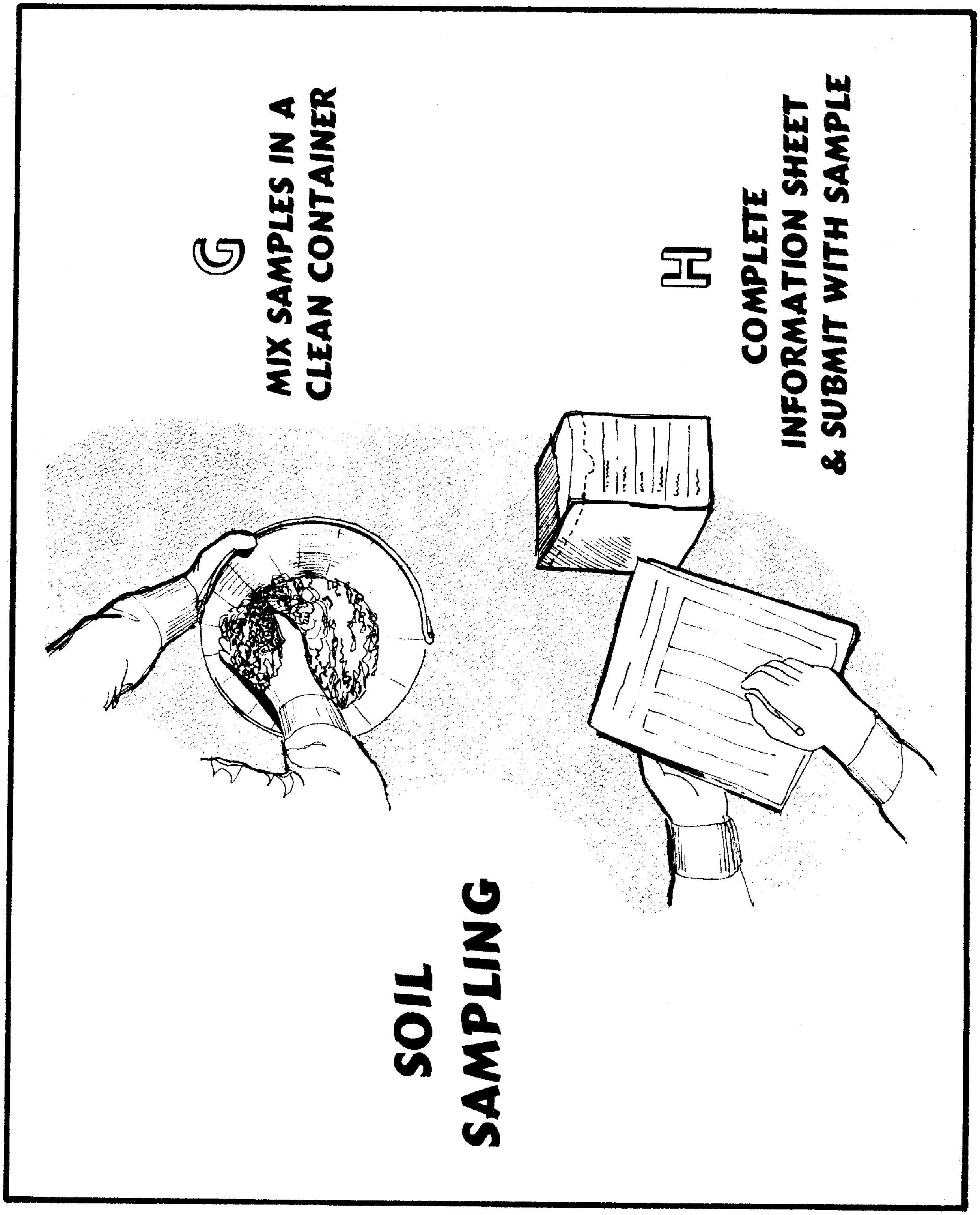
1. Chemical condition of the soil
2. Physical condition of the soil
3. Crop to be grown
4. Climatic conditions
5. Time

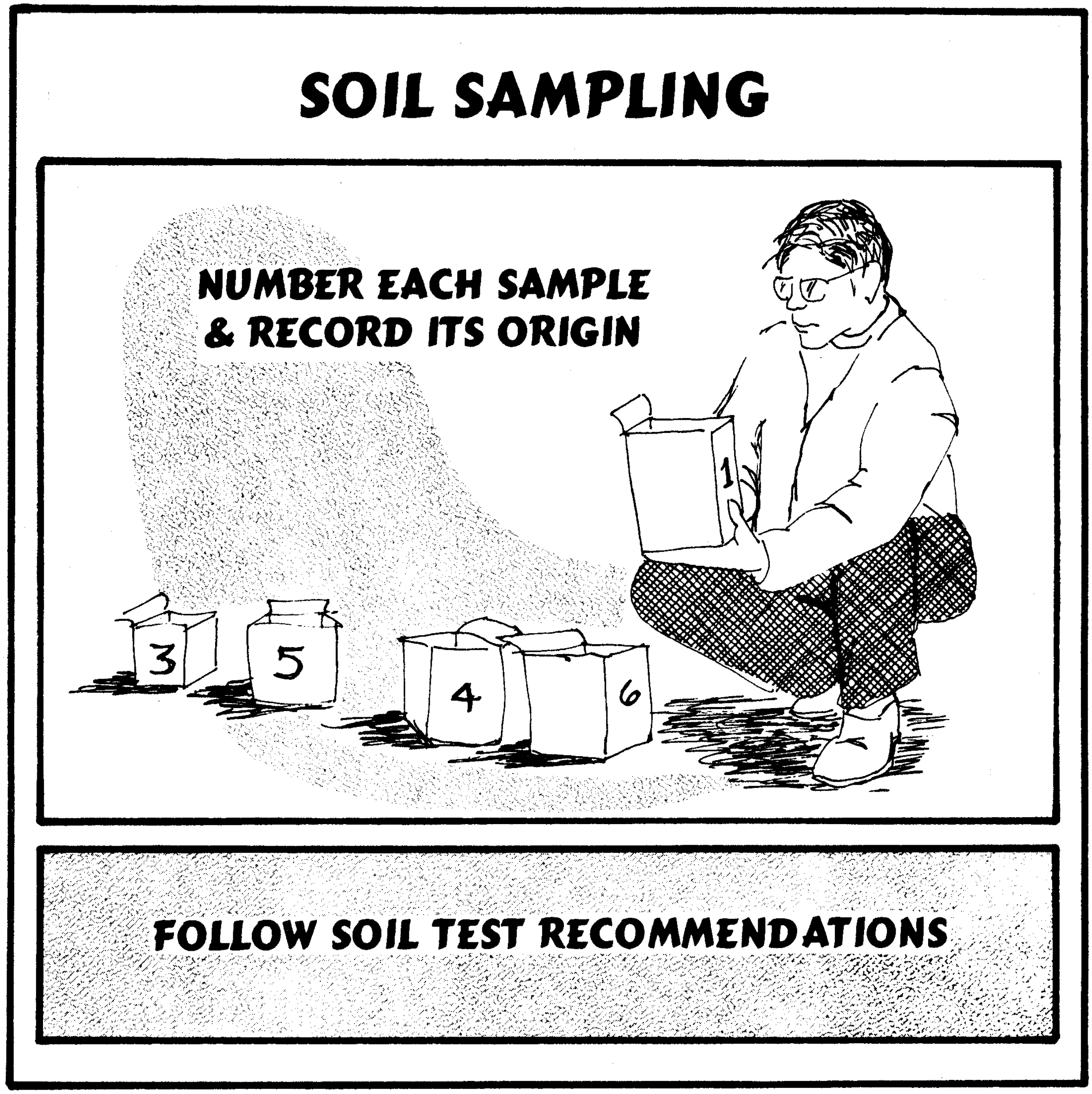
SOIL → Sampling




SOIL SAMPLING
C
DO NOT SAMPLE UNUSUAL AREAS : eroded areas, fence lines, terrace channels, windbreaks, near trees, wet spots, boundaries between slopes & bottom land, etc,.
D
DIVIDE FIELDS INTO UNIFORM AREAS FOR SAMPLING
depending on soil types, topography, etc.

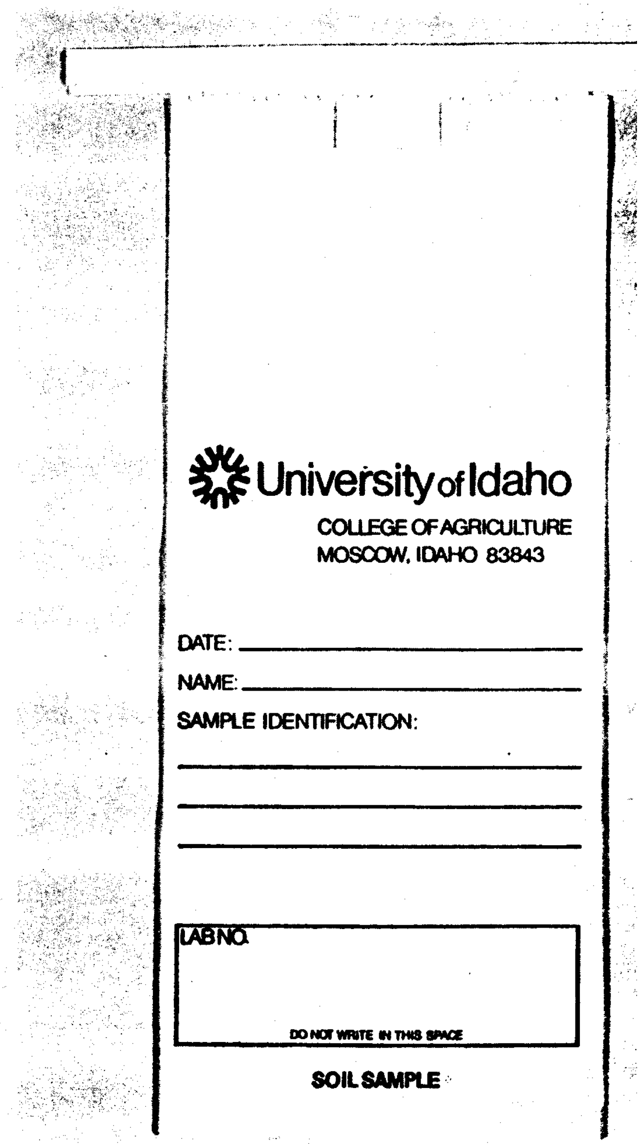

SOIL SAMPLING
E
PASTURE AREA
FIELD CROP AREA
COLLECT A COMPOSITE SAMPLE FROM 10—15 PLACES
F
WITH A SPADE OR GARDEN TROWEL DIG A V—SHAPED HOLE, THEN TAKE A ½" SLICE FROM THE SMOOTH SIDE OF THE HOLE


SOIL
SAMPLING
G
MIX SAMPLES IN A
CLEAN CONTAINER
H
COMPLETE
INFORMATION SHEET
& SUBMIT WITH SAMPLE


SOIL SAMPLING
NUMBER EACH SAMPLE & RECORD ITS ORIGIN
1
3
5
4
6
FOLLOW SOIL TEST RECOMMENDATIONS

Soil Sample Bag

1. Identify and number each sample before filling.
2. Fill soil sample bag 1/2 to 2/3 full with mixed soil from pail.
3. Securely close the bag.
4. Complete soil test report form by filling in field information section and checking the soils tests desired.
5. Send immediately to testing laboratory.



Soil Test Request and Report Form

Form #88

Analytical Services Laboratory
College of Agriculture
Moscow, ID 83843-4196
(208) 885-6201

University of Idaho

DO NOT WRITE IN THIS SPACE
Lab no. ______
Fee ______
Status: Paid Bill Other ______
Check no. ______

Mailing Name ______________________ Phone: ______________

Address ______________________

______________________ Date: ______________

____

FIELD INFORMATION			
Irrigation: ☐ Sprinkler ☐ Furrow ☐ None			
Rotation	Crop	Fertilizer applied lb/acre	Yield
Next crop			
Previous crop			
Grown in 19( )			
Grown in 19( )			

County: ______________

Grower: ______________

Sample Identification:

____

____

____

☑ CHECK TEST REQUIRED: Please make checks payable to **Bursar, University of Idaho.**

☐ Standard Fertility Test* ($10.00)
*Includes drying and grinding ($1.50), pH, P, K and O.M.

___ Bicarbonate P & K ___ Acetate P & K

☐ pH (soil reaction)	$ 1	
☐ Available P (ppm P)	$ 3	
☐ Available K (ppm K)	$ 3	
☐ Organic matter (%)	$ 3	
Other Tests:		
☐ Sulfate-S (ppm S)	$ 3	
☐ Boron (ppm B)	$ 5	
☐ Total Salts (E.C.) (mmhos/cm)	$ 2	
☐ Gypsum Requirement	$20	
☐ Lime Requirement	$ 4	
☐ Cation Exchange Capacity (meq/100g)	$ 7	
☐ Zinc (ppm Zn)	$ 4	
☐ Copper (ppm Cu)	$ 4	
☐ Manganese (ppm Mn)	$ 4	
☐ Iron (ppm Fe)	$ 4	

Depth (feet)	Nitrate N (ppm)	Ammonium N (ppm)	Available Moisture (inches)
0-1	☐	☐	☐
1-2	☐	☐	☐
2-3	☐	☐	☐
3-4	☐	☐	☐
4-5	☐	☐	☐
5-6	☐	☐	☐
6-7	☐	☐	☐
Total			

$3 per test ppm × 4 = lb/acre

Cations:	Extractable	Soluble
Calcium	☐	☐
Magnesium	☐	☐
Sodium	☐	☐
Potassium	☐	☐

$3 per test SAR ______

Contact the Analytical Services Laboratory for other special analyses.

FERTILITY GUIDE

Pounds Per Acre						
N	P_2O_5	K_2O				

Remarks: ______________________

____

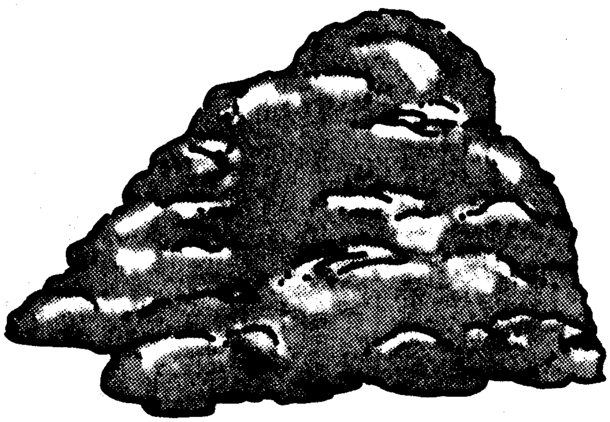
____

TM 14

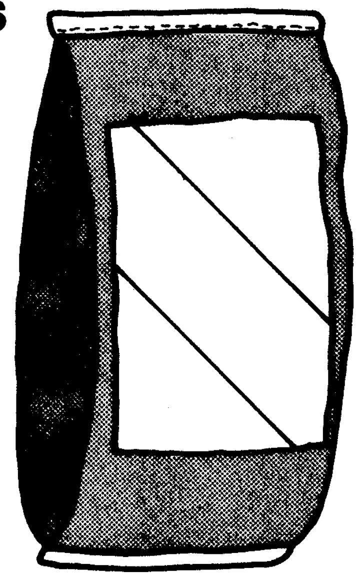
If you wish further details or have questions concerning the soil analysis, please contact your University of Idaho County Extension Agent.

White — Grower copy • Yellow — Fertilizer Dealer copy • Pink — Ag Agent copy • Goldenrod — Laboratory copy

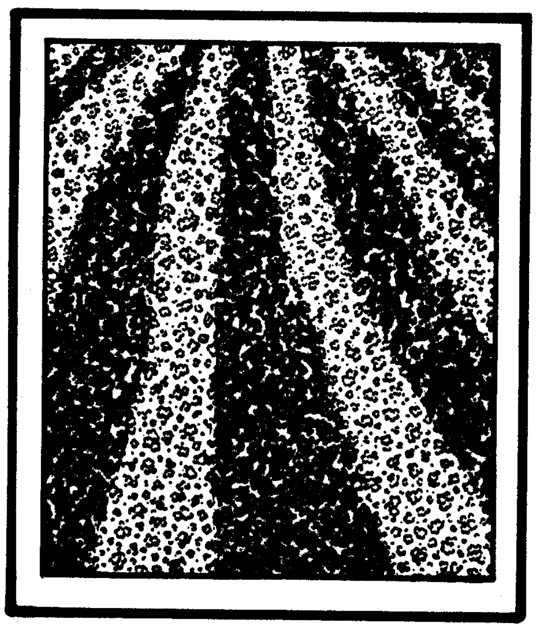
Nutrient Sources



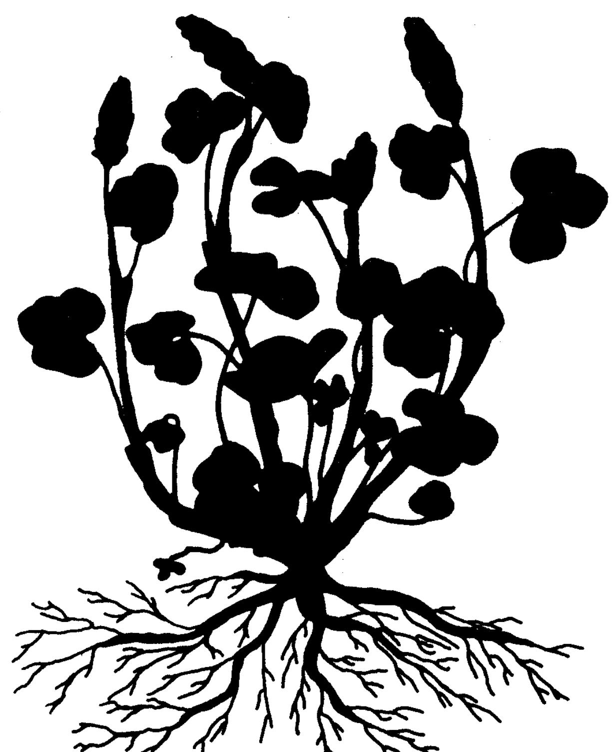
Animal manure



Commercial fertilizers

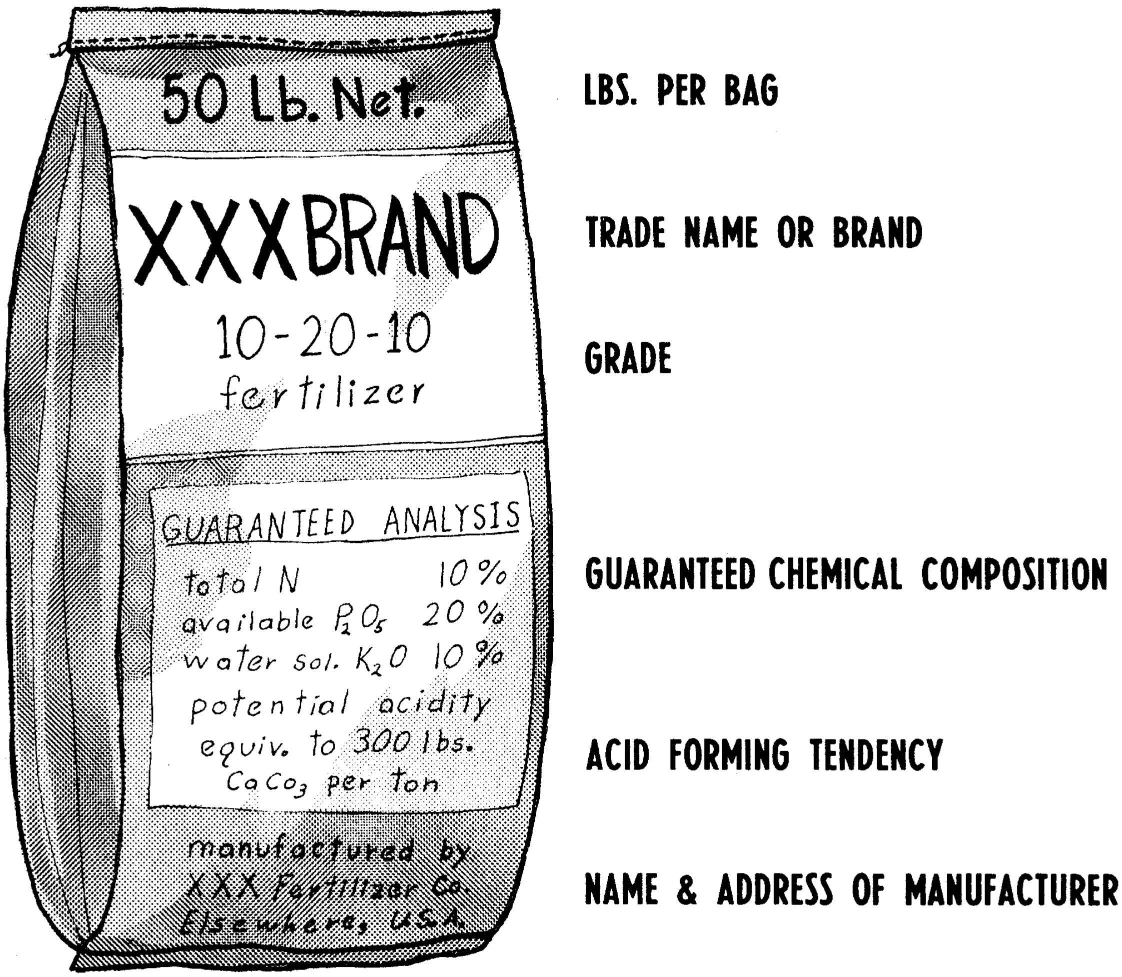


Crop residues



Green manure crop

INFORMATION COMMONLY FOUND ON A FERTILIZER BAG

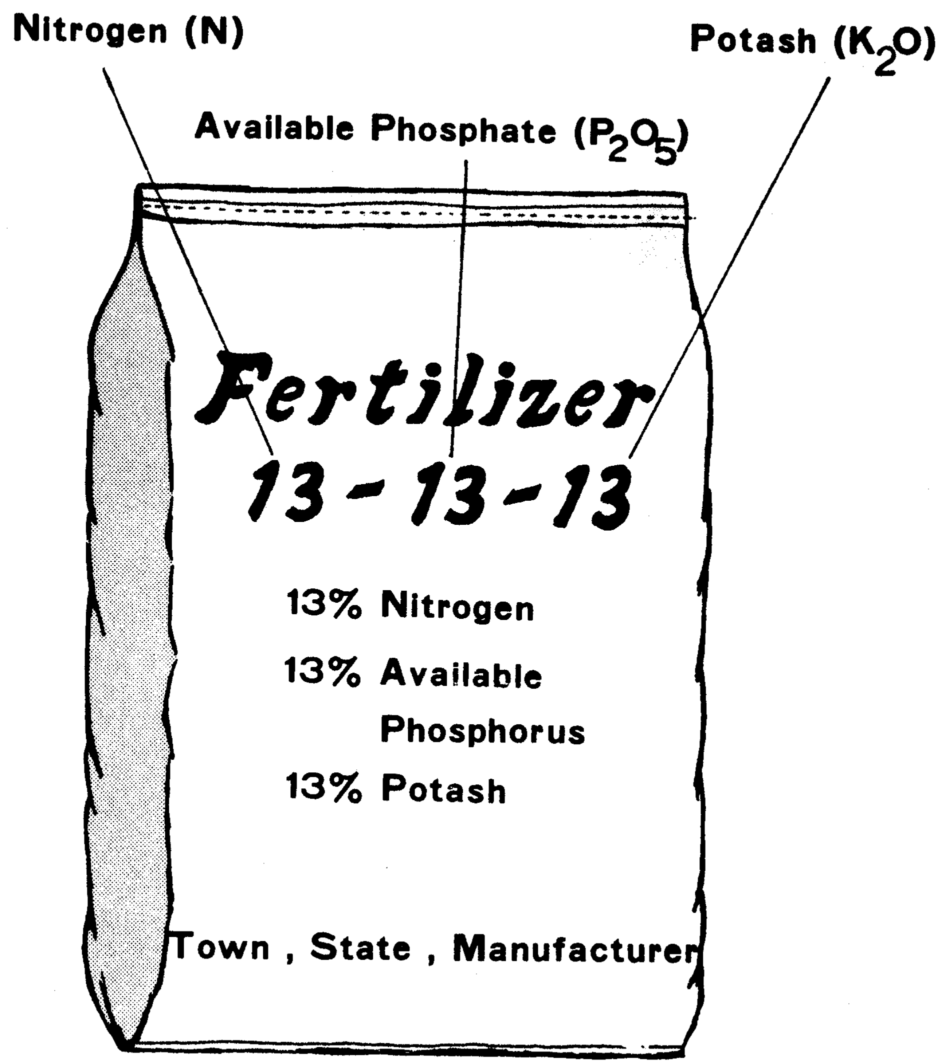


Fertilizer Analysis

20 - 10 - 10

Total nitrogen available	Total phosphorus expressed as P_2O_5	Water soluble potash expressed as K_2O

PLANT NUTRIENT BLENDS



13 N — 13 P_2O_5 — 13 K_2O = 1—1—1 Ratio

13 Lbs. of Each Primary Nutrient = 39 Lbs. per 100 Lbs. of Fertilizer

Compare Cost Per Pound of Nutrient, **Not** Cost Per Pound of Fertilizer!

$$\frac{\text{Price of fertilizer}}{\text{Net weight in lbs.} \times \text{Guaranteed \%}} = \text{Price per pound of nutrient}$$

Calculate Amount of Fertilizer to Apply

$$\frac{\text{Amount to apply per acre}}{\text{\% nutrient in fertilizer}} = \text{Amount of fertilizer to apply per acre}$$

SOIL FERTILITY

AG 510 - B

ASSIGNMENT SHEET #1--CALCULATE NUMBER OF POUNDS OF ACTUAL NITROGEN, PHOSPHORUS AND POTASSIUM AVAILABLE FROM DIFFERENT FERTILIZER ANALYSES

Name______________________________________ Score__________________________

Compare the pounds of actual nitrogen, phosphorus and potassium available for each fertilizer. Use 80# as a base for all problems. When you have completed the problems, return to your instructor for evaluation.

a. Fertilizer analysis 10-20-10 _____ N _____ P _____ K

b. Fertilizer analysis 18-46-0 _____ N _____ P _____ K

c. Fertilizer analysis 13-0-44 _____ N _____ P _____ K

d. Fertilizer analysis 82-0-0 _____ N _____ P _____ K

e. Fertilizer analysis 0-45-0 _____ N _____ P _____ K

SOIL FERTILITY

AG 510 - B

ASSIGNMENT SHEET #2--CALCULATE COST PER POUND OF NITROGEN FOR DIFFERENT FERTILIZER ANALYSES

Name____ Score_______________________________

Compare the cost per pound of actual nitrogen for each fertilizer. When you have completed the problems, return to your instructor for evaluation. Ask instructor for the local price per ton of each analysis.

	Fertilizer	Local price/ton	Cost per pound N
1.	Ammonium nitrate 33.0%	__________________	__________________
2.	Anhydrous ammonia 82.0%	__________________	__________________
3.	Urea 45.0%	__________________	__________________
4.	Ammonium sulfate 21.0%	__________________	__________________

SOIL FERTILITY

AG 510 - B

ASSIGNMENT SHEET #3--CALCULATE APPLICATION RATES OF FERTILIZERS

Name____ Score_________________________

Calculate the amount of nutrients needed using the different fertilizer analyses. When completed, return to instructor for evaluation.

a. A farmer desires to plant wheat with an application of 100 lbs phosphate per acre with a 0-20-0 analysis. How many pounds of fertilizer would be needed?

b. How many pounds of 0-0-60 would be needed to apply 40 lbs of K20 per acre?

c. How many pounds of 82-0-0 would be needed to apply 100 lbs of N per acre?

SOIL FERTILITY

AG 510 - B

ASSIGNMENT SHEET #4--FORMULATE A FERTILIZER BLEND, CALCULATE TOTAL COST AND COST PER ACRE

Name____ Score_______________________________

You are raising 40 acres of silage corn. Following a soil test, you and the county agent determine that you need to apply 80 lbs N per acre, 40 lbs of P per acre and 10 lbs of Potassium per acre. The fertilizers available at the local cooperative are: (1) Urea 46-0-0 at $184.00 per ton, (2) Diammonium Phosphate 18-46-0 at $192.00 per ton, and (3) Potassium Chloride 0-0-60 at $120.00 per ton.

a. Formulate a fertilizer blend, using the available fertilizers, that will meet your requirements.

b. What will be the total cost per acre using your fertilizer blend?

c. What will be the total cost for 40 acres using your fertilizer blend?

SOIL FERTILITY

AG 510 - B

ASSIGNMENT SHEET #5--COMPLETE A SOIL TEST REPORT FORM

Name____ Score__________________________

Secure a soil sample and answer the necessary information concerning the crop to be grown and the cropping history of the plot. Check the type of soil test desired. Have the sample analyzed. Using fertilizers available in your community and local prices, recommend the fertilizers to use and the amount. When completed, return to instructor for evaluation and discussion purposes.

(Note: Soil Test Report Forms, fertilizer guides and instructions may be obtained from your local cooperative extension agent.)

Available Fertilizers	Cost/Ton	Amount Require	Total Cost
1.			
2.			
3.			
4.			

SOIL FERTILITY

AG 510 - B

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

a. 8# N, 16# P, 8# K

b. 14.4# N, 36.8# P, 0# K

c. 10.4# N, 0# P, 35.2# K

d. 65.6# N, 0# P, 0# K

e. 0# N, 36# P, 0# K

Assignment Sheet #2

Cost will vary according to local cost of fertilizers.

Assignment Sheet #3

a. 500 lbs of 0-20-0

b. 67 lbs of 0-0-60

c. 122 lbs of 82-0-0

Assignment Sheet #4

a. 17# of 0-0-7 (potassium chloride)

87# of 18-46-0 (diammonium phosphate)

139# of 46-0-0 (urea)
243# of fertilizer per acre

b. 17# of 0-0-60 @ 6¢/lb = $1.02

87# of 18-46-0 @ 10¢/lb = $8.70

139# of 46-0-0 @ 9¢/lb = $12.51
Cost per acre = $22.23

c. $22.23 X 40 acres = $889.20

Assignment Sheet #5

Evaluated to satisfaction of instructor.

SOIL FERTILITY

AG 510 - B

UNIT TEST

Name____ Score__________________________

1. Match terms associated with soil fertility to the correct definitions. Write the correct numbers in the blanks.

_____a.	Natural, manufactured or processed material or mixture of materials that contains one or more of the essential nutrients; available in dry, liquid or gaseous form		1.	Essential nutrient
			2.	Deficiency
			3.	Symptom
_____b.	Plant condition where an essential nutrient is not sufficiently available		4.	Fertilizer
_____c.	Percentage water soluble content of nitrogen (N), phosphorus (P) expressed as P_2O_5 and potassium (K) expressed as K_2O in the fertilizer		5.	Analysis
			6.	Brand
_____d.	Trademark of the company which produced the fertilizer		7.	Complete fertilizer
_____e.	A visual sign or condition that results from a deficiency; aids in diagnosing a deficiency			
_____f.	Fertilizer which supplies all three of the primary nutrients (N, P, K)			
_____g.	Element necessary for plant growth and reproduction, for example: nitrogen, phosphorus and potassium			

2. Classify the following essential nutrients as primary (P), secondary (S) or micronutrient (M). Write the correct letters in the blanks.

_____a. Sulphur (S)

_____b. Potassium (K)

_____c. Zinc (Zn)

_____d. Nitrogen (N)

_____e. Calcium (Ca)

_____f. Phosphorus (P)

_____g. Boron (B)

_____h. Molybdenum (Mo)

_____i. Iron (Fe)

_____j. Magnesium (Mg)

3. Match the functions of nutrients for crop growth to the correct nutrient. Write the correct numbers in the blanks.

_____a. Gives dark green color to plant; promotes rapid growth; increases protein and yields; aids and promotes seed and fruit development

_____b. Speeds decay of organic matter; stimulates formation of nitrates; promotes root and leaf growth; is necessary for nodulation of legumes

_____c. Necessary for production and translocation of carbohydrates; produces plumper seeds; controls water intake and respiration; stiffens straw and stalks

_____d. Necessary for chlorophyll or green plant color; increases absorption of phosphorus; aids in formation of fats and oils; important in plant enzyme system

_____e. Important to germinating seedlings; contributes to early maturing crops; necessary for seed and fruit formation; stimulates root growth

_____f. Necessary for nodule formation on legumes; associated with plant enzyme systems; stimulates seed production; affects protein and crop quality

1. Nitrogen (N)
2. Phosphorus (P)
3. Potassium (K)
4. Sulphur (S)
5. Calcium (Ca)
6. Magnesium (Mg)

4. Match nutrients to the correct deficiency symptoms. Write the correct numbers in the blanks.

_____a. Stunted and spindly; yellow, yellowish-green or light green color in foliage; older leaves affected first

_____b. Stunted growth; very dark green color; purple leaves in advanced stages; older leaves affected first

_____c. Shorter plants; bronzing or browning of leaf color; lodging occurs

_____d. Young plants have stunted appearance; leaves light green to yellow color; stems are thin and spindly

_____e. Leaf parts between veins show a whitish color; interveinal chlorosis; leaves curl upward along the margins

1. Magnesium
2. Sulphur
3. Nitrogen
4. Potassium
5. Phosphorus

5. Select from the following list factors that influence the use of fertilizers. Write an "X" in the blank before each correct answer.

    _____a. Fertility of soil

    _____b. Crops to be grown

    _____c. Physical condition of soil

    _____d. Insects

    _____e. Climatic conditions

    _____f. Diseases

    _____g. Time of application

6. Discuss the major points in collecting and handling a representative soil sample.

    ____

    ____

    ____

    ____

    ____

    ____

    ____

    ____

    ____

7. Using the following information for irrigated field corn, calculate the pounds of nitrogen to apply per acre. Show all work.

    a. Field information

        1. Soil pH--6.7

        2. Available total N--15 ppm (0-24" depth)

        3. Previous crop--Barley; 3 tons/acre residue returned

b. Nitrogen fertilizer rated based on N soil test

N soil test (0-24" depth) N (ppm)	N application * (lb. N/acre)
0	160
10	120
20	80
30	40
over 40	0

* Add 20 lbs N for each ton of grain straw plowed under up to 50 lbs N/acre

c. Pounds of N to apply per acre ______________________________

____

____

____

8. Discuss the major points in collecting and handling a representative plant tissue sample.

____

____

____

____

____

____

9. List four sources of nutrients.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

10. Select from the following list the information that must be stamped on all fertilizer bags according to state law. Write an "X" in the blank before each correct answer.

_____a. Net weight

_____b. Name, brand or trademark

_____c. Cost per pound

_____d. Name and address of manufacturer or distributor

_____e. Guaranteed analysis of the material

_____f. Materials added for bulk

11. Match the fertilizer analyses to the correct description. Write the correct numbers in the blanks.

_____a.	Over 30% plant nutrients	1.	High analysis
_____b.	20% to 30% plant nutrients	2.	Ordinary analysis
_____c.	Less than 20% plant nutrients	3.	Concentrated analysis

12. Match the types of fertilizers to the correct description. Write the correct numbers in the blanks.

_____a.	Granulated fertilizer made by combining selected plant nutrient materials to obtain certain ratios and quantities of plant nutrients	1.	Liquid
		2.	Dry mixed
_____b.	Liquid fertilizer containing solid fertilizer materials which is dispensed under pressure and usually contains a higher analysis than clear liquid mixes	3.	Gas
_____c.	Fertilizer made by dissolving the correct proportion of the solid plant nutrient carriers into water; may be in solution or suspension		

13. By calculating cost per pound of nitrogen for each of the following fertilizers, determine which is the cheapest source of nitrogen. Show all work.

a. 34-0-0 (ammonium nitrate) at $122/ton

____

____

____

b. 82-0-0 (anhydrous ammonia) at $160/ton

____

____

____

c. Cheapest source of N is____

14. Formulate a fertilizer blend using the following information. Show all work.

a. Amount of nutrients to apply per acre

1. 100 lbs nitrogen

2. 150 lbs phosphate

b. Available fertilizers

1. 46-0-0 (urea)

2. 18-46-0 (diammonium phosphate)

c. Amount of fertilizer to apply

1. Urea ______________________

2. Diammonium phosphate ______________________

3. Total amount applied/acre ______________________

d. Calculations ____

____

____

15. List three methods of fertilizer application

a. ____

b. ____

c. ____

SOIL FERTILITY

AG 510 - B

ANSWERS TO TEST

1. a. 4 b. 2 c. 5 d. 6 e. 3 f. 7 g. 1

2. a. S b. P c. M d. P e. S f. P g. M h. M i. M j. S

3. a. 1 b. 5 c. 3 d. 6 e. 2 f. 4

4. a. 3 b. 5 c. 4 d. 2 e. 1

5. a, b, c, e, g

6. Answer should include information from the following: (for more detailed information, refer to pages 510B-11 and 510B-12)

   Steps involved in taking a good soil sample; Materials needed to collect sample; When to take sample; Sampling area; Collecting a representative sample; Sending sample to be tested; How often to test soil

7. 100 lbs N/acre from soil test
   50 lbs N/acre for incorporated residue
   150 lbs N/acre total needed

8. Answer should include the following information: (for more detailed information, refer to pages 510B-14 and 510B-15)

   Collecting plant tissue samples; Handling of plant tissue samples; Interpretation of results of plant tissue analysis

9. Animal manure; Crop residues; Green manure crops; Commercial fertilizers

10. a, b, d, e

11. a. 3 b. 1 c. 2

12. a. 2 b. 3 c. 1

13. a. 18¢/lb of N
    b. 10¢/lb of N
    c. 82-0-0 (anhydrous ammonia)

14. 1. 89 lbs of 46-0-0
    2. 326 lbs of 18-46-0
    3. 415 lbs total amount applied/acre

15. Answer should include three of the following:

    Broadcast; Soil injection; Banding; With irrigation water

SOIL CONSERVATION

AG 510 - C

UNIT OBJECTIVE

After completion of this unit, students should be able to list types of erosion and management practices that aid in conservation. Students should also be able to select from a list factors that determine cropping systems and conservation practices for reducing erosion. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with soil conservation practices to the correct definitions.
2. Name three types of erosion.
3. List the six factors and corresponding symbols related to average annual cropland soil erosion.
4. List and describe the four categories of water erosion.
5. List five factors that influence soil erosion.
6. List six conservation practices that will reduce soil erosion caused by wind.
7. List four mechanical conservation practices that will reduce soil erosion caused by water.
8. List four cropping conservation practices that will reduce soil erosion caused by water.
9. List seven factors that determine the type of cropping system to use.
10. Name three organizations involved with soil conservation.

SOIL CONSERVATION

AG 510 - C

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Conserving Soil: Teaching Soil and Water Conservation*, available from Soil Conservation Service, United States Department of Agriculture.

b. *Soil and Water Conservation*, 250-page loose-leaf packet; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $12.50; order no. 229.

c. The following Current Information Series publications are available from Agricultural Communications Center, Ag Publications Building, Building J40, Idaho Street, University of Idaho, Moscow, Idaho 83843-4196 (208-885-7982).

A Buried Drain Erosion and Sediment Loss Control System, approximate cost $.35; order no. CIS 760.

Conservation Tillage for Control of Soil Loss by Water Erosion Under Dryland Crop Production, approximate cost $.35; order no. CIS 824.

Crop Management Series: Effective Conservation Farming Systems; approximate cost $.50; order no. PNW 275.

Five-Point Program: Divided Slope Farming for Soil Erosion Control Under Dryland Crop Production, approximate cost $.35; order no. CIS 638.

Five-Point Program: Soil Erosion Control Under Dryland Crop Production, approximate cost $.25; order no. CIS 483.

Furrow Erosion and Topsoil Losses, approximate cost $.35; order no. CIS 586.

Furrow Erosion Reduces Crop Yields, approximate cost $.35; order no. CIS 761.

Reducing Soil Losses by Sediment Retention, approximate cost $.35; order no. CIS 696.

Reducing Soil Losses with Filter Strips, approximate cost $.35; order no. CIS 587.

Slot Mulching for Residue Management and Erosion Control, approximate cost $.25; order no. PNW 231.

Soil Erosion--How Much?, approximate cost $.35; order no. CIS 563.

The Chisel Planter--A Minimum Tillage System for Winter Wheat, approximate cost $.35; order no. CIS 476.

The Farmer and Erosion: Factors Influencing the Use of Control Practices, approximate cost $1.00; order no. EXP 601.

2. Filmstrips, slideshows, etc.

   a. *Conservation Farming*, slide set; available from John Deere Service Publications, Dept. F, John Deere Rd., Moline, Illinois 61265; approximate cost $109.00.

   b. *Conservation Tillage*, 2 cassettes, 2 filmstrips and program guide; available from Teaching Aids, Inc., P. O. Box 1798, Costa Mesa, California 92626; approximate cost $70.00; order no. P1319.

   c. *Universal Soil Loss Equation*, filmstrip with script; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $15.00; order no. 336.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information and assignment sheets, and laboratory exercise.

E. Discuss information and assignment sheets.

F. Demonstrate and discuss procedures outlined in laboratory exercise.

G. Take students on field trips to see types of erosion and cropping systems.

H. Invite person from SCS to address the class on combatting erosion in your community.

I. Review and give test.

J. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Generalized Soil Erosion Map of the United States
2. TM 2--Soil Detachment by Raindrops
3. TM 3--Water Erosion--Infiltration Rate Effects Erosion Due to Runoff
4. TM 4--Erosion Caused by Running Water
5. TM 5--Factors Influencing Soil Erosion
6. TM 6--Wind Erosion Control Practices
7. TM 7--Water Erosion Control Practices
8. TM 8--Management Practices Used in Controlling Erosion

E. Assignment sheets

1. AS 1--How Do You Rate as an FFA Conservationist?
2. AS 2--Conserving Soil Crossword Puzzle
3. AS 3--Locating Good and Poor Conservation Practices

F. Answers to assignment sheets

G. Laboratory exercise

1. LE 1--How Much Water Will Soil Hold?

H. Test

I. Answers to test

III. Unit references

A. *Conserving Soil*, United States Department of Agriculture, Soil Conservation Service.

B. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

C. *Crops, Soils, and Fertilizer Resource Manual*, Vo-Ed No. 73, University of Idaho, Department of Ag Education, Moscow, Idaho, 1978.

D. Donahue, Roy L., Follett, Roy H., Tulloch, Rodney W., *Our Soils and Their Management*, 5th edition, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1983.

E. Hartmann, Hudson T., Kofranek, Anton M., Rubatzky, Vincent E., Flocker, William J., Plant Science: Growth, Development and Utilization of Cultivated Plants, 2nd edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

F. Instructional Materials for Vocational Agriculture, Texas A & M University, Agriculture Education Department, Teaching Materials Center, College Station, Texas.

G. Knuti, Williams and Hide, Profitable Soil Management, 4th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

H. Oklahoma Curriculum Guide for Vocational Agriculture, Oklahoma State University and the Oklahoma State Board for Vocational-Technical Education, Stillwater, Oklahoma.

SOIL CONSERVATION

AG 510 - C

INFORMATION SHEET

I. Terms and definitions

A. Erosion--Removal of soil by tillage, wind and/or water

B. Water outlet--Ditch which carries the excess water from farm

C. Terracing--Structure designed to slow down running water and control erosion on sloping land

D. Crop rotation--Rotation of crops on a field from one crop to another

E. Strip-cropping--Practice of growing soil-conserving and soil-depleting crops in alternate strips running perpendicular to the slope of the land or the direction of prevailing winds for the purpose of reducing erosion

F. Diversion ditch--Ditch which prevents erosion by diverting water around a field rather than across

G. Cover crop--Crop used to cover the soil surface to decrease erosion

II. Types of erosion (Transparencies 1, 2, 3)

A. Water erosion

B. Wind erosion

C. Tillage erosion

III. Factors (and symbols) related to average cropland soil erosion

(Note: These factors are used to calculate the Universal Soil Loss Equation, which is a mathematical statement of the relationship between the six factors and the expected rate of soil loss.)

A. Potential of rainfall to cause erosion (R)

B. Capacity of soil to resist erosion (K)

C. Length of slope (L)

D. Steepness of slope (S)

E. Cropping management (C)

F. Erosion control practices (P)

IV. Categories of water erosion (Transparency 4)

A. Splash--Caused by the effect of falling raindrops

(Note: A single raindrop may splash soil as far as 5 feet. A single beating one-inch rain may splash as much as one inch of soil depth by raindrop erosion. The weight of an acre of soil one inch deep is approximately 170 tons.)

B. Sheet--The removal of soil in a uniform layer from an entire surface area

(Note: This type of erosion occurs continuously over periods of time, and the landowner may hardly be aware of its existence.)

C. Rill--Small channels are made by running water over the surface of the soil

(Note: The tendency is for water to flow along the path of least resistance; therefore, it concentrates in low places to form channels. Continued flow in these channels develops minor rills. Number, size and pattern of rills depends on slope shape.)

D. Gully--An advanced stage of rill erosion; occurs when rills flow together into larger streams; cannot be crossed by equipment

V. Factors influencing soil erosion (Transparency 5)

A. The nature of the soil

1. Texture

2. Structure

3. Organic matter content

B. Climate

(Note: Climate is the combined effect of wind, temperature and rainfall. When soil is frozen, the permeability of the soil is greatly reduced. If rainfall comes at this time, and other conditions are conducive, severe erosion will occur.)

C. Vegetative cover

(Note: Vegetation will hold the soil particles together, cushion the impact of raindrops, and increase infiltration, all of which will decrease wind and water erosion.)

D. Slope and horizontal length

(Note: The steepness and horizontal length of land will have a great effect on erosion. As water moves down a slope, it increases in velocity and carrying capacity. For example, doubling the percent of slope will increase the soil loss 2.5 times. Doubling the length of slope will increase soil loss 1.4 times.)

E. Management of the soil

(Note: The way a soil has been managed will determine, to a large degree, the amount of erosion. The good farmer recognizes erosion as a problem and works to overcome it.)

VI. Wind erosion conservation practices (Transparency 6)

A. Strip-cropping

B. Prevention of burning

C. Prevention of overgrazing

D. Moisture conservation

E. Emergency cover crops

F. Emergency tillage operations

G. Windbreak tree planting

H. Shelter belt of trees

VII. Water erosion conservation practices (Transparency 7)

A. Mechanical

(Note: Mechanical measures are designed to supplement the cropping program as well as control the movement of large quantities of rainfall on steeper slopes.)

1. Terracing

2. Diversions

3. Grass waterways

4. Land drainage

5. Land preparation

6. Construction of ponds and dams

B. Cropping

(Note: Cropping practices recommended are an attempt to give as much protection to the ground surface as possible while lands are being used, and also to increase the absorption of rainfall.)

1. Subsoiling or chiseling

2. Contour furrowing

3. Contour listing

4. Stubble mulching

5. Strip-cropping

6. Crop rotation

VIII. Factors determining cropping system (Transparency 8)

(Note: Efficient use of the land should be the primary consideration of any good farmer. By efficient use is meant the use of land in such a way that maximum income and satisfaction is realized with minimum damage to the land. For example, crops planted on steep land may result in more loss due to damage to the land than is realized from the added income. The farmers should try to use the land in such a way that they will realize income while at the same time protect the land.)

A. Slope

B. Erodibility

C. Drainage

D. Moisture

E. Soil depth

F. Fertility

G. Economics

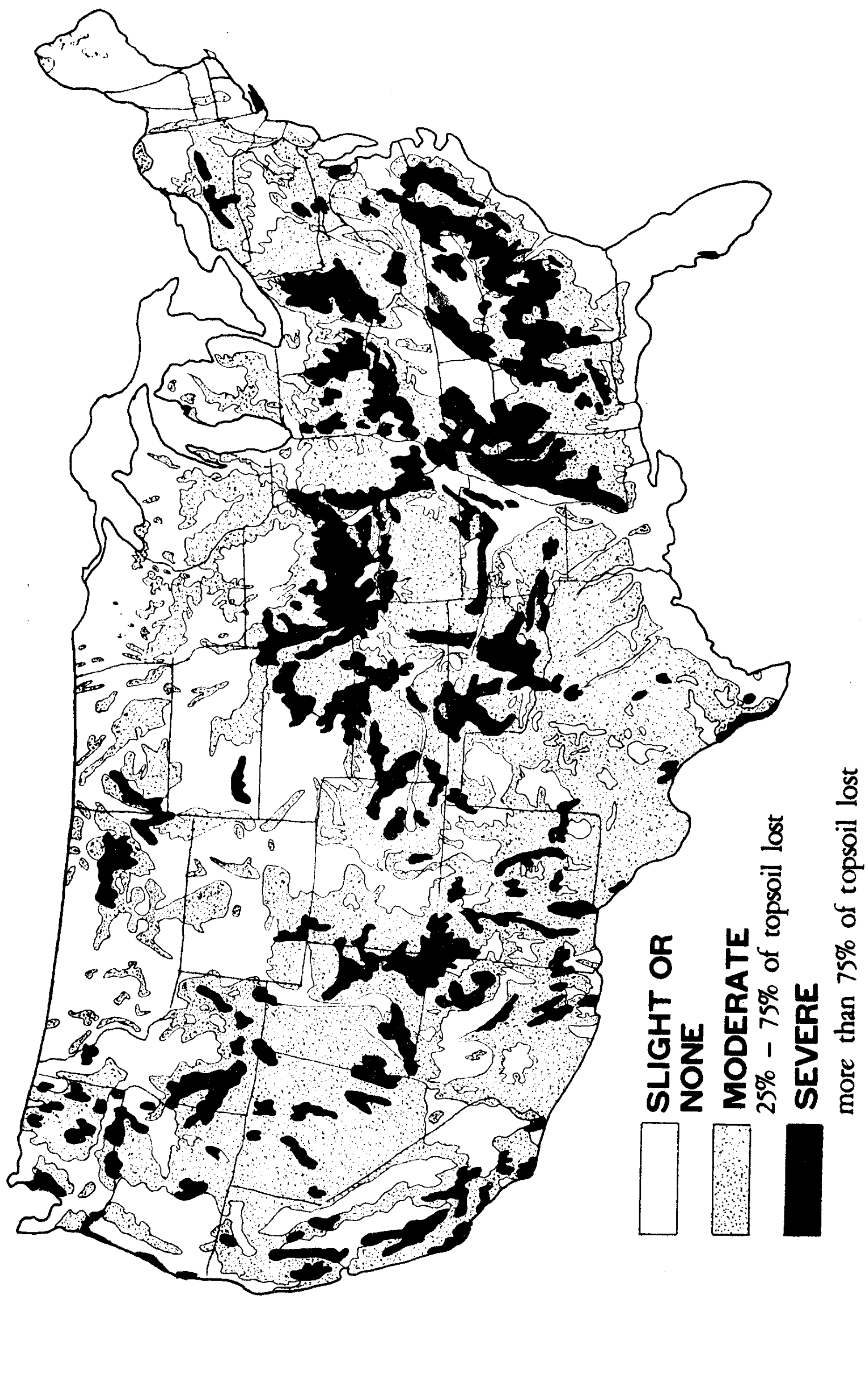
IX. Organizations involved with soil conservation

A. Soil Conservation Service (SCS)

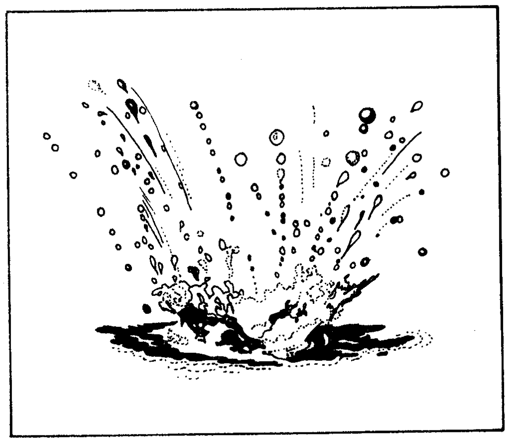
B. Agricultural Stabilization and Conservation Service

C. Local soil and water conservation districts

GENERALIZED SOIL EROSION MAP OF THE UNITED STATES

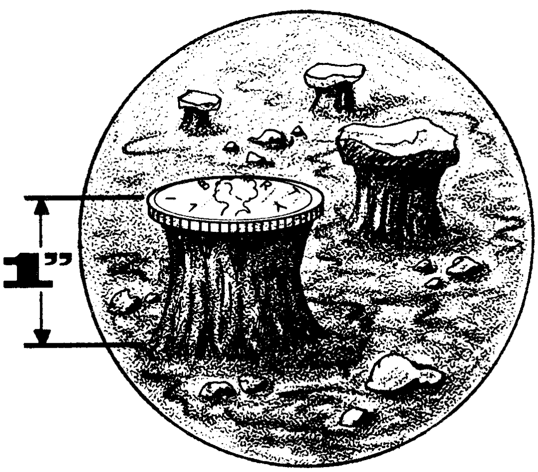


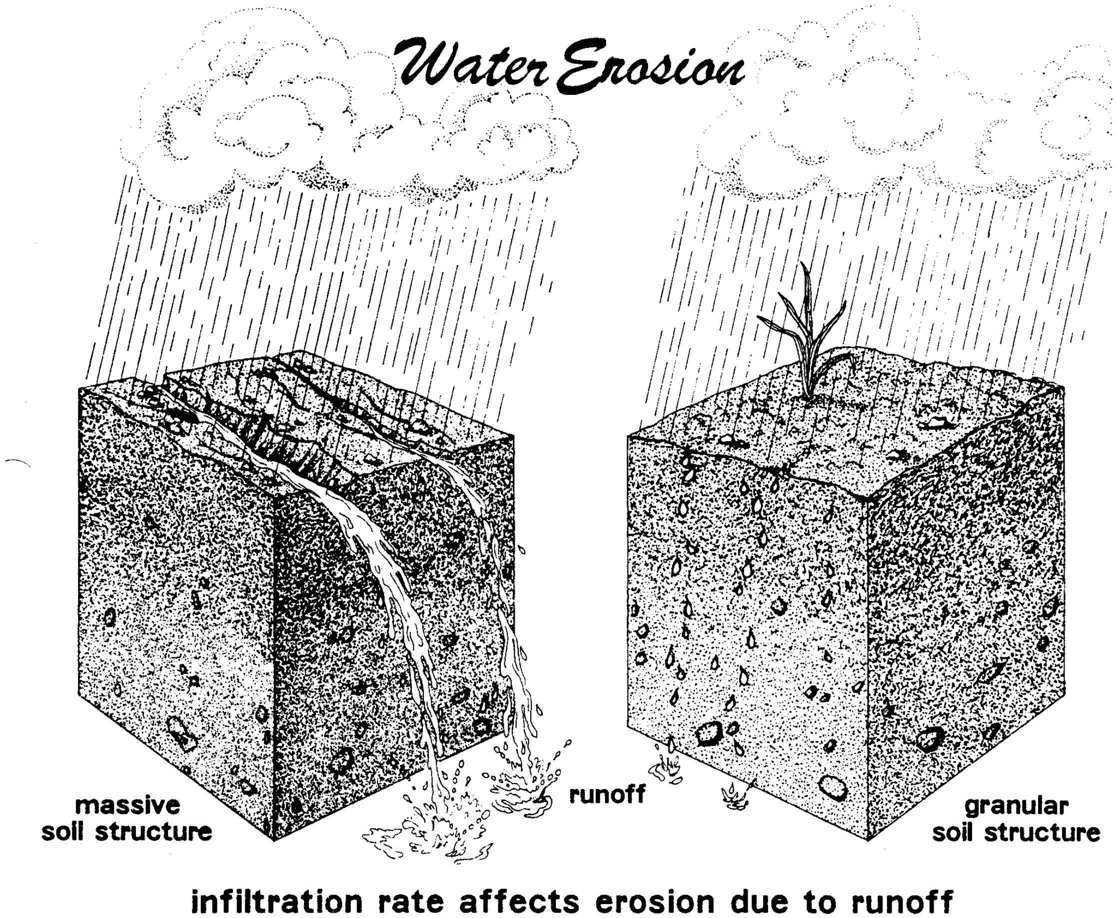
SOIL DETACHMENT BY RAINDROPS



a raindrop may splash soil as far as 5 feet

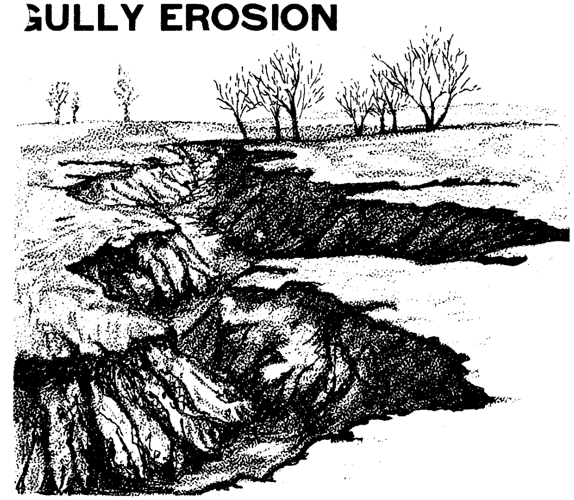
a 1 inch rain may remove 1 inch of soil per acre (150 tons)



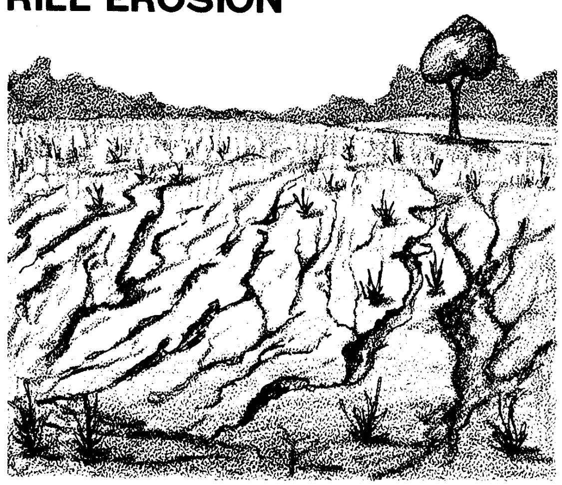

Water Erosion
massive
soil structure
runoff
granular
soil structure
infiltration rate affects erosion due to runoff

EROSION CAUSED BY RUNNING WATER

GULLY EROSION



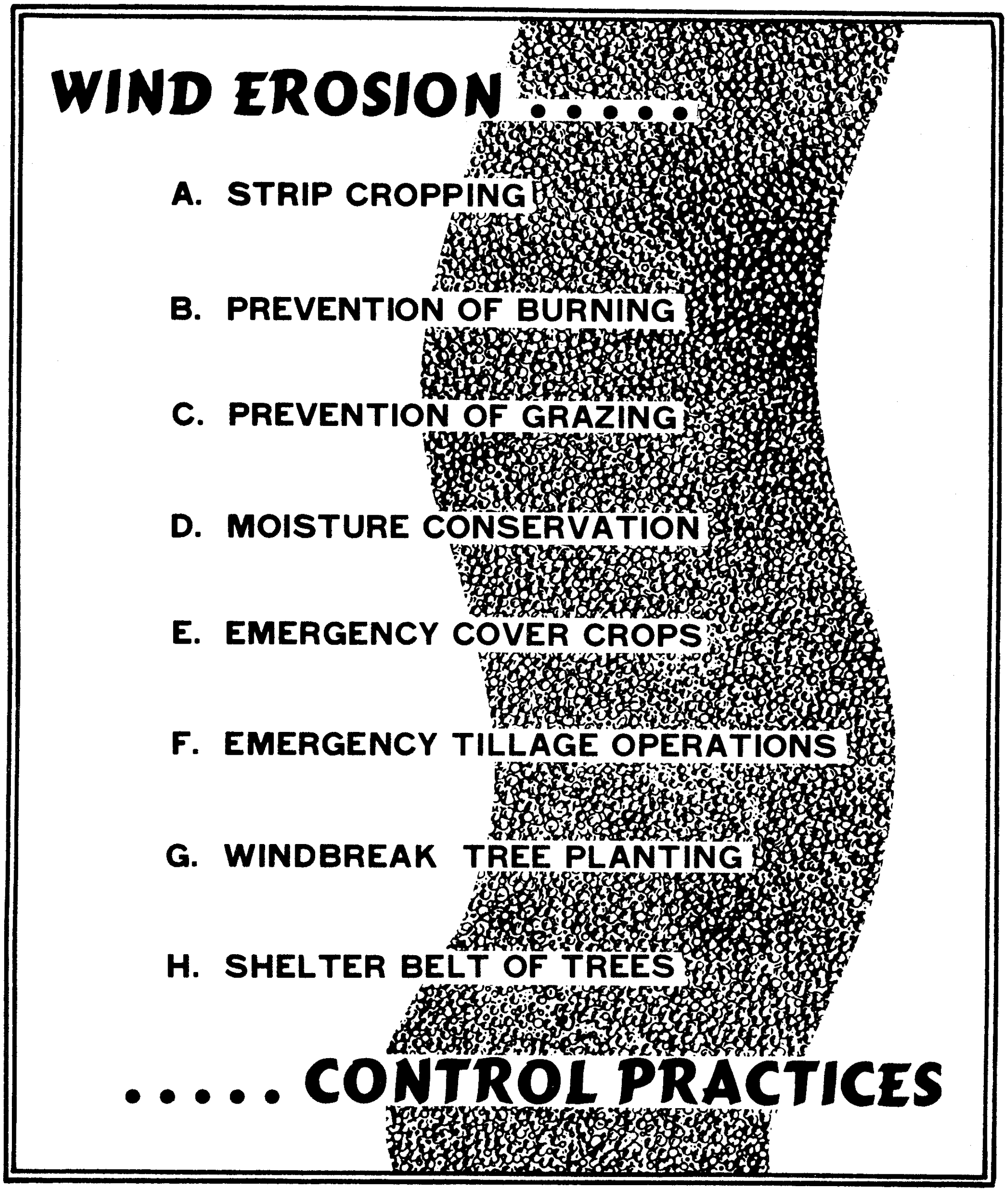
RILL EROSION



SHEET EROSION

Factors Influencing Soil Erosion

A. Nature of the soil
   1. Texture
   2. Structure
   3. Depth of soil
   4. Organic matter content
B. Climate
C. Vegetative cover
D. Slope and horizontal length
E. Management of the soil


WIND EROSION . . . . . .
A. STRIP CROPPING
B. PREVENTION OF BURNING
C. PREVENTION OF GRAZING
D. MOISTURE CONSERVATION
E. EMERGENCY COVER CROPS
F. EMERGENCY TILLAGE OPERATIONS
G. WINDBREAK TREE PLANTING
H. SHELTER BELT OF TREES
. . . . . CONTROL PRACTICES

WATER EROSION CONTROLS

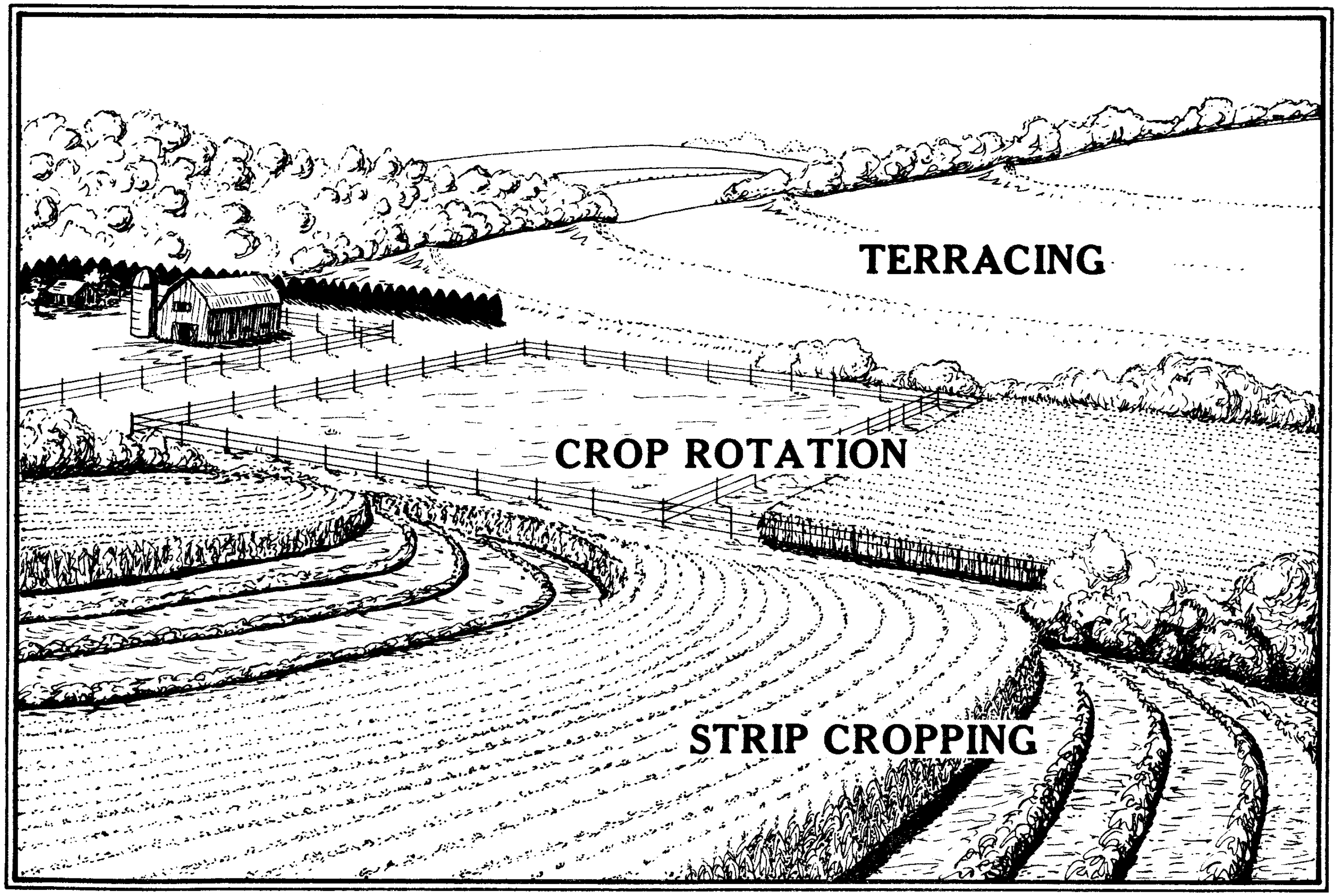
MECHANICAL

- TERRACING
- DIVERSIONS
- GRASSED WATERWAYS
- LAND DRAINAGE
- LAND PREPARATION (SHAPING, SMOOTHING, LEVELING)
- CONSTRUCTION OF PONDS & DAMS

CROPPING

- SUBSOILING OR CHISELING
- CONTOUR FURROWING
- CONTOUR LISTING
- STUBBLE MULCHING
- STRIP CROPPING

MANAGEMENT PRACTICES USED IN CONTROLLING EROSION



SOIL CONSERVATION

AG 510 - C

ASSIGNMENT SHEET #1--HOW DO YOU RATE AS AN FFA CONSERVATIONIST?

Name____ Score_________________________

Answer each of the questions below and on the following page. Turn in to the instructor. If the question applies to you or your farming operation, answer YES; if it does not apply to you, answer NO.

		YES	NO
1.	Are droughts on your farm less severe than they used to be?	______	______
2.	Can you cultivate as soon after a rain as you once could?	______	______
3.	Do the rains seem to soak into your soil faster and deeper than they once did?	______	______
4.	Do streams flood less frequently?	______	______
5.	Do your fields drain properly?	______	______
6.	Are your crop yields increasing?	______	______
7.	When you plow, does your soil seem darker in color than it was a few years ago?	______	______
8.	Do you notice fewer clay spots in the fields when you plow?	______	______
9.	Are gullies getting smaller in size and fewer in number?	______	______
10.	Does your soil drift against the fences less now than it once did?	______	______
11.	When you dig post holes, do you find plant roots all the way to the bottom of the holes?	______	______
12.	After a beating rain, does the surface of your soil still appear open and porous like a sponge?	______	______
13.	Is it becoming less difficult to prepare a good seedbed?	______	______
14.	Does your soil crust over less now than it once did?	______	______
15.	Do you spread manure on your land as fast as it is produced?	______	______
16.	Do you grow a soil-building legume at least one year in three?	______	______
17.	Do you plow under or incorporate all crop residues into your soil?	______	______
18.	Do your crops grow better in dry weather than they once did?	______	______

		YES	NO
19.	Does it take less power to plow your fields than it did a few years ago?	______	______
20.	Do you cultivate just often enough to control weeds?	______	______
21.	Do you use a disc and chisel more now than you do a turning plow?	______	______
22.	Do you follow the recommended planting dates for all farm crops?	______	______
23.	Do you follow a recommended crop rotation plan for all fields?	______	______
24.	Do you plant the highest yielding varieties of crops?	______	______
25.	Does your cropping system produce the most possible forage for your livestock?	______	______
26.	Are your yields per acre as high as any in your neighborhood?	______	______
27.	Have you increased the productivity of all of your fields and pastures?	______	______
28.	Do you use as much limestone as any farmer on similar land in the neighborhood?	______	______
29.	Do you fertilize your fields and pastures as much as do any of your neighbors?	______	______
30.	Do you graze the right number of livestock on your range and pasture land?	______	______
31.	Are your livestock healthy?	______	______
32.	Do you have a home garden as good as any in your neighborhood?	______	______
33.	Have you had your soil tested on all gardens, fields and pastures within the past three years?	______	______

Your rating as an FFA conservationist:

Total answers which are YES______ NO______

I am Good................... (22-33 YES answers)
Fair .... (11-21 YES answers)
Poor .... (0-10 YES answers)

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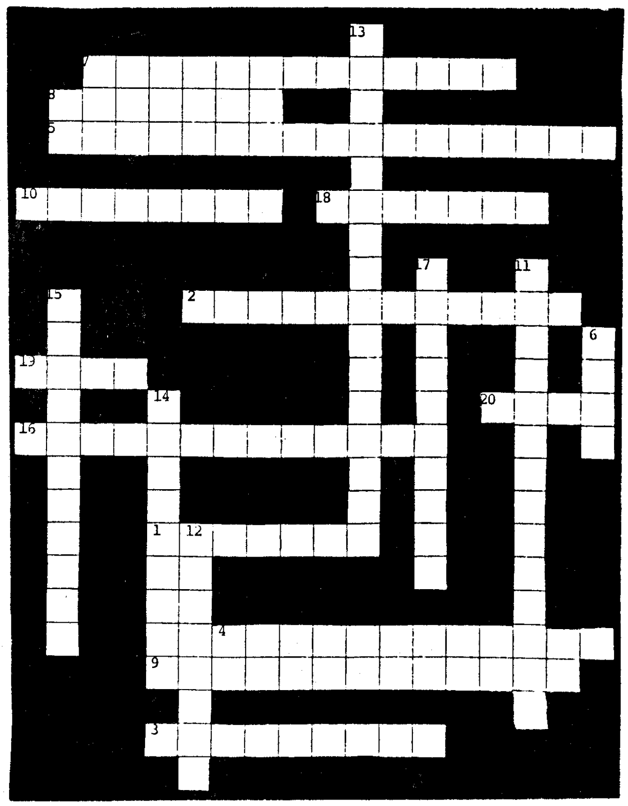
SOIL CONSERVATION

AG 510 - C

ASSIGNMENT SHEET #2--CONSERVING SOIL CROSSWORD PUZZLE

Name____ Score_______________________



DOWN

6. ______ erosion is characterized by many small channels cut in to the soil by running water.
11. Farming around the slopes rather than up and down.
12. Alternating row crops with sod type crops to increase organic matter and reduce annual sod loss.
13. Office will give assistance free of charge for conservation planning.
14. A good ground cover (decreases, increases) water intake.
15. _____ _____ protects the soil's surface during parts of the season that crops are not grown.
17. The shape of the ground surface, as determined by major features such as hills, mountains, or plains.

ACROSS

1. The wearing away of the soil by forces of water and wind.
2. Removal of soil in a uniform layer.
3. A crop grown to cover and protect the soil for a certain part of the year.
4. Advanced stage of rill erosion.
5. The wearing away of the soil by forces which are natural and without interference by man is called____________.
7. Erosion caused by raindrops.
8. Measure to intercept running water and move it around the slope or into a tile line.
9. Practice of planting strips of row crops with strips of meadow, small grains, etc. to slow down water.
10. Grassed ditch-like structure to carry excess water.
16. Soils with high _____ _____ content have increased absorption capacity.
18. _______is usually dark in color.
19. Structure to hold or impound water.
20. The natural medium for the growth of plants. A mixture of minerals, organic matter and reduce annual sod loss.

SOIL CONSERVATION

AG 510 - C

ASSIGNMENT SHEET #3--LOCATING GOOD AND POOR CONSERVATION PRACTICES

Name_______________________________________ Score__________________________

Survey your home community and list five examples of good conservation practices.

1.

2.

3.

4.

5.

List five examples of poor conservation practices.

1.

2.

3.

4.

5.

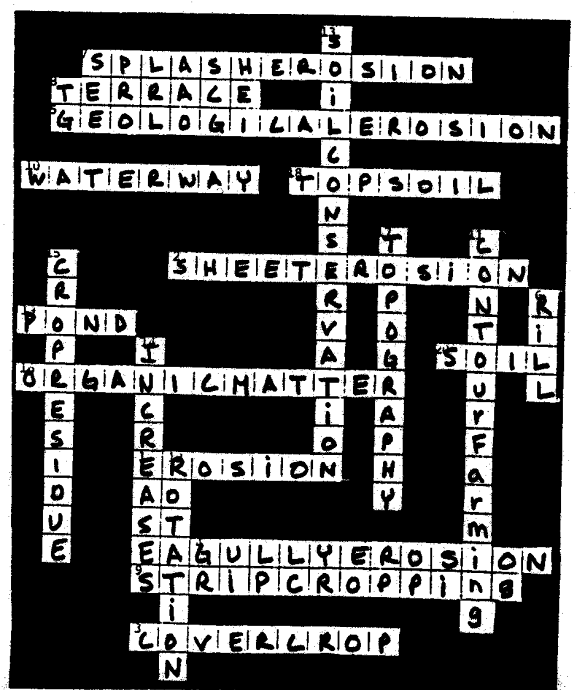
SOIL CONSERVATION

AG 510 - C

ANSWERS TO ASSIGNMENT SHEETS

1. Evaluated to satisfaction of instructor.

2.



3. Evaluated to satisfaction of instructor.

SOIL CONSERVATION

AG 510 - C

LABORATORY EXERCISE #1--HOW MUCH WATER WILL SOIL HOLD?

Name____ Score_______________________________

Suppose you were to pick up a handful of soil and rub it between your hands. You might say that it feels like very small pieces of rock. You would be correct because soil is made of rock particles of different sizes. The particles can be the size of dust or they can be much larger. The particles are also different shapes. All the different particles are mixed together in soil.

When you rubbed the soil between your hands, you may have noticed that it felt wet or damp. Soil particles do not fit together like pieces of a puzzle. Rather they are loosely packed like pieces of candy in a bag. Water in the soil is in spaces between the soil particles. Also, some of the particles may hold water like a towel does. The amount of water that soil can hold after it gets wet is called its water holding ability. How can you tell what the water holding ability of soil is?

Materials needed:

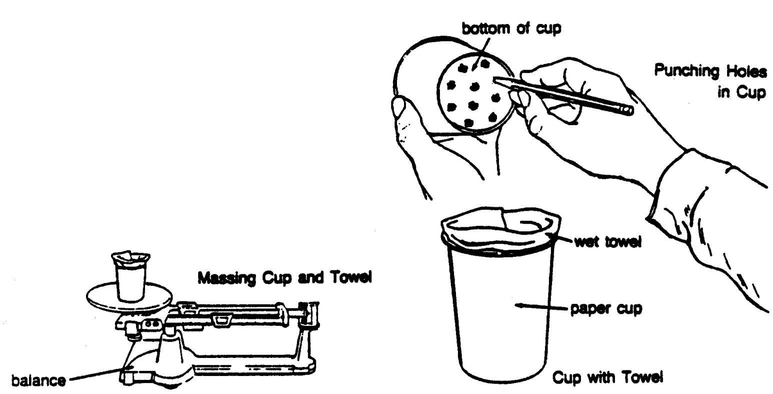
Paper cups-2	Large container	Pencil	Dry soil
Paper towels-2	Dry sand	Balance	Graduated cylinder

Part I: Procedure

1. Using a pencil, punch several holes in the bottom of a paper cup. CAUTION: Be very careful and work slowly as you punch the holes.

2. Line the cup with a soaked paper towel.

3. Take the mass of the cup with its towel on a balance. Record the mass in the table on page 510C-25.



4. Fill the cup three-fourths full with soil.

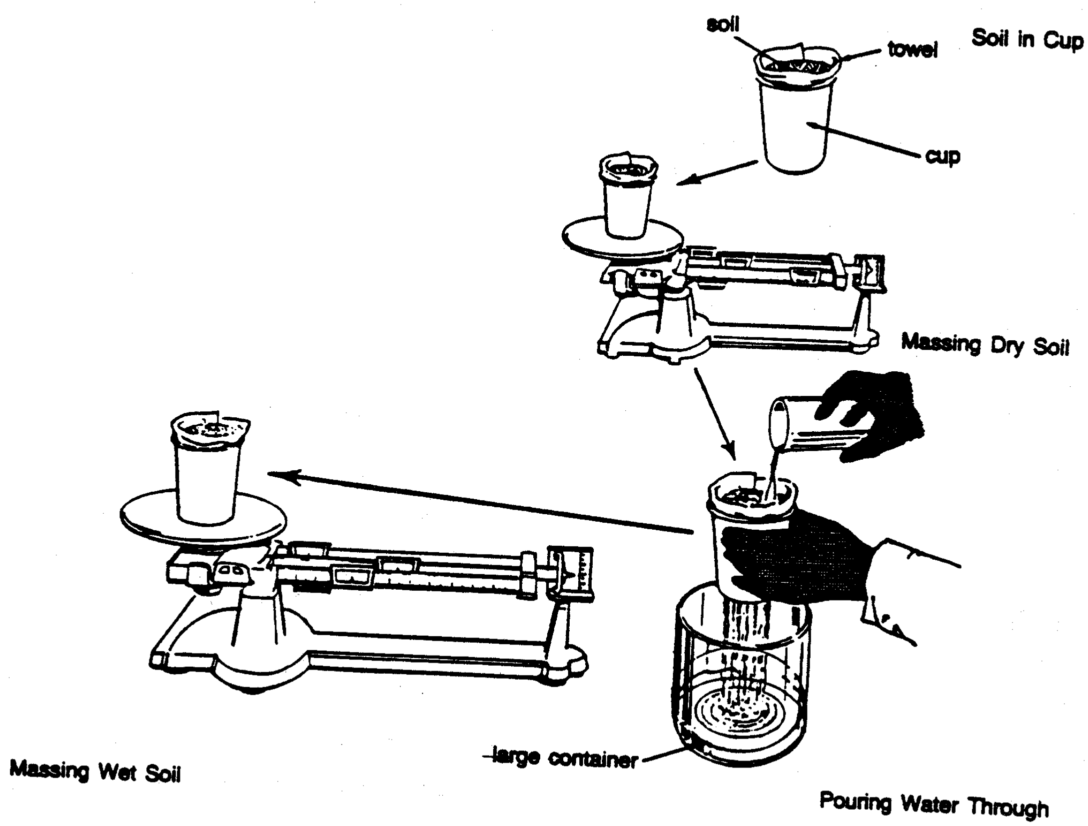
5. Take the mass of the cup, towel and soil. Calculate the mass of the dry soil and record it in the table on the following page.

6. Hold the cup over the large container. Slowly add 500 ml of water to the cup of soil. Let the water drain through the soil into the container.

7. When no more water drips through the bottom of the cup, mass the cup of wet soil. Record the mass in the table.

8. Repeat steps 2 to 7 using sand this time in place of soil. Record your measurements in the table.

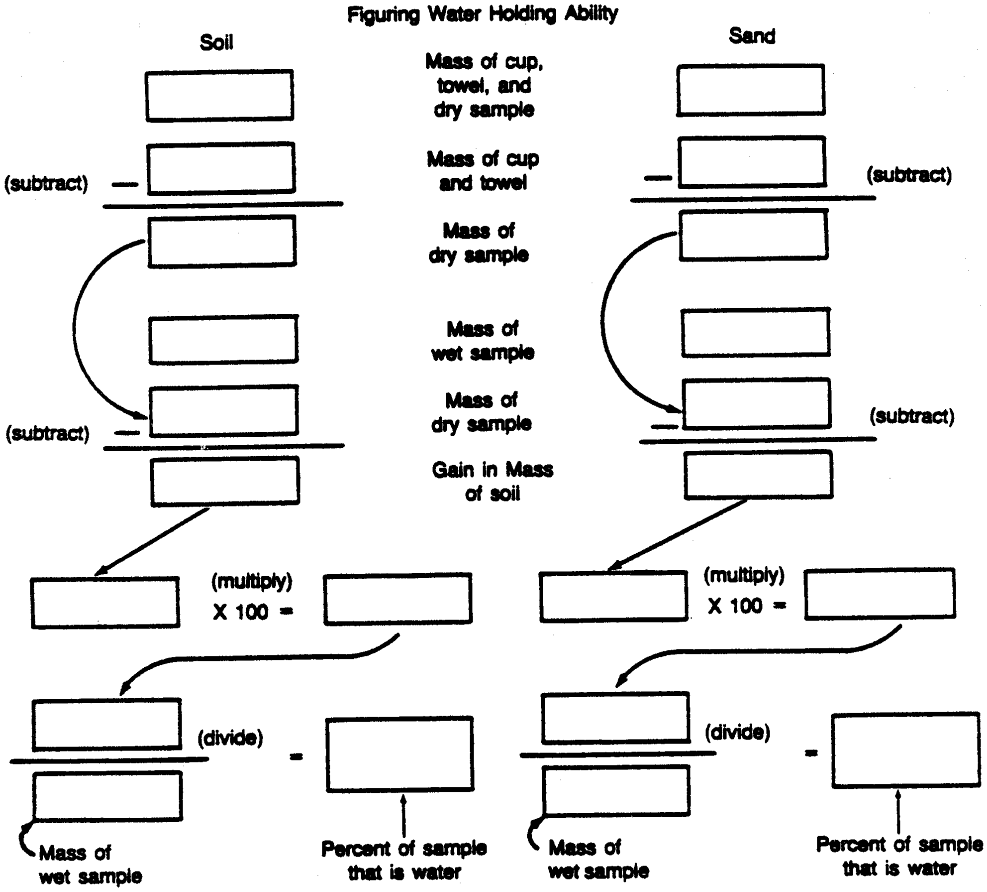
9. Complete the boxes in the diagrams on the following page using the data from your table. Follow the steps shown to calculate the water holding ability of each sample.



Finding Water Holding Ability

	Mass of Sample	
	Soil	Sand
Cup and Towel (A)		
Cup, towel, and dry sample (B)		
Dry sample (B-A)		
Wet Sample		
Gain in mass (Wet sample minus dry sample)		

Figuring Water Holding Ability



Part II: Analysis

1. a. What percent of the soil sample is water?____

   b. What percent of the sand sample is water?____

   c. Which holds more water, soil or sand?____

2. What determines whether soil can hold more or less water?________________________________

3. What does it mean when a soil sample has a 50% water holding ability? ____________________

   ____

4. Do all soil samples have the same water holding ability?___________________________________

   Explain your answer.____

   ____

   ____

5. Suppose soil particles become tightly packed together. What will happen to the water holding ability of the soil? ____

   ____

   Explain your answer.____

   ____

   ____

6. Suppose soil particles become more loosely packed. What will happen to the water holding ability of the soil? ____

   ____

   Explain your answer.____

   ____

   ____

Part III: Applications

1. Why do gardeners use a hoe to break up soil clumps in a garden? ___________________________

   ____

2. Suppose you have a garden that stays too wet most of the time. Your friend tells you to dump a truckload of sand onto the garden and to mix it with the garden soil. Explain why this information could be good advice. ____

____

3. Are soil and water biotic or abiotic parts of an ecosystem? ____________________

SOIL CONSERVATION

AG 510 - C

ANSWERS TO LABORATORY EXERCISES

Lab #1

Part II:

1. a. Example: Silt loam, medium textured Range (15-40%).

   b. Sand (10-20%).

   c. Soil.

2. Mostly organic matter and clay (particle size) content as they influence pore space.

3. It can hold half its weight in water.

4. No, depends on clay (particle size) and organic matter content as it relates to pore space and size.

5. It will decrease.

   Explain--decreasing the pore space that is responsible for holding the water.

6. Increase (but not necessarily directly related).

   Explain--As your particles become loosely packed the pore space will increase, however, large size pores cannot hold water against the force of gravity and do not contribute to water-holding capacity.

Part III:

1. Mostly to increase aeration and drainage.

2. Sand doesn't pack so it helps maintain large pores which aids in drainage.

3. Biotic (related to biological activity of the ecosystem).

SOIL CONSERVATION

AG 510 - C

UNIT TEST

Name____ Score_______________________________

1. Match terms associated with soil conservation practices to the correct definitions. Write the correct numbers in the blanks.

_____a.	Rotation of crops on a field from one crop to another	1.	Erosion
_____b.	Ditch which prevents erosion by diverting water around a field rather than across	2.	Water outlet
_____c.	Removal of soil by tillage, wind and/or water	3.	Terracing
_____d.	Structure designed to slow down running water and control erosion on sloping land	4.	Crop rotation
_____e.	Crop used to cover the soil surface to decrease erosion	5.	Strip-cropping
_____f.	Practice of growing soil-conserving and soil-depleting crops in alternate strips for the purpose of reducing erosion	6.	Diversion ditch
_____g.	Ditch which carries excess water from farm	7.	Cover crop

2. List three types of erosion.

a. ____

b. ____

c. ____

3. List the six factors and corresponding symbols related to average annual cropland soil erosion.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

4. List and describe the four categories of water erosion.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

5. List five factors that influence soil erosion.

a. ____

b. ____

c. ____

d. ____

e. ____

6. List five conservation practices that reduce wind erosion.

a. ____

b. ____

c. ____

d. ____

e. ____

7. List four mechanical cropping practices used in water erosion conservation.

a. ____

b. ____

c. ____

d. ____

8. List four cropping practices used in water erosion conservation.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

9. List five factors that determine cropping systems.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

10. Name three organizations involved with soil conservation.

a. ______________________________

b. ______________________________

c. ______________________________

SOIL CONSERVATION

AG 510 - C

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 1
   d. 3
   e. 7
   f. 5
   g. 2

2. Water; Wind; Tillage

3. Potential of rainfall to cause erosion (R); Capacity of soil to resist erosion (K); Length of slope (L); Steepness of slope (S); Cropping management (C); Erosion control practices (P)

4. Splash: Caused by the effect of falling raindrops; Sheet: The removal of soil in a uniform layer from an entire surface area; Rill: Small channels are made by running water over the surface of the soil; Gully: An advanced stage of rill erosion; occurs when rills flow together into larger streams; cannot be crossed by equipment

5. Answer should include five of the following:

   Nature of the soil (texture, structure, organic matter, content); Climate; Vegetative cover; Slope and horizontal length; Management of the soil

6. Answer should include five of the following:

   Strip-cropping; Prevention of burning; Prevention of overgrazing; Moisture conservation; Emergency cover crops; Emergency tillage operations; Windbreak tree planting; Shelter belt of trees

7. Answer should include four of the following:

   Terracing; Diversions; Grass waterways; Land drainage; Land preparation; Construction of ponds and dams

8. Answer should include four of the following:

   Subsoiling; Chiseling; Contour furrowing; Contour listing; Stubble mulching; Strip-cropping; Crop rotation

9. Answer should include five of the following:

   Slope; Erodibility; Drainage; Moisture; Soil depth; Fertility; Economics

10. Soil Conservation Service; Agricultural Stabilization and Conservation Service; Local soil and water conservation districts

INTRODUCTION TO PLANT SCIENCE

AG 510 - D

UNIT OBJECTIVE

After completion of this unit, students should be able to discuss the importance of plants and crop production. Students should also be able to list the major crops of Idaho and the United States, classify plants and discuss factors affecting crop production. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with plant science to the correct definitions.
2. List six necessities that are furnished by plants.
3. List six crops of Idaho that rank in the top three in production in the United States.
4. Name five major crops grown in the U.S.
5. List two cereals, root crops, tree crops, pulses, oil seed crops and forage crops.
6. Match the category of land use in the U.S. with the correct percentage.
7. State the number of acres of farmland in Idaho.
8. State the number of farms and the average farm size in Idaho.
9. Match the category of land ownership in Idaho with the correct percentage.
10. Match common crops of Idaho with their average yields.
11. List five factors that affect the amount of crop that can be produced.
12. State the purpose of the Idaho Crop Improvement Association.
13. List the five services provided by the Idaho Crop Improvement Association.
14. Discuss the information put together by the Idaho Agricultural Statistics Service and the people who use this information.

INTRODUCTION TO PLANT SCIENCE

AG 510 - D

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

   A. Order materials to supplement unit.

      1. Literature

         a. *Idaho Agricultural Statistics*; available from Idaho Agricultural Statistics Service, Boise, Idaho; cost $5.00.

         b. *Summary of Findings and Recommendations of the Governor's Task Force on Idaho Agricultural Policy*, 1980.

   B. Make transparencies and necessary copies of materials.

   C. Provide students with objective sheet and discuss.

   D. Provide students with information sheet and discuss.

   E. Construct and administer pretest on crop science.

   F. Invite someone to speak on careers in crop science.

   G. Review and give test.

   H. Reteach and retest if necessary.

II. Instructional materials

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Transparency masters

      1. TM 1--Good Things We Get From Plants

      2. TM 2--Idaho Crop-Reporting Districts

      3. TM 3--Major Crops of Idaho

      4. TM 4--Major Uses of Land

      5. TM 5--Major Crop Areas - United States

      6. TM 6--Major Crop Areas - World

E. Test

F. Answers to test

III. Unit references

A. *1989 Agricultural Statistics*, Idaho Agricultural Statistics Service, Boise, Idaho.

B. *Careers,* National Agricultural Statistics Service, United States Department of Agriculture, 1989.

C. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

D. Delorit, R.J., et al., *Crop Production*, 5th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

E. Hartmann, H.T., et al., *Plant Science - Growth, Development, and Utilization of Cultivated Plants,* 2nd edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1988.

F. *In Small Grains, Let's Aim For Quality,* Idaho Crop Improvement Association, Boise, Idaho.

G. Janick, J., et al., *Plant Science*, 2nd edition, W.H. Freeman and Co., San Francisco, California, 1974.

H. *Summary of Findings and Recommendations of the Governor's Task Force on Idaho Agricultural Policy*, Boise, Idaho, 1980.

INTRODUCTION TO PLANT SCIENCE

AG 510 - D

INFORMATION SHEET

I. Terms and definitions

A. Agronomy--Science of crop production and soil management

B. Arable land--Land which is capable in its present condition of producing crops requiring tillage

C. Arid climate--Climate in which the annual rainfall is less than 10 inches

D. Cereal--Grass grown to be used for feed or seed

E. Forage--Livestock feed, such as pasture, hay or silage

F. Legume--Soil improving plant which manufactures nitrogen

G. Pulse--Leguminous plants or their seeds; this includes chiefly those plants with large seeds used for food

H. Range--Extensive area of natural pasture land

I. Weed--Undesirable plant growing with a crop

J. Native plant--Plant originating in North America

K. Introduced plant--Plant brought in from countries outside the United States

L. Cwt--Hundred weight, 100 pounds

M. Bushel--Thirty-two dry quarts; a common measurement for small grains

N. Ton--Two thousand pounds; a common measurement for forage, sugarbeets and sweet corn

II. Plants furnish the following necessities (Transparency 1)

A. Oxygen for man and animals to breathe

B. Fuel for heating and transportation

C. Building materials

D. Medicine and drugs

E. Food for man and animal nutrition

F. Fabric for clothing and other purposes

G. Paper

H. Cover against wind and water

I. Habitat for animals

(Note: Plants furnish most of the necessities of life for man either directly or indirectly. If plant life suddenly disappeared, man and animal would also disappear. Plants are the basis of all food we eat and all the oxygen we breathe.)

III. Major agronomic crops grown in Idaho (1988) (Transparencies 2, 3)

	Crop	Rank Among States	Production	Unit	Percent of U.S.
1.	Potatoes	1	99,320,000	Cwt	32.3
2.	Barley	1	51,000,000	Bu	17.6
3.	Wrinkled peas for seed	1	653,000	Cwt	74.0
4.	Lentils	2	414,000	Cwt	21.2
5.	Dry edible peas	2	860,000	Cwt	37.6
6.	Alfalfa seed	2	16,150,000	Lbs	14.0
7.	Kentucky Bluegrass seed	3	14,955,000	Lbs	25.7
8.	Sugarbeets	3	4,067,000	Ton	16.4
9.	Hops	3	3,920,000	Lbs	7.2
10.	All mint	3	974,000	Lbs	13.7
11.	Onions (summer storage)	3	4,028,000	Cwt	16.5
12.	Prunes and plums (fresh)	4	6,500	Ton	12.5
13.	Dry edible beans	5	2,249,000	Cwt	11.7
14.	Sweet corn for processing	5	163,800	Ton	6.9
15.	Sweet cherries	6	2,300	Ton	1.2
16.	Alfalfa hay	6	3,496,000	Ton	5.0
17.	All wheat	8	75,520,000	Bu	4.2
18.	Apples	10	135,000,000	Lbs	1.5
19.	All hay	15	3,881,000	Ton	3.1

IV. Major crops of the United States

A. Corn

B. Wheat (winter and spring)

C. Oats

D. Barley

E. Rye

F. Grain sorghum

G. Cotton

H. Tobacco

I. Rice

J. Sugar crops

K. Alfalfa

L. Soybeans

M. Peanuts

V. Classes of plants

A. Cereals

1. Barley
2. Wheat
3. Corn
4. Oats
5. Rice

B. Root crops

1. Potatoes
2. Sugarbeets

C. Tree crops

1. Prunes and plums
2. Apples
3. Sweet cherries

D. Pulses

1. Peas
2. Lentils
3. Beans

E. Oil seed crops

1. Sunflower
2. Soybean

3. Peanut

4. Cotton seed

F. Forage crops

1. Alfalfa hay

2. Field corn

3. Most grasses

VI. Land use in the U.S. (1981) (Transparencies 4, 5, 6)

A. United States

		Percent
1.	Total acres--2,271 million acres	
2.	Cities, roads, railroads, parks, etc.	6.3%
3.	Desert, swamp, rock, etc.	12.9%
4.	Cropland	20.2%
5.	Grassland, pasture and grazing land	27.8%
6.	Forest land	32.8%

B. Idaho

1.	Total land area	52,916,000 acres
2.	Land in farms	15,100,000 acres
3.	Percent of land area in farms	28.5%
4.	Number of farms	23,900
5.	Average size of farm	632 acres
6.	Land ownership	
a.	Private lands	31.0%
b.	County and municipal	.2%
c.	State lands	4.8%
d.	Federal	64.0%

(Note: Compare county statistics with state statistics.)

VII. How much crop can be produced per acre?

A. Average yields in Idaho for 1988 include:

1. Barley — 60 bu/acre
2. Corn for grain — 130 bu/acre
3. Dry beans, combined — 18.9 cwt/acre
4. Alfalfa hay — 3.8 ton/acre
5. Lentils — 13 cwt/acre
6. Potatoes — 286 cwt/acre
7. Sugarbeets — 24.5 ton/acre
8. Wheat — 65.7 bu/acre

B. Record yields recorded

1. Potatoes — 1,000 cwt/acre
2. Dry land wheat — 208 bu/acre

VIII. Factors that affect amount of crop produced

A. Crop being raised

(Note: This is dictated by area and will be related to the presence or absence of other factors such as length of growing season, soil type, pests, etc.)

B. Climate

1. Annual precipitation
2. Temperature
3. Length of growing season
4. Methods of modifying climate available
   a. Irrigation
   b. Frost protection
   c. Variety selection
   d. Seedbed preparation
   e. Field choice, for example: north slope vs. south slope

C. Pests

1. Resistant varieties

2. Pesticides

3. Plant dates

D. Soil features

1. Seedbed preparation

2. Cultivation

E. Economics

(Note: This is the least controllable of all factors. The goal of crop production is to get the highest amount of yield with the fewest inputs. The maximum yield is not always the same as the maximum profit point. The crop can cost you money by (1) decreased yields or (2) money for added inputs. Manage to reach the point of maximum profit.)

IX. Purpose of Idaho Crop Improvement Association--To maintain and make available to the public a maximum amount of high quality seeds of superior plant varieties at a reasonable price

X. Services provided by the Idaho Crop Improvement Association

A. Field inspections

B. Seed cleaning supervision

C. Seed lot sampling and testing

D. Educational programs

E. Program to certify virus-free potato stock

XI. Idaho Agricultural Statistics Service

A. The "fact finders" for Idaho agriculture

1. Prospective production and supplies of food and fiber

2. Prices paid and received by farmers

3. Farm labor and wages

4. Storage holding of commodities

5. Numbers and sizes of farms

6. Weekly weather and crop bulletins

B. Information users include:

1. Farmers and ranchers--Decisions on how much to plant, how many cattle to raise or when to sell

2. Manufacturers--Help predict demand

3. Business persons

4. Economists

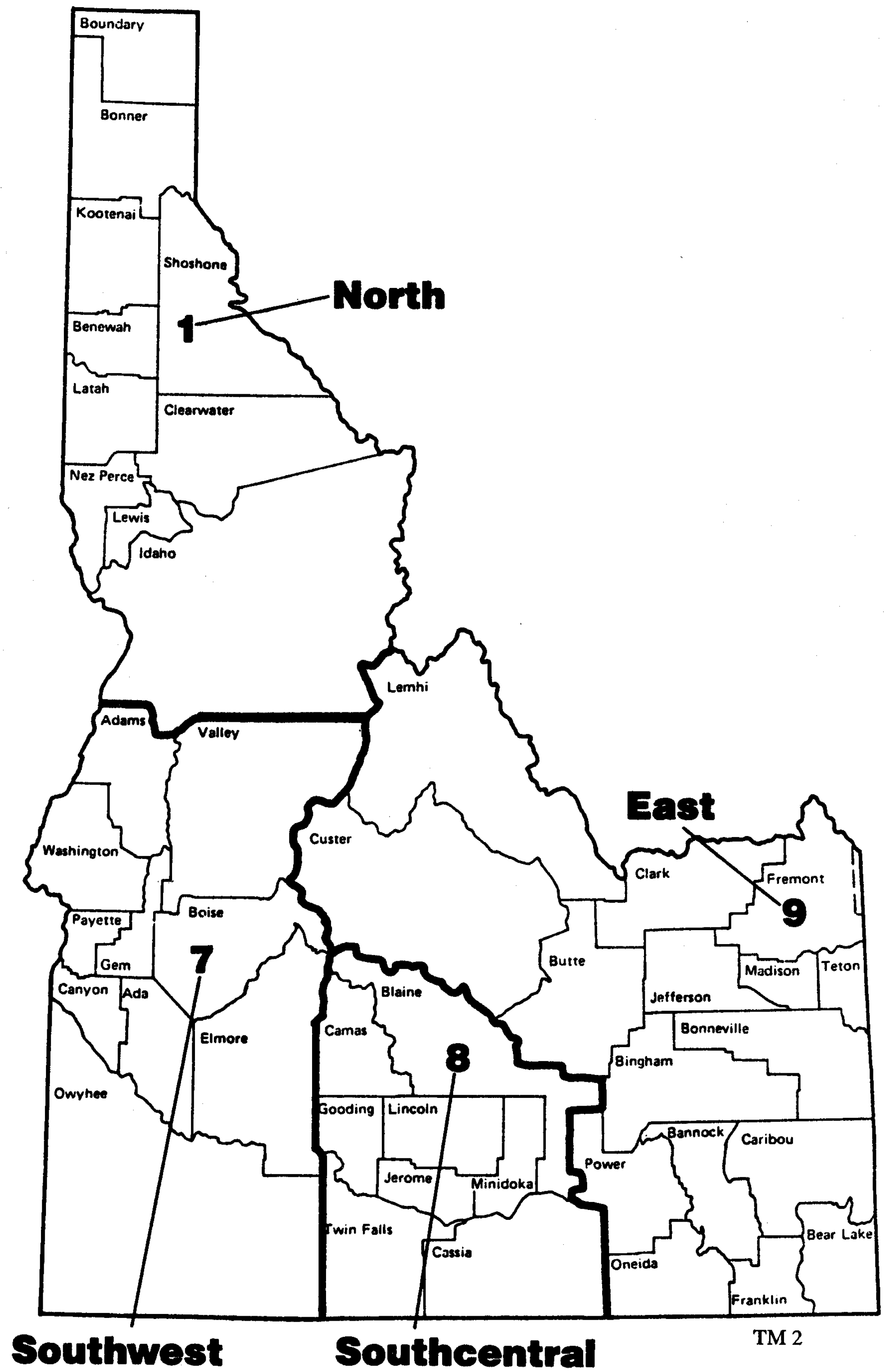
5. State and federal officials

6. Members of Congress

Good Things We Get From Plants

1. Oxygen for man and animal to breath
2. Fuel for heating and transportation
3. Building materials
4. Medicines and drugs
5. Food for man and animal nutrition
6. Fabric for clothing and other purposes
7. Paper
8. Cover against wind and water
9. Habitat for animals

Idaho Crop-Reporting Districts



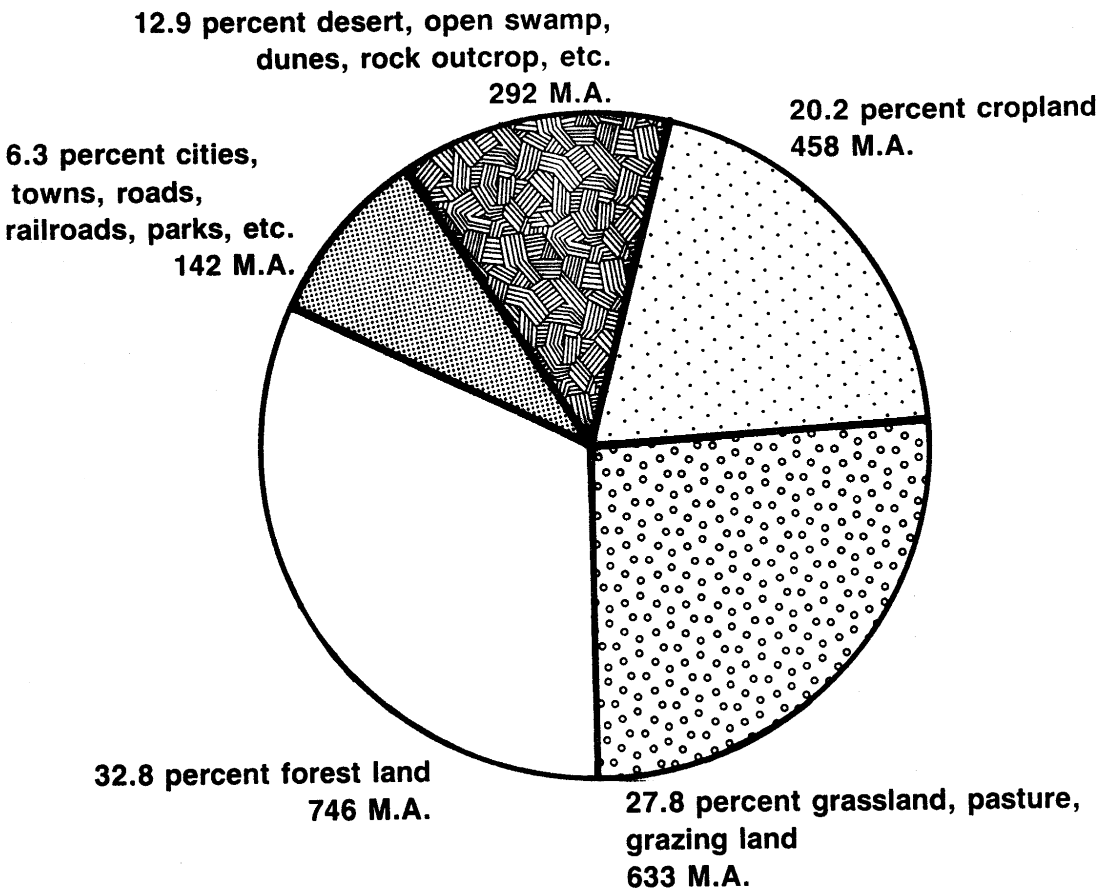
TM 2

MAJOR CROPS OF IDAHO

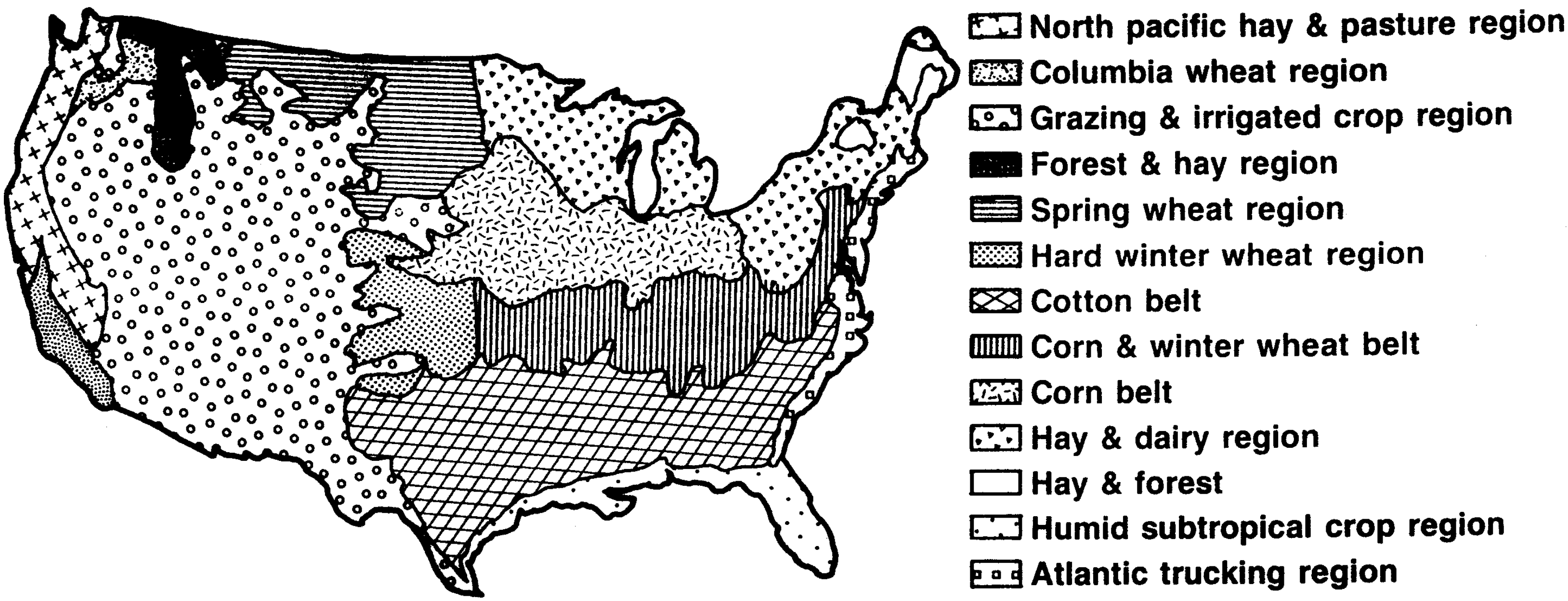
	Crop	Rank Among States	Production	Unit	Percent of U.S.
1.	Potatoes	1	99,320,000	Cwt	32.3
2.	Barley	1	51,000,000	Bu	17.6
3.	Wrinkled peas for seed	1	653,000	Cwt	74.0
4.	Lentils	2	414,000	Cwt	21.2
5.	Dry edible peas	2	860,000	Cwt	37.6
6.	Alfalfa seed	2	16,150,000	Lbs	14.0
7.	Kentucky Bluegrass seed	3	14,955,000	Lbs	25.7
8.	Sugarbeets	3	4,067,000	Ton	16.4
9.	Hops	3	3,920,000	Lbs	7.2
10.	All mint	3	974,000	Lbs	13.7
11.	Onions (summer storage)	3	4,028,000	Cwt	16.5
12.	Prunes and plums (fresh)	4	6,500	Ton	12.5
13.	Dry edible beans	5	2,249,000	Cwt	11.7
14.	Sweet corn for processing	5	163,800	Ton	6.9
15.	Sweet cherries	6	2,300	Ton	1.2
16.	Alfalfa hay	6	3,496,000	Ton	5.0
17.	All wheat	8	75,520,000	Bu	4.2
18.	Apples	10	135,000,000	Lbs	1.5
19.	All hay	15	3,881,000	Ton	3.1

Major Uses of Land

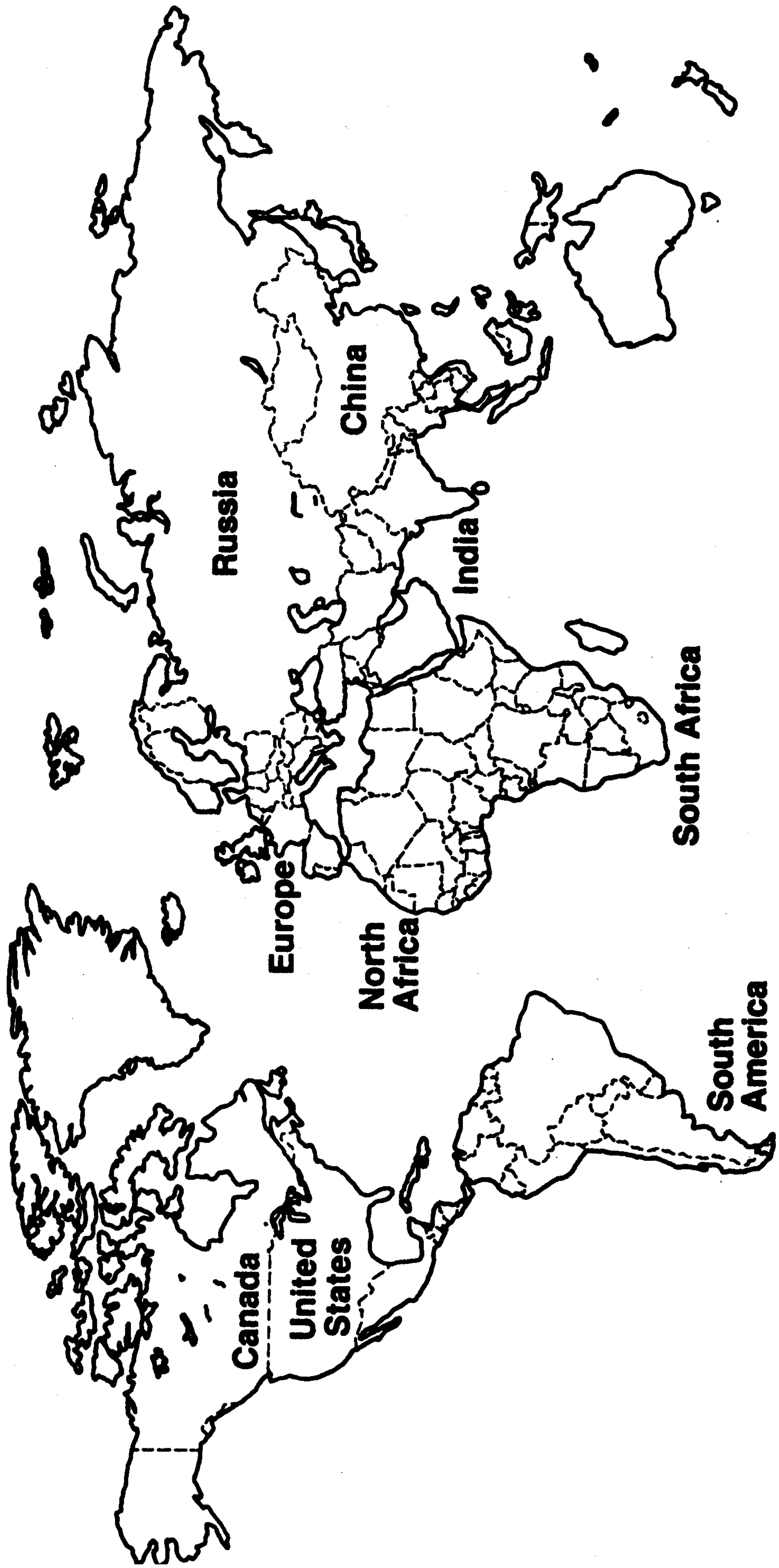
Total U.S. Acreage
2,271 Million Acres (50 States)



Major Crop Areas United States



Major Crop Areas - World



INTRODUCTION TO PLANT SCIENCE

AG 510 - D

UNIT TEST

Name____ Score______________________________

1. Match terms associated with plant science to the correct definitions. Write the correct numbers in the blanks.

_____a.	Extensive area of natural pasture land	1.	Agronomy
_____b.	100 pounds	2.	Arable land
_____c.	Grass grown to be used for feed or seed	3.	Arid climate
_____d.	Plant originating in North America	4.	Cereal
_____e.	Undesirable plant growing with a crop	5.	Forage
_____f.	Livestock feed, such as pasture, hay or silage	6.	Legume
_____g.	Land which is capable in its present condition of producing crops requiring tillage	7.	Pulse
		8.	Range
_____h.	Soil improving plant which manufactures nitrogen	9.	Weed
_____i.	Science of crop production and soil management	10.	Native plant
_____j.	Plant brought in from countries outside the United States	11.	Introduced plant
_____k.	Thirty-two dry quarts; a common measurement for small grains	12.	Cwt
		13.	Bushel
_____l.	Leguminous plants or their seeds; this includes chiefly those plants with large seeds used for food	14.	Ton
_____m.	2,000 pounds; a common measurement for forage, sugarbeets and sweet corn		
_____n.	Climate in which the annual rainfall is less than 10 inches		

2. List six necessities that are furnished by plants.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

   f. ____________________

3. List six crops of Idaho that rank in the top three in production in the United States.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

   f. ____________________

4. Name five major crops grown in the United States.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

5. List two examples for each of the following crops.

   Cereals

   a. ____________________

   b. ____________________

   Root crops

   a. ____________________

   b. ____________________

Tree crops

a. ____

b. ____

Pulses

a. ____

b. ____

Oil seed crops

a. ____

b. ____

Forage crops

a. ____

b. ____

6. Match the category of land use in the U.S. with the correct percentage. Write the correct numbers in the blanks.

		1.	32.8%
_____a.	Cities, roads, railroads, parks, etc.	2.	27.8%
_____b.	Desert, swamp, rock, etc.	3.	5.6%
_____c.	Cropland	4.	20.2%
_____d.	Grassland, pasture, grazing land	5.	28.9%
_____e.	Forest land	6.	12.9%
		7.	52.0%
		8.	6.3%

7. State the number of acres of farmland in Idaho.

____

8. State the number of farms and the average farm size in Idaho.

Number of farms ____

Average farm size ____

9. Match the category of land ownership in Idaho with the correct percentage. Write the correct numbers in the blanks.

		1.	52.0%
_____a.	Federal lands	2.	31.0%
_____b.	Private lands	3.	.6%
_____c.	County and municipal	4.	.2%
_____d.	State lands	5.	4.8%
		6.	64.0%
		7.	73.0%

10. Match common crops of Idaho with the correct average yield. Write the correct numbers in the blanks.

		1.	286 bu/acre
_____a.	Potatoes	2.	60 bu/acre
_____b.	Lentils	3.	130 bu/acre
_____c.	Corn for grain	4.	18.9 cwt/acre
_____d.	Barley	5.	3.8 ton/acre
_____e.	Wheat	6.	3.8 bu/acre
_____f.	Sugarbeets	7.	13 cwt/acre
_____g.	Dry beans	8.	286 cwt/acre
_____h.	Alfalfa hay	9.	24.5 ton/acre
			10.65.7 bu/acre

11. List five factors that affect the amount of crop that can be produced.

a. ____

b. ____

c. ____

d. ____

e. ____

12. State the purpose of the Idaho Crop Improvement Association.

____

____

____

13. List the five services provided by the Idaho Crop Improvement Association.

a. ____

b. ____

c. ____

d. ____

e. ____

14. Discuss the information put together by the Idaho Agricultural Statistics Service and the people who use this information.

____

____

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INTRODUCTION TO PLANT SCIENCE

AG 510 - D

ANSWERS TO TEST

1. a. 8 e. 9 i. 1 m. 14
   b. 12 f. 5 j. 11 n. 3
   c. 4 g. 2 k. 13
   d. 10 h. 6 l. 7

2. Answer should include six of the following:

   Oxygen for man and animals to breathe; Fuel for heating and transportation; Building materials; Medicine and drugs; Food for man and animal nutrition; Fabric for clothing and other purposes; Paper; Cover against wind and water; Habitat for animals

3. Answer should include six of the following:

   Potatoes; Barley; Sugarbeets; Hops; Mints; Onions; Wrinkled peas for seed; Lentils; Dry edible peas; Alfalfa seed; Kentucky bluegrass seed

4. Answer should include five of the following:

   Corn; Wheat; Oats; Barley; Rye; Grain sorghum; Cotton; Tobacco; Rice; Sugar crops; Alfalfa; Soybeans; Peanuts

5. Answer should include two of each of the following crops:

   <u>Cereals</u>: Barley; Wheat; Corn; Oats; Rice
   <u>Root crops</u>: Potatoes; Sugarbeets
   <u>Tree crops</u>: Prunes and plums; Apples; Sweet cherries
   <u>Pulses</u>: Peas; Lentils; Beans
   <u>Oil seed crops</u>: Sunflower; Soybean; Peanut; Cotton seed
   <u>Forage crops</u>: Alfalfa hay; Field corn; Most grasses

6. a. 8 b. 6 c. 4 d. 2 e. 1

7. 15,100,000 acres

8. 23,900 farms; 632 acres

9. a. 6 b. 2 c. 4 d. 5

10. a. 8 e. 10
    b. 7 f. 9
    c. 3 g. 4
    d. 2 h. 5

11. Crop being raised; Climate; Pests; Soil features; Economics

12. To maintain and make available to the public a maximum amount of high quality seeds of superior plant varieties at a reasonable price

13. Field inspections; Seed cleaning supervision; Seed lot sampling and testing; Educational programs; Program to certify virus-free potato stock

14. Answer should include information from the following:

    The "fact finders" for Idaho agriculture; Prospective production and supplies of food and fiber; Prices paid and received by farmers; Farm labor and wages; Storage holding of commodities; Numbers and sizes of farms; Weekly weather and crop bulletins; Farmers and ranchers--Decisions on how much to plant, how many cattle to raise or when to sell; Manufacturers--Help predict demand; Business persons; Economists; State and federal officials; Members of Congress

BASIC PLANT PROCESSES

AG 510 - E

UNIT OBJECTIVE

After completion of this unit, students should be able to list the important plant processes, illustrate the process of photosynthesis and select factors that affect photosynthetic rate. Students should also be able to briefly explain the processes of absorption and transpiration. This knowledge will be demonstrated by completing the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with basic plant processes to the correct definitions.
2. Label the parts of a common plant cell.
3. Match the parts of a common plant cell to the correct functions.
4. Name the four important plant processes in food manufacture and growth.
5. Discuss why photosynthesis is the most important process in the world.
6. Explain the process of photosynthesis.
7. List five factors that affect photosynthetic rate.
8. Explain the process of respiration.
9. Classify characteristics as that of photosynthesis or respiration.
10. Match ways nutrients and water are absorbed by the plant to the correct definitions.
11. Explain the process of absorption by plant roots.
12. Explain the process of transpiration.
13. List five factors affecting water loss by transpiration.
14. Study the effect of light on dry weight.
15. Demonstrate photosynthesis, respiration and fermentation.
16. Describe what factors affect respiration.
17. Examine how light affects photosynthesis.
18. Examine when osmosis occurs in living cells.
19. Study the movement of substances across membranes.

20. Measure loss from transpiration.

21. Measure the rates of photosynthesis in different environments.

22. Examine the movement of water through plants.

BASIC PLANT PROCESSES

AG 510 - E

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

   A. Order materials to supplement unit.

   B. Make transparencies and necessary copies of materials.

   C. Provide students with objective sheet and discuss.

   D. Provide students with information and assignment sheets, and laboratory exercises.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss procedures outlined in laboratory exercises.

   G. Review and give test.

   H. Reteach and retest if necessary.

II. Instructional materials

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Transparency masters

      1. TM 1--Important Plant Processes

      2. TM 2--Importance of Photosynthesis

      3. TM 3--Photosynthesis

      4. TM 4--Photosynthesis and Respiration in Relation to Dry Weight

      5. TM 5--Transpiration

      6. TM 6--Root Hairs, Soil Particles and Moisture

      7. TM 7--How a Water Solution From the Soil Moves Within a Root

E. Assignment sheet

1. AS 1--Effect of Light on Dry Weight

F. Answers to assignment sheet

G. Instructor notes for laboratory exercises

H. Laboratory exercises

1. LE 1--Demonstrating Photosynthesis, Respiration and Fermentation

2. LE 2--What Factors Affect Respiration?

3. LE 3--How Does Light Affect Photosynthesis?

4. LE 4--When Does Osmosis Occur in Living Cells?

5. LE 5--Studying the Movement of Substances Across Membranes

6. LE 6--Measuring Loss From Transpiration

7. LE 7--Measuring Rates of Photosynthesis in Different Environments

8. LE 8--Water Movement Through Plants

I. Answers to laboratory exercises

J. Test

K. Answers to test

III. Unit references

A. Cooper, Elmer L., *Agriscience Fundamentals and Applications,* Delmar Publishers, Inc., Albany, New York 12212, 1990.

B. Delorit, R.J., et al., *Crop Production, 5th edition*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

C. Fridline, C.R., *Plant Growth and Development*, Ohio State University, Ohio Agricultural Education Curriculum Materials Service, Columbus, Ohio, 1980.

D. Hartmann, Hudson T., et al., *Plant Science - Growth, Development, and Utilization of Cultivated Plants,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

E. Janick, J., et al., *Plant Science, 2nd edition,* W.H. Freeman and Co., San Francisco, California, 1974.

F. Otto, James H., Towle, Albert, *Modern Biology,* Holt, Rinehart and Winston, New York, 1985.

G. Raven, P.H., et al., *Biology of Plants*, 3rd edition, Worth Publishers, Inc., New York, New York, 1981.

H. Slesnick, Irwin L., et al., *Biology*, Scott, Foresman and Company, Glenview, Illinois, 1985.

BASIC PLANT PROCESSES

AG 510 - E

INFORMATION SHEET

I. Terms and definitions

A. Photosynthesis--The process of making sugars in green plants from water and carbon dioxide in the presence of sunlight

B. Respiration--The process of using the stored foods of a plant in which energy is obtained or released

C. Transpiration--The evaporation of water vapor from the stoma on the leaves of a plant

D. Absorption--The taking in of water and mineral nutrients through the roots of a plant

E. Stoma--A small opening in the epidermis of leaves and stems through which gases pass

F. Mesophyll--The photosynthetic tissue of a leaf, located between the layers of epidermis

G. Chlorophyll--The green pigment of plant cells; necessary for photosynthesis

H. Chloroplast--A cellular organelle in which chlorophyll is contained; site of photosynthesis

I. Phloem--Food conducting tissue of plants

J. Root hairs--Outgrowths of the epidermal cells of the root; greatly increase absorption area of the root system

K. Permeable membrane--A membrane through which liquid substances may diffuse, such as the plasma membrane of root hair cells

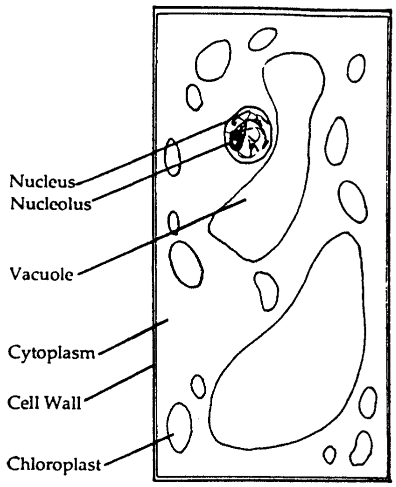
L. Epidermis--The outermost layer of cells of the leaf and of young stems and roots

M. Cortex--Cells of a stem or root bound externally by the epidermis and internally by the vascular system

N. Xylem--Tissue through which most of the water and minerals of a plant are conducted

O. Osmosis--The diffusion of water through a selectively permeable membrane

II. Parts of a common plant cell



III. Functions of plant cell parts

A. Cell wall--Supports and gives shape to cell

B. Cell membrane--Regulates passage of liquids and gases into and out of cell; provides surface for chemical reactions to take place

C. Vacuoles--Provide water storage space

D. Chloroplast--Site of photosynthesis (food production)

E. Nucleus--Controls cell activities; contains genetic material responsible for all inherited characteristics

F. Organelles

1. Mitochondria--Site of respiration; involved in protein synthesis

2. Endoplasmic reticulum--Transport system between cell parts

3. Plastids--Involved in carbohydrate metabolism

IV. Important plant processes in food manufacture and growth (Transparency 1)

A. Photosynthesis

B. Respiration

C. Transpiration

D. Absorption

V. Reasons photosynthesis is the most important process in world (Transparency 2)

A. Plants produce food by photosynthesis

B. Plants produce food used directly by man

C. Plants produce food used indirectly by man through meat and milk produced by livestock

(Note: Green plants, through the process of photosynthesis, are the basic factories of the world on which all life is dependent. A corn plant produces about 5 grams of sugar during 14 hours of sunlight. During a 100-day period, a 20-acre field of corn with 20,000 plants per acre could produce two and one-half tons of sugar. An estimated 150 billion tons of sugar are produced by plants each year by photosynthesis. This would be a pile of sugar 40 miles square at the base and 2 miles high at the peak.)

VI. Process of photosynthesis (Transparency 3)

A. Carbon dioxide (CO_2) enters the leaf from the surrounding air through the stoma

(Note: After CO_2 enters the stoma, it enters the intercellular spaces of the mesophyll tissue. Here it comes in contact with the wet walls of the mesophyll cells. The CO_2 dissolves in the water of the mesophyll cells.)

B. Water moves from the soil into the root, stems and leaves through the xylem tissue

C. The molecules of water (H_2O) and carbon dioxide (CO_2) are synthesized (put together) in the chlorophyll of a plant with energy from sunlight

D. The end result is the formation of sugar which is transported by the phloem tissue to the part of the plant where it is used

(Note: The process can be illustrated by the chemical equation which is written: 6 parts carbon dioxide (6 CO_2) + 6 parts water (6 H_2O) + 672 K cal of radiant energy (sunlight) in the presence of chlorophyll of plants = sugar ($C_6H_{12}O_6$) retained by the plant + oxygen (6 O_2) given off into the atmosphere.)

VII. Factors that affect photosynthetic rate

A. Water supply

B. Temperature

C. Light quality

D. Light intensity

E. Deficiency of certain plant nutrients

VIII. Process of respiration

(Note: As with all living things, plants require energy to carry out their growth and development process. This energy comes from a very complex process called respiration. In a sense, respiration in plants is the reverse of photosynthesis as sugar is broken down to produce energy.)

A. Sugar is broken down to produce energy for essential plant functions

B. Respiration consumes oxygen (O_2) and glucose ($C_6H_{12}O_6$)

C. Respiration gives off carbon dioxide (CO_2) and water (H_20)

(Note: The process can be illustrated by the chemical equation which is written: Sugar ($C_6H_{12}O_6$) + 6 parts oxygen (6 O_2) = 6 parts carbon dioxide (6 CO_2) + 6 parts water (6 H_2O).)

IX. Relationship between photosynthesis and respiration (Transparency 4)

	Photosynthesis		**Respiration**
1.	A building process (+)	1.	A destruction process (-)
2.	Sugars manufactured	2.	Sugars consumed
3.	CO_2 is consumed	3.	CO_2 is given off
4.	Oxygen is given off	4.	Oxygen is consumed
5.	Requires light	5.	Goes on day and night
6.	Only takes place in cells containing chlorophyll	6.	Carried on in all cells
7.	Sugar ($C_6H_{12}O_6$) is the end product	7.	Energy produced for plant functions is end product

(Note: A green plant grown in the dark loses in weight because its stored foods are respired and nothing is added through photosynthesis.)

X. Absorption of nutrients and water

A. Diffusion--Movement of gases or liquid from an area of high concentration to an area of low concentration

B. Osmosis--Movement of a substance from a place of greater concentration through a semi-permeable membrane to a place of lesser concentration

C. Non-root feeding (leaf feeding)--Nutrients and water entering the plant through leaves and stems

XI. The process of absorption

A. The soil solution enters the root hairs by the process of osmosis

(Note: The soil solution is composed of water and minerals in solution.)

B. After the soil solution is absorbed by the root hairs, it moves through the epidermal cells, cortex and phloem to the xylem

C. The xylem conducts the solution to other parts of the plant

XII. The process of transpiration (Transparencies 5, 6, 7)

A. Water enters plant through root hairs

B. Water passes to xylem and up the stem to the leaves

C. A small amount of water is used in photosynthesis

D. The remainder is lost by transpiration

(Note: Water loss occurs mainly through the stoma on the leaves. When stoma are open, water vapor, which is low in carbon dioxide, escapes from the leaf and is replaced by dry air higher in carbon dioxide.)

XIII. Factors affecting water loss by transpiration

A. Climatic conditions

B. The number of stoma on the leaves

C. Availability of soil moisture to the plant

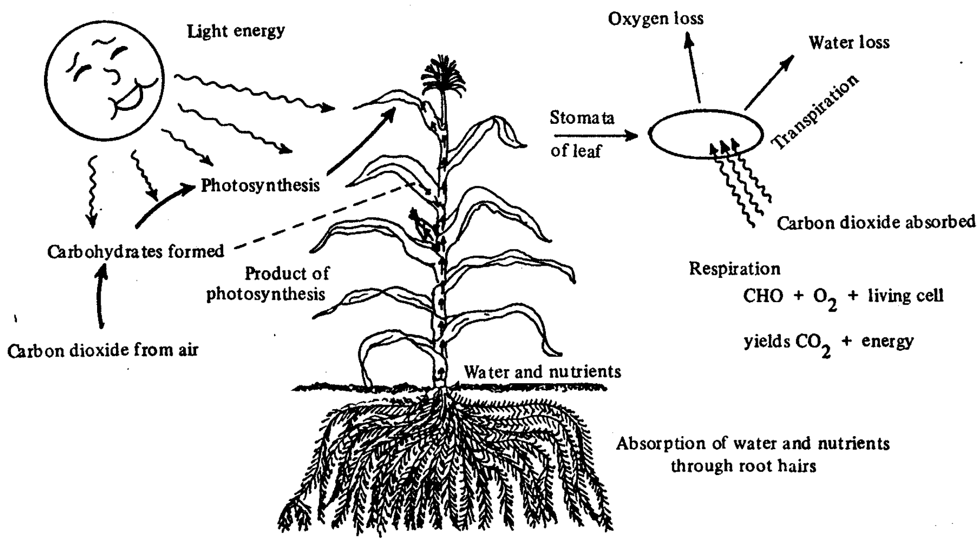
D. General plant structure

(Note: Some plants have a waxy covering called a cuticle which inhibits evaporation of water. Some plants have stoma only on lower side of leaf where temperatures are cooler.)

E. Soil fertility

(Note: Transpiration is greater for plants in fertile soils than poor soils; therefore, the plant uses more water on fertile soils than poor soils.)

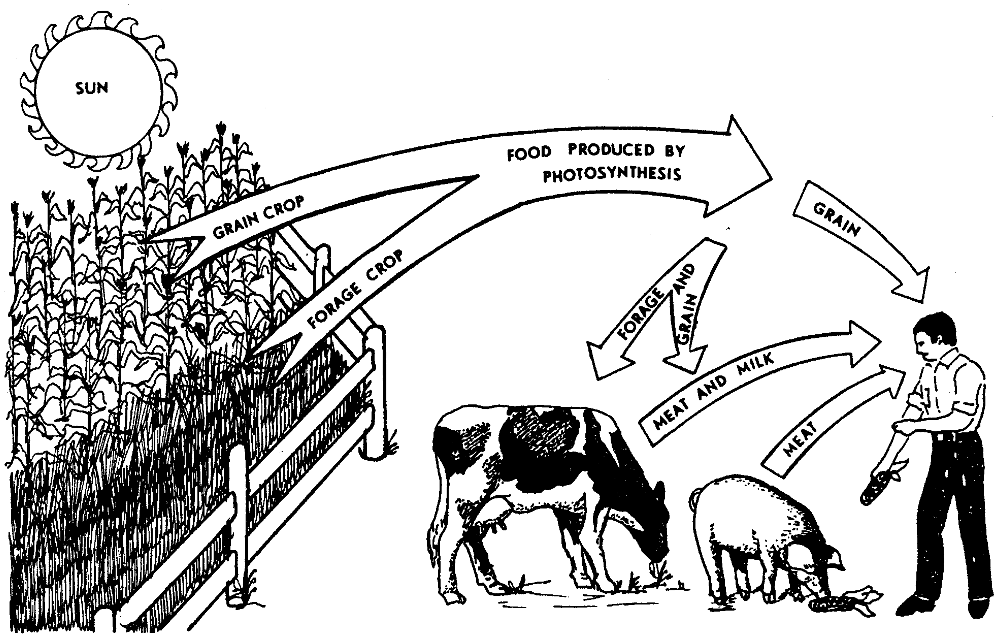
Important Plant Processes



A series of events must take place for plant growth to occur. Important ones are:

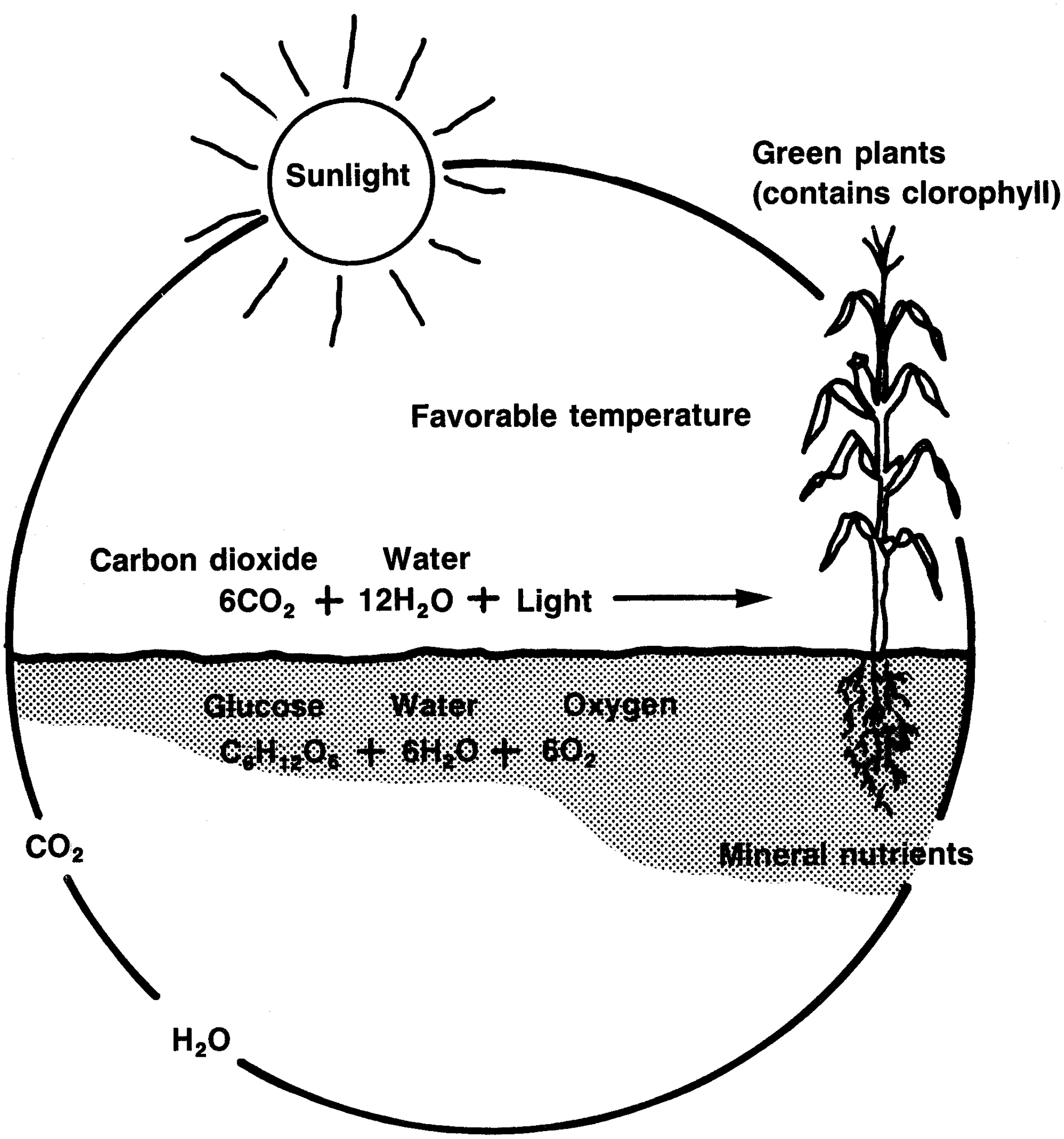
- **Photosynthesis**
- **Respiration**
- **Transpiration**
- **Absorption**

Importance of Photosynthesis

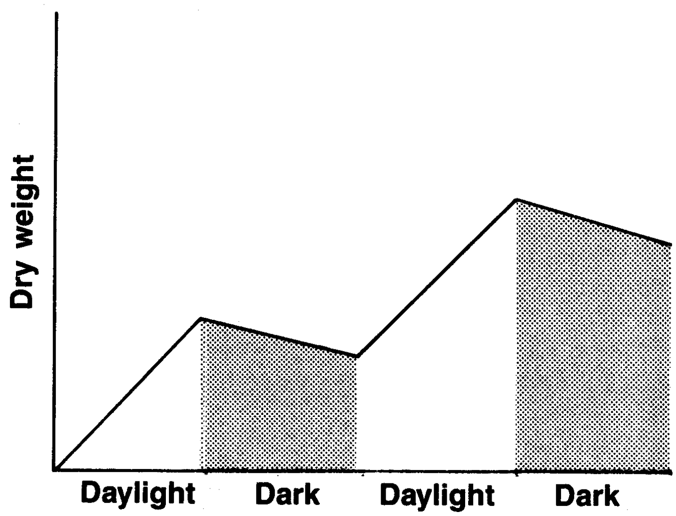


Through the process of photosynthesis, crop plants produce food. This plant-produced food is used directly by man or indirectly through meat and milk produced by livestock.

Photosynthesis



Photosynthesis and Respiration in Relation to Dry Weight



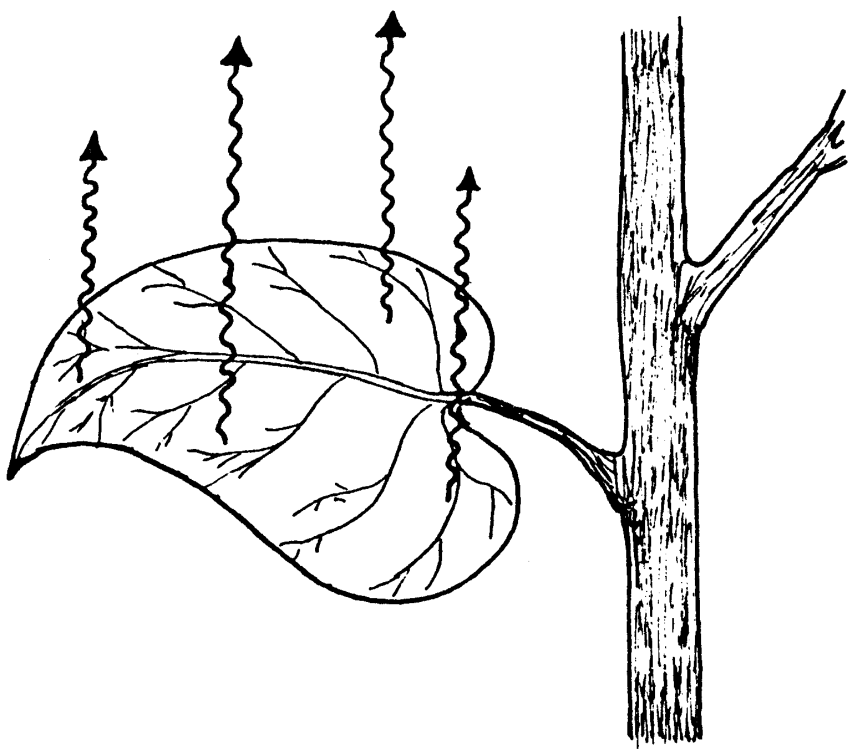
Daylight hours

- **The sugar produced by photosynthesis is greater than the sugar used by respiration.**
- **Result is increase in dry weight.**

Dark hours

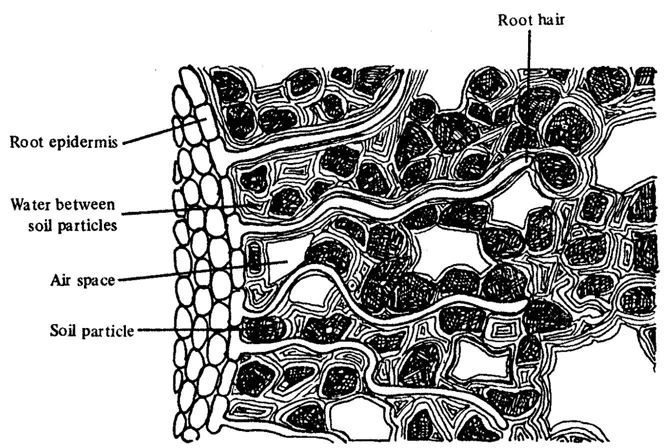
- **No sugar is produced by photosynthesis.**
- **Sugar is used by respiration.**
- **Result is decrease in dry weight.**

Transpiration



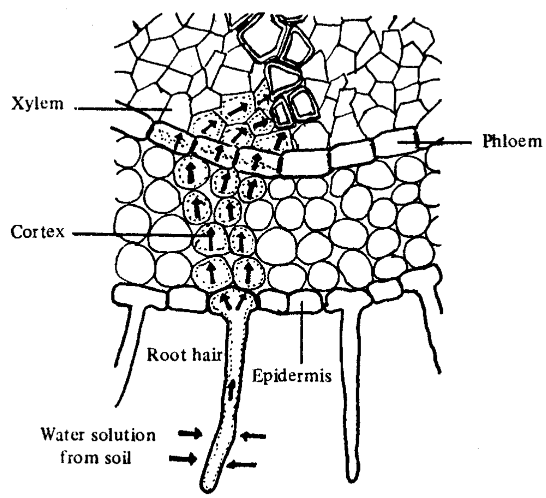
Is the loss of water from plants by evaporation

Root Hairs, Soil Particles and Moisture



1. **Root hairs increase the absorption area of the root system 3 to 5 times.**
2. **Water and minerals in solution enter the plant mainly through the root hairs.**

How a Water Solution From the Soil Moves Within the Root



1. **Solution enters the root hair by osmosis.**
2. **Solution moves through the epidermal cells, the cortex and the phloem to the xylem tissue.**
3. **Solution is transported by the xylem to other parts of the plant.**

BASIC PLANT PROCESSES

AG 510 - E

ASSIGNMENT SHEET #1--EFFECT OF LIGHT ON DRY WEIGHT

Name____ Score___________________________

Part I

Three hundred bean seeds were divided into three lots of 100 each. One lot of 100 seeds was used to measure the percent moisture in the seeds, from which it was possible to calculate the dry weight of the other two lots. A second lot of seeds was sown in sand in a suitable box and kept in a dark room. The third lot was likewise sown in sand in a suitable box and kept under a daily cycle of 15 hours of light and 9 hours of dark. These two lots of seeds were kept at a temperature of 75oF. Four weeks after planting, each lot of resulting seedlings was harvested and the dry weight of each was measured. The resulting data are tabulated.

Environmental Condition	Calculated Dry Weight of Seeds Planted	Dry Weight of Seedlings at End of Four Weeks	Difference Between Dry Weight of Seed-lings and Dry Weight of Seeds Planted
Seedlings in light	57.9 g	82.2 g	+24.3 g
Seedlings in dark	57.9 g	23.4 g	-34.5 g

Part II

a. What one environmental factor was varied in this experiment?

b. How do you account for the increase in dry weight of the seedlings in light as compared with the dry weight of the seeds which were planted in darkness?

c. Why do the seedlings that developed in the dark not gain in dry weight?

d. Why do the seedlings that developed in the dark actually decrease in dry weight?

e. Is light necessary for the utilization of food in the growth of plants?

BASIC PLANT PROCESSES

AG 510 - E

ANSWERS TO ASSIGNMENT SHEET

Assignment Sheet #1

a. Light

b. Photosynthesis is greater than respiration

c. Respiration is greater than photosynthesis

d. Sugars are utilized by respiration for basic functions of the plant without being replenished by photosynthesis

e. Yes

BASIC PLANT PROCESSES

AG 510 - E

INSTRUCTOR NOTES FOR LABORATORY EXERCISES

Lab #1

Allow an average of 10 minutes for the initial setup of each procedure in this laboratory. Allow 30-40 minutes of observation time for both procedures.

Recommended Student Grouping: Teams of Two

Students can set up Part I, do Part II, and then complete their observations for Part I.

Solution preparation:

The following general instructions apply for the preparation of most solutions: Solvents should be added to solutes. Use distilled water, not tap water, for all reagents. When preparing an acid or base solution, *slowly* add the acid or base to the water. Never add water to a concentrated acid or base.

To make percentage solutions measure 1 ml of solute per percentage. Add the solute to enough solvent to make 100 ml of solution. When dissolving a solid in water, measure 1 g of solute per percentage and mix the solute with enough water to make 100 ml of the solution.

<u>Brom thymol blue solution (0.1%)</u>

Dissolve 0.5 g brom thymol blue in 500 ml of distilled water. If the solution is green, add 0.4% sodium hydroxide [NaOH] drop by drop until the solution turns blue. *CAUTION: Sodium hydroxide is a skin and eye irritant. Avoid contact. Immediately flush with water if contact occurs.*

<u>Sucrose solution (10%)</u>

Dissolve 15 g of sucrose in 135 ml of distilled water. Refrigerate.

Part I:

Elodea sprigs should be kept in darkness for two days prior to the laboratory. This will prevent the buildup of ATP in the chloroplasts, which can be used during the dark reactions.

To make yeast suspension, dissolve 0.2 g of yeast in 100 ml of warm (37^{o}C) water. Add 2 g of sugar.

Part II:

Extra-credit questions: The *Elodea* plant used in Procedure A was kept in darkness before you used it in the laboratory. Explain why this is necessary. (HINT: Think of the reactions that can occur in the light and dark reactions of photosynthesis.) (Without light, plants use their reserve of ATP. Therefore, the dark reactions, which cause carbon dioxide production, cannot take place unless the plants receive energy from the light reactions during the experiment whether plants are kept in light or dark environments.)

Carbon dioxide is a by-product of both fermentation and respiration. Name an observable difference between these processes. On which by-product does this difference depend? (The smell. Ethyl alcohol.)

<u>Lab # 2</u>

Part I:

Time required: Setting up for both parts may be done in 50 minutes. However, Part I should run for 1 day; Part II for 3 days.

Carbon dioxide forms carbolic acid in the presence of water.

Caution students not to fill the test tube too full with the brom thymol blue solution.

Brom thymol blue solution: Dissolve 0.5 g of brom thymol blue in 50 ml of water. Add small amounts of ammonium hydroxide to the water until it just turns a deep blue.

Part II:

This section is best suited for a demonstration. Fresh apple cider should be used; it should not be pasteurized or have had any preservatives added.

Be sure that the thermometer extends into the apple cider so that heat can be measured. The rise in temperature over the 72-hour period is visible evidence that heat energy is being produced.

<u>Lab #3</u>

Solution preparation:

In order to prepare a solution of a given percentage, use the number of grams of material equal to the percentage and add enough solvent to equal 100 ml. For example, a 10% sodium hydroxide solution is prepared by dissolving 10 g sodium hydroxide in 90 ml water.

To reduce the concentration of an existing solution, pour the required percentage number of milliliters of the solution into a graduated cylinder. Add enough distilled water to bring the total volume in milliliters to equal the percentage of the original solution. For example, to reduce 95% alcohol to 80%, pour 80 ml of 95% alcohol into a graduated cylinder. Add enough distilled water to bring the volume to 95 ml. You now have 95 ml of 80% alcohol

<u>Hydrochloric acid, 20%</u>

20 parts concentrated hydrochloric acid
16 parts water
Carefully pour acid into water. *Never pour water into the acid.*

Part I:

Time required: 30 minutes for Part I; 40-50 minutes for Part II.

This investigation may be done as a group demonstration. Assign students to perform different activities involved in the Investigation.

Anacharis should be cut by the teacher from sprigs that are kept under water.

Watch for the bubbles being emitted from the stem; *Anacharis* does not release oxygen through the leaves.

Part II:

Visible light is a mixture of wavelengths or colors. Each wavelength possesses a different amount of energy.

Lab # 4

Solution preparation:

In order to prepare a solution of a given percentage, use the number of grams of material equal to the percentage and add enough solvent to equal 100 ml. For example, a 10% sodium hydroxide solution is prepared by dissolving 10 g sodium hydroxide in 90 ml water.

To reduce the concentration of an existing solution, pour the required percentage number of milliliters of the solution into a graduated cylinder. Add enough distilled water to bring the total volume in milliliters to equal the percentage of the original solution. For example, to reduce 95% alcohol to 80%, pour 80 ml of 95% alcohol into a graduated cylinder. Add enough distilled water to bring the volume to 95 ml. You now have 95 ml of 80% alcohol

Part I:

Time required: 50 minutes.

The principles observed in this investigation apply to all cells both plant and animal.

Vegetables not placed in the solutions will show slight loss of turgor due to some water loss to the atmosphere.

Part II may be done during the half hour waiting period.

Part II:

Watch the *Elodea* cells carefully when solutions are added.

Loss of cell turgor will be observable as will be the resulting plasmolysis.

Answers will vary depending on the amount of remaining salt solution. But the cytoplasm should expand with the increased turgidity.

Lab #5

Solution preparation:

The following general instructions apply for the preparation of most solutions: Solvents should be added to solutes. Use distilled water, not tap water, for all reagents. When preparing an acid or base solution, *slowly* add the acid or base to the water. Never add water to a concentrated acid or base.

To make percentage solutions measure 1 ml of solute per percentage. Add the solute to enough solvent to make 100 ml of solution. When dissolving a solid in water, measure 1 g of solute per percentage and mix the solute with enough water to make 100 ml of the solution.

<u>Albumin solution (10%)</u>

Add 20 g of egg albumin or 30 ml of egg white to 180 ml of distilled water. Refrigerate until needed.

<u>Benedict's Solution (also available ready-made)</u>

Add 173 g of sodium or potassium citrate and 100 g of anhydrous sodium carbonate [Na_2CO_3] to 700 ml of distilled water. Heat until chemicals are dissolved. Filter. Dissolve 17.3 g crystalline copper sulfate [$CuSO_4$] in 100 ml of distilled water. Slowly pour the first solution into the copper sulfate solution, stirring constantly. Dilute with distilled water to make exactly 1 L of Benedict's solution.

<u>Glucose solution (10%)</u>

Dissolve 50 g of glucose in 450 ml of distilled water. Refrigerate.

<u>Iodine solution (also available ready-made)</u>

Dissolve 5.0 g of potassium iodide [KI] and 1.5 g of iodine crystals in 500 ml of distilled water. Store in brown bottle or other glass container that shields the liquid from light. *CAUTION: Iodine dust and vapors are toxic and irritating. Avoid body contact and inhalation from fumes. Should body contact occur, flush immediately with water.*

<u>Salt solution (10%) [NaCl]</u>

Dissolve 40 g of salt in 360 ml of distilled water. Refrigerate.

<u>Starch solution (10%)</u>

Dissolve 100 g of cornstarch in 250 ml of distilled water, forming a paste. Pour the paste into 650 ml of boiling (distilled) water. Cook for several minutes, stirring constantly. Cool and refrigerate.

Dialysis tubing should be at least 25 mm in diameter.

It is recommended that students wear safety glasses or goggles throughout this laboratory exercise.

You may wish to provide equipment for setting up hot water baths in step 10.

You may wish to prepare the mixture for the inside of the cell model ahead of time.

Part I:

Step 5: Make sure that the students tie off the ends of their cell models securely. If liquid leaks out of their cell models, have the student empty the liquid into a container and retie the ends securely before proceeding with the experiment.

Step 7: Cell model should sit in the iodine solution for at least 30 minutes. The longer it stays in the iodine, the closer to equilibrium the solutions will be.

Step 9: Students can use the end of the string to pull the cell model out of the iodine solution. Students should use a spoon to transfer the cell to another clean container.

Step 10: Students can also test for oil by placing several drops of the liquid on a piece of brown paper. After the water evaporates, a translucent spot indicates the presence of oil.

Caution students to be careful when using the Bunsen burner. Make sure that loose hair and clothing are secured away from the flame.

Students can also detect starch by adding two drops of iodine solution to 2 ml of liquid from the beaker. This test may yield a stronger color change if starch is present.

Part II:

If aquarium water is not available, use dechlorinated tap water. Allow several liters of tap water to stand out in an open container, such as an aquarium, for several days.

A biuret, nitric acid or ninhydrin test can also be used to test for protein. Caution students to handle these reagents carefully if you decide to use these tests. Contact with the skin can cause stains or burn the skin.

EXTENSION: Students can do Part II using an animal cell such as a cheek or blood cell.

Part IV:

The *Elodea* cells returned to normal because the concentration of water was greater on the outside of the cell when the cell was placed in aquarium water. Water flowed into the cell by osmosis, restoring it to its normal dimensions.

The vacuole of the cell shrank because the concentration of water inside the cell was higher than that outside the cell. Water left the vacuole by osmosis, restoring the cell to its normal state.

<u>Lab #7</u>

Make sure the Elodea plant is very healthy by exposing it to several hours of bright light a few days before students perform this laboratory.

Students can set up Part II while they are waiting to measure oxygen production for plants in Part I.

Part I:

Step 2: Warn students to use caution when using sharp instruments.
Step 3: Add about 1/2 teaspoon of sodium bicarbonate to each test tube.
Step 4: Provide a fluorescent light for growing plants for the bright light environment.
Step 5: In choosing these light environments, try to control for temperature.
Place test-tube racks in appropriate areas around the room in which the students can place their labeled test tubes in Step 5 of Part I.
Step 6: Remind students that plants are adapted to a variety of conditions. For some plants adapted to shade, long exposure to bright light may harm the plant. In the short run, bright light will increase the rate of photosynthesis of almost any plant.

Part II:

You may reuse *Elodea* sprigs from Part I in Part II.

Table I: More bubbles will be released in the bright light.

Table II: More bubbles will be released in the warm temperature than the hot, cool or freezing temperatures.

Part III:

Extensions: Ask students to design an experiment to find out how the color of light affects the rate of photosynthesis.

Lab #8

Part I:

Freshly removed leaves provide the best observation.

Part II:

Demonstrate the pairing of the cobalt paper on the leaves.

Part III:

Celery, freshly removed from the stalk, could be used as a substitute for the coleus.

BASIC PLANT PROCESSES

AG 510-E

LABORATORY EXERCISE #1--DEMONSTRATING PHOTOSYNTHESIS, RESPIRATION AND FERMENTATION

Name____ Score________________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

You can identify many chemical processes by their by-products. For example, usually when you see dark smoke, you conclude something is burning. An aroma may indicate food is being cooked. You can also recognize chemical processes that occur in cells from the by-products that the cells give off. In this laboratory you will demonstrate the processes of photosynthesis, respiration and fermentation by studying the by-products of these reactions.

Materials needed

4 test tubes	25 ml 0.1% brom thymol blue solution	Tap water
Test-tube rack	2 *Elodea* sprigs	Grease pencil
Sodium bicarbonate	Scissors or scalpel	5 ml yeast suspension
Spoon	4 rubber or cork stoppers to plug test tubes	10 ml 10% sucrose solution
Medicine dropper or 10-ml graduated cylinder		2 ml vegetable oil
		Clock or watch

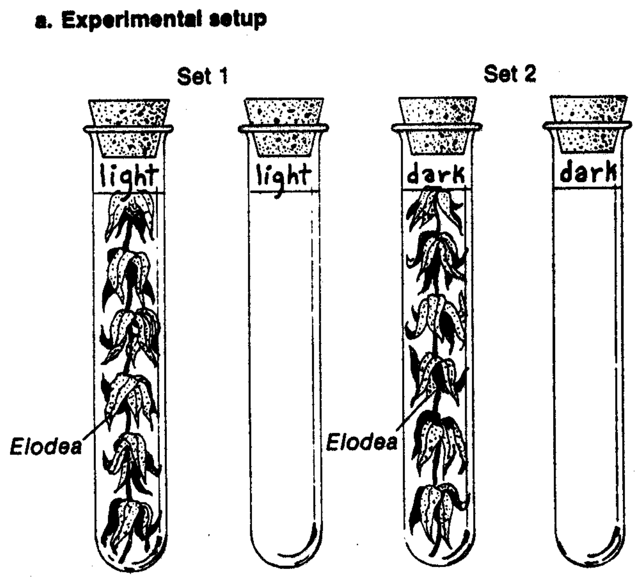
Part I: Photosynthesis and Respiration

1. Plants give off carbon dioxide when they respire and use carbon dioxide during photosynthesis. Fill each of four test tubes about two-thirds full of tap water. Add about 1 g of sodium bicarbonate to each test tube. Sodium bicarbonate releases carbon dioxide when mixed with water.

2. To each test tube stir in 3 ml brom thymol blue solution. In Table I on the following page, record the color of the liquid after stirring. Carbon dioxide forms carbonic acid when released in water. Brom thymol blue turns turquoise, green or yellow in the presence of acid. What is indicated by a change in color of the water in any of the test tubes?

   (a) ____

3. Use sharp scissors or a scalpel to cut two healthy sprigs from an *Elodea* plant. Each sprig should be about 10 cm long. Make a clean diagonal cut across the bottom of each sprig. Place each *Elodea* sprig in a test tube, as shown in a on the following page. Plug all the test tubes with stoppers.



4. Separate the test tubes into two sets. Each set should have one test tube with an Elodea sprig and one test tube containing only liquid. What is the purpose of the tubes that contain only liquid?

(b) ____

____

5. Use a grease pencil to label one set "light." Place these test tubes in bright light for at least 30 minutes. Label the second set of test tubes "dark." Place these test tubes in an area where they will receive no light for at least 30 minutes. Which cell reaction, photosynthesis or respiration, can be carried out completely only in light?

(c) ____

6. After 30 minutes have passed, observe and record the color of the liquid in each test tube in Table I. Dispose of the contents of your test tubes, and clean your equipment.

Table I. Photosynthesis and respiration

	Color of Liquid	
Test tube	**Beginning of lab**	**After 30 minutes**
Light	-------------------------	------------------------
Elodea		
Liquid only		
Dark	-------------------------	------------------------
Elodea		
Liquid only		

Part II: Fermentation

1. Yeast cells can obtain energy by fermentation. In this process the yeast cells give off carbon dioxide and ethyl alcohol. You can detect carbon dioxide in water with brom thymol blue solution, and you can detect ethyl alcohol by its odor. Obtain two clean test tubes. Label one test tube "yeast." Label the second test tube "water." Add 5 ml of yeast suspension to the test tube labeled "yeast." Add 5 ml of water to the other test tube. Add 5 ml of sucrose solution to each test tube. Stir the liquid in each test tube. What is the purpose of the test tube containing only water and sucrose?

   (d) ____

2. Add 5 ml of brom thymol blue solution to each test tube. Record the color of the liquid in Table II below. Note the odor of the liquid.

Table II. Fermentation

Table II. Fermentation

Color of liquid		
Minutes	**Yeast**	**Water**
0		
10		
20		
30		
40		

3. Fill a medicine dropper with oil. Tip one of the test tubes and gently dribble the oil down the side of the test tube. The oil seals the surface of the liquid so that other gases in the test tube cannot diffuse into the liquid. Repeat this step with the other test tube.

4. Place the test tubes in a warm spot in the room. Observe and record the color of the liquid in each test tube every 10 minutes for a total of 40 minutes. Note the odor of each test tube's contents.

5. Dispose of the contents of your test tubes, and clean your equipment and work area.

Part III: Analysis

1. Which by-product of respiration could you detect in this laboratory? How?

   ____

2. Which gas is essential for photosynthesis to occur? How could you detect its use?

   ____

3. Explain your results from Part I.

____

____

4. What do your results from Part II indicate? Explain.

____

____

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #2--WHAT FACTORS AFFECT RESPIRATION?

Name____ Score______________________________

Materials needed

Anacharis
8 test tubes
2 test tube racks
Graduated cylinder
Brom thymol blue
Ammonium hydroxide
Aquarium water
Fresh apple cider
Dry yeast
2 thermos bottles
2 gas bottles
Thermometer
Rubber tubing
2 two-hole stoppers to fit thermos bottles
2 one-hole stoppers to fit gas bottle
4 pieces of glass tubing

Part I: Production of Carbon Dioxide by Anacharis

Plant cells as well as animal cells respire. In this investigation, you will demonstrate that carbon dioxide and energy are produced during respiration.

In this part, you will demonstrate that plants respire by testing for the presence of carbon dioxide.

Brom thymol blue is blue in an alkaline environment, but turns yellow in an acid environment. Carbon dioxide in the presence of water forms a weak acid.

Prepare a solution containing 50 ml of aquarium water and 20 ml of brom thymol solution. Fill 8 test tubes to within 3 cm of the top with this solution. Add a sprig of *Anacharis* to 4 of the test tubes.

a. Why did you leave 4 test tubes without *Anacharis* _______________________________________

____

Place 2 test tubes with the *Anacharis* and 2 without plants in the dark. Put the other test tubes in bright sunlight. Observe the tubes the next day.

b. Which of the tubes showed a change in color?

____

c. Why did this happen? ____

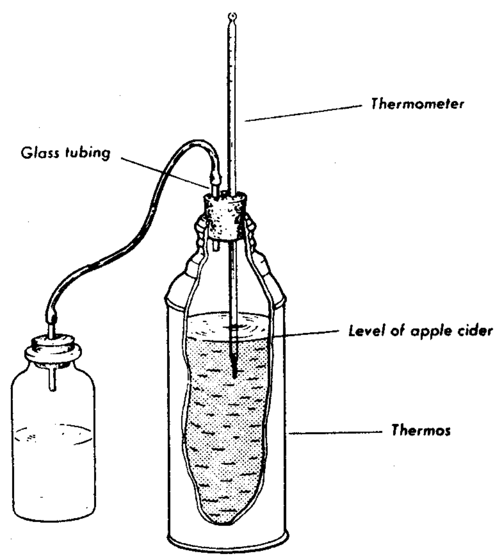
____

d. What process has taken place? ____

Part II: Energy Release During Respiration

In this part, you will use the process of fermentation. Fermentation is a type of respiration in which glucose is oxidized and carbon dioxide and ethyl alcohol are formed. You will determine how much energy is released as heat during this process.

Fill a thermos bottle two thirds full with fresh apple cider. Add 2 g of dried yeast. Insert a piece of glass tubing, as shown below, into one of the holes of a two-hole stopper. Then insert a thermometer into the apple cider when the stopper is placed in the thermos bottle. Fill a gas bottle one half full of brom thymol blue. Now put the stopper in the thermos bottle and insert the long end of the glass tubing into the one-hole stopper of the gas bottle, as shown. Identify this thermos bottle as the experimental bottle. As a control, set up a similar apparatus but omit the yeast. Observe the experiment carefully. Record the temperature of both the experimental and control bottles at the beginning and at 24-hour intervals for 3 days.



a. Was energy produced in either of the thermos bottles?____

____

____

b. If so, why did this occur? ____

____

____

c. Describe the contents of both bottles. ____

____

d. Did you notice any change in the gas bottle? ____

____

e. If so, why was there a change? ____

____

f. Was there any product other than carbon dioxide produced during fermentation? ____________

g. What type of respiration is being performed by the yeast cells? __________________________

____

Fill in the table with your data.

	Temperature			
Thermos Bottle	**Start**	**24 hours**	**48 hours**	**72 hours**
Control				
Experimental				

Part III: Summary

a. What evidence did you find that respiration occurs in *Anacharis*? ______________________

____

b. Why must a control be used in the *Anacharis*-respiration investigation? __________________

____

c. Why did fermentation take place in one thermos and not in the other ___________________

____

d. How can you prove that a product other than carbon dioxide is produced during fermentation?

____

<u>Part IV: Investigations On Your Own</u>

1. You may be interested in finding out whether germination seeds release carbon dioxide. To do this, soak some seeds (wheat, corn, peas) in 5% formalin solution for about 20 minutes. Wash the seeds in cold water and soak overnight. Fill a gas bottle one third full with the seeds. Fill a

second bottle about one third full with brom thymol blue. Use a U-tube to connect the two gas bottles. Set up a similar apparatus as a control. However, destroy the seeds in the control by soaking them in 10% formalin for an hour. Observe what occurs in the demonstration bottle and in the control. Draw conclusions from your observations.

2. Design an original experiment that involves the influence of different foods on yeast respiration rates. Draw conclusions from your observations.

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #3--HOW DOES LIGHT AFFECT PHOTOSYNTHESIS?

Name____ Score________________________________

Materials needed

Anacharis (Elodea)
6 Pyrex test tubes
4 pieces of glass rod (5 cm)
150-watt reflector lamp
Sodium bicarbonate
Dilute brom thymol blue solution
0.1% hydrochloric acid solution
6 test tube stoppers
Medicine dropper
Forceps
Test-tube rack
250-ml beaker
6 sheets of cellophane; 7 cm by 15 cm; red, yellow, green, blue and 2 clear
Soda straw
Rubber bands

Part I: The Rate of Photosynthesis

The rate at which photosynthesis takes place can be determined by recording the number of oxygen bubbles that escape from the cut end of a sprig of *Anacharis*. In this part, you will observe the effect of light on the rate of photosynthesis.

Fill 4 test tubes with water within 3 cm of the top. Select 4 sprigs of *Anacharis* that have been growing in bright light. Each sprig should be about 7 cm. Wind each sprig around a glass rod and immerse in one of the test tubes. Sodium bicarbonate forms carbon dioxide in water. Add a small amount of sodium bicarbonate to each test tube.

a. Why should this be done? ____

____

Place one test tube under bright sunlight or a reflector lamp; the second should be in daylight; the third in diffuse light; and the fourth in total darkness. Allow the plants to remain in these light conditions for 15 minutes. Observe the cut ends of each plant. Use a timer or a watch with a second hand and count the number of oxygen bubbles given off by each plant in 1 minute.

b. What do the bubbles tell you about the rate of photosynthesis? ______________________________

____

c. Under which condition is the bubble count the greatest? ___________________________________

____

d. Under which light condition is the bubble count the least?__________________________________

____

e. What conclusions can you draw from this investigation? ___________________________________

____

____

Continue to record the results of the investigation by counting the bubbles for 5 minutes. Record your observations in the table provided.

Environmental Condition	**Rate per Minute**	**Rate per 5 Minutes**	**Average Rate per Minute**
Sunlight or reflector lamp			
Day light			
Diffuse Light			
Darkness			

f. How do you account for the variation in the rate of bubbles in the 4 plants? ___________________

____

____

____

Part II: The Effect of Wavelengths of Light on Photosynthesis

In Part I, the effect of light on photosynthesis was clearly indicated. In this part, you will examine the effect of the different wavelengths (colors) of light on photosynthesis. Different wavelengths of light contain varying amounts of energy.

Fill a beaker with 100 ml of water. Add brom thymol blue to color the water a pale blue. Using a soda straw, blow into the solution. This will cause a change in color.

a. What color does the solution become? ____

____

b. What causes this color change?____

____

Place 5 test tubes in a test tube holder and insert a sprig of *Anacharis* in each. Add the solution from the beaker to cover the sprigs of *Anacharis* in the test tubes. Place a stopper in each test tube. Fill a sixth test tube with the same solution, but do not place an *Anacharis* sprig in it. Stopper this tube.

c. What function does this tube perform? ____

____

Wrap a cellophane sheet of a different color around each test tube. Wrap one tube containing *Anacharis* and one without the plant with clear cellophane. Use rubber bands to secure the cellophane sheets. Expose the test tubes in the rack to the light of the lamp for about 20 minutes. Examine each test tube and record your results in the table below.

Test Tube	**Color of Indicator after 20 minutes**	**Number of drops of Hydrochloric Acid to Restore Color**
Red		
Yellow		
Green		
Blue		
Clear		

d. How do you account for the changes in the test tubes? ______________________________________

____

____

e. What substance were the *Anacharis* sprigs absorbing? ______________________________________

____

f. Which wavelength (color) was most effective in increasing the rate of photosynthesis? __________

____

g. Which color was least effective in increasing the rate of photosynthesis? ______________________

____

Remove the *Anacharis* from the 5 test tubes. Add 0.1% hydrochloric acid drop by drop to each test tube until the original color returns. Count the number of drops necessary for each to change color. Record your findings in the second column of the table.

h. Why does the hydrochloric acid return the color to the original? ____________________________

____

i. What was the color of the liquid in the tube without the *Anacharis*? __________________________

____

j. What was the purpose of this test tube? ______________________________

____

Part III: Summary

a. How can the rate at which photosynthesis takes place be determined?______________________________

____

b. Why was sodium bicarbonate added to the test tubes in Part I of this investigation?______________

____

c. Under which condition of light was the bubble count the greatest? ______________________________

____

____

d. Under which condition of light was the bubble count the least?______________________________

____

e. What conclusions did you draw from Part I of this investigation? ______________________________

____

f. What substance was absorbed by the *Anacharis* sprigs in Part II of the investigation? ___________

____

g. Which wavelength was most effective in speeding up the rate of photosynthesis? ______________

____

h. How do you know this is so? ______________________________

____

<u>Part IV: Investigations On Your Own</u>

1. The effect of temperature on the rate of photosynthesis can also be determined. Prepare 4 sprigs of *Anacharis* as you did for Part I. Place one test tube in a water bath and, using ice chips, reduce the temperature to 10oC. Record the oxygen bubbles given off after 1 minute and after 5 minutes. Add hot water to the water bath and separately raise the temperature to 20oC, 30oC, and 40oC. Use a separate test tube of *Anacharis* at each temperature and record the number of oxygen bubbles released. Draw conclusions from your investigation concerning the effect of temperature on the rate of photosynthesis.

2. Design an original investigation that will show how different concentrations of carbon dioxide affect the rate of photosynthesis.

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #4--WHEN DOES OSMOSIS OCCUR IN LIVING CELLS?

Name____ Score ____________________________

Materials needed

Potato slices	Sprig of A*nacharis (Elodea)*
Cucumber	Microscope
4 culture dishes	Glass slides
Distilled water	Cover glass
1% NaCl solution	Dropper
15% NaCl solution	Filter paper

Part I: Turgor in Plant Tissues

Turgor is the rigidity or stiffness of plants due to the water present in their cells. In this part, you will observe the presence and loss of turgor pressure.

Fill 2 culture dishes with distilled water and 2 with 15% NaCl solution. Place some of the slices of potato in one of the dishes with distilled water and in one dish with 15% NaCl solution. Place cucumber slices in the remaining 2 dishes. Leave the dishes for about one-half hour. Observe the fresh vegetables that had not been placed in any of the dishes.

a. How would you describe their stiffness and texture?

____

Remove some of the vegetables from the distilled water.

b. How would you describe their stiffness and texture?

____

c. Has the turgidity of the cells in the distilled water increased or decreased? ____________________

____

d. What conclusions can you draw from this observation?

____

Remove some of the slices from 15% salt solution.

e. How would you describe their stiffness and texture?

f. Do these slices have greater or lesser turgidity than the slices that were not in any of the dishes?

g. Draw conclusions concerning the turgidity of the slices in the NaCl solution.

h. Did osmosis occur in this part of the investigation?

Part II: Osmosis in Plant Cells

In this part, you will observe microscopically what happens to cells placed in solutions of varying salt concentrations.

Remove one leaf from a sprig of *Anacharis* and prepare a wet mount slide with tap water. Examine under high power.

a. What do you see?

b. Describe the position of the cell membrane and chloroplasts

In the space provided, draw the cell that you observed.

Place one drop of 15% NaCl solution at the edge of the cover glass. About every 30 seconds, add another drop of NaCl solution until you observe a change in appearance of the cell.

c. How many drops of NaCl were added before a change was noticed?

d. Do you think that water moved in or out of the cell?

____

e. Why do you think this change occurred? ______________________

____

In the space provided, draw the cell that you observed after the NaCl was added.

Place a piece of filter paper at the edge of the cover glass and absorb as much of the salt solution as possible. Add distilled water at the edge of the cover glass, a drop at a time, watching the cells closely.

f. Do you observe any changes in the cells?______________________

____

In the space provided, draw the cell that you observed after the distilled water was added.

Part III: Summary

a. Did diffusion take place when NaCl solution was added to the *Anacharis* cells?__________

b. If so, explain why it took place. ______________________

____

c. How would you explain the condition of the vegetable slices that were in the salt solution?

____

d. How would you define turgidity? ______________________________________

____

e. Of what value is turgidity to a plant? ____________________________________

____

f. What purpose did the freshly cut vegetables (not placed in any culture dishes) serve in this investigation?

____

Part IV: Investigations On Your Own

1. The permeability of cell membranes can be tested effectively by using red blood cells. In this investigation, you can test the effect of temperature (as you did in Part III) on the cell membrane. Prepare four test tubes of tap water. One should be 0oC; one at 25oC; one at 50oC; and one at 65oC. Mix each test tube of water with three drops of blood. Place a stopper in each tube and invert a few times. The bursting of red blood cells is called hemolysis. You will know that this has occurred in your test tubes when the cloudiness in a test tube becomes clear. Draw conclusions from this investigation.

2. Design your own investigation that tests the effects of one factor on the diffusion process. It might be interesting to use acids and bases in testing the effects of pH on diffusion.

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #5--STUDYING THE MOVEMENT OF SUBSTANCES ACROSS MEMBRANES

Name____ Score ____________________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

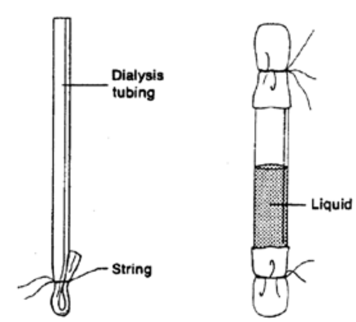
To carry out basic life functions, cells need to exchange materials with their environment. These materials move in and out of the cell, passing through the cell membrane. Some molecules can move easily and quickly across the cell membrane by diffusion. Other molecules cannot diffuse across the cell membrane. In this laboratory you will make a model of a cell. Then, you can study the diffusion of various substances across a material that is *selectively permeable* to certain materials, as is a cell membrane. You will also observe plant cells in different environments to learn how the movement of water across the cell membrane affects the cell.

Materials needed

Dialysis tubing, 15 cm long
Tap water
Thread, 30 cm
50-ml graduated cylinder
250-ml graduated cylinder
Large beaker, small bowl
or small container
10 ml 10% starch solution
10 ml 10% glucose solution
3 ml vegetable oil
10 ml 10% albumin solution
Stirring rod
Small funnel
500-ml beaker
200-ml dilute iodine solution
Spoon
2 test tubes
Medicine dropper
2 ml Benedict's solution
Bunsen burner
Test-tube holder
3 *Elodea* leaves
3 microscope slides
3 coverslips
Grease pencil
Aquarium water
10% salt solution
Distilled water
Compound microscope

Part I: Diffusion Across the Membrane of a Model Cell

1. Soak a piece of dialysis tubing in tap water for several minutes. To separate the tube walls, rub the surfaces of the tube between your thumb and forefinger. Fold one end of the tubing, and secure that end with string, as shown in **a.**



a. Setting up dialysis tubing   b. Cell model

2. Measure and mix 10 ml of starch solution with 10 ml of glucose solution and 10 ml of albumin (protein) solution. Then, add 3 ml of oil to the mixed solutions. Stir this mixture, and pour it into a graduated cylinder. On the line below, record the volume of the liquid.

   (a) ______________________________

3. Using a funnel, pour the liquid from step 2 into your dialysis tubing until the tubing is half full. Firmly tie off the open end of the tubing as shown in **b.** on previous page. Leave the long thread attached. Record the amount of liquid left in the graduated cylinder on the line below.

   (b) ______________________________

4. To find the volume of liquid in your cell model, subtract the volume recorded on line (a) from that recorded on line (b). Write this sum on the space in Table I below.

5. Invert your cell model over the sink. Make sure that no liquid leaks from your cell model. Then, rinse the surface of the cell model under tap water. Place the cell model in a clean 250-ml beaker.

6. Fill the larger graduated cylinder with about 200 ml of iodine solution. *CAUTION: Avoid getting iodine on your hands. It stains and is poisonous if ingested.* Record the volume of iodine solution on the line below.

   (c) ______________________________

7. Pour enough iodine solution over your cell model to cover the top surface of the cell model. Record on line (d) the volume of iodine solution remaining in your graduated cylinder.

   (d) ______________________________

8. Allow your cell model to remain in the iodine solution overnight. To find the amount of iodine surrounding the cell, subtract the volume on line (c) from that on line (d). In the space in the table, record the amount of iodine solution surrounding your cell model.

Table 1. Movement of substance across a membrane.

Liquid	Volume		Iodine present		Starch present		Oil present		Glucose present		Albumin present	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Liquid surrounding cell model												
Liquid inside cell												

9. After at least 24 hours have passed, use the attached string to lift the cell model out of the beaker. Let the excess liquid drip back into the beaker. Place the cell model in a clean, empty beaker, bowl, or container. Measure the amount of liquid remaining in the 250-ml beaker, and record this amount in the table.

10. Run the following tests on the liquid in the 250-ml beaker to determine if any of the substances inside the cell model have diffused through the membrane. If starch crossed the membrane, it would react with iodine, producing a blue-violet color. In Table I, record if a reaction of starch and iodine occurred. Look for oil droplets on the surface of the liquid. Record your observations in the table. Put about 2 ml of liquid into each of two test tubes. You will test the liquid in one test tube for albumin and the liquid in the other test tube for glucose. To test for albumin, heat the test tube over a Bunsen burner until the contents in the test tube come to a boil. A cloudy, white precipitate indicates albumin is present. To test for glucose, add 1 ml of Benedict's solution to the second test tube. Heat the test tube over the Bunsen burner for five minutes. If glucose is present, the heated liquid will turn green, orange, yellow, red or brown.

11. Remove the cell model from the container and untie one end of the dialysis tubing. Pour the liquid into the smaller graduated cylinder. Record in Table I the volume of liquid in the graduated cylinder. This amount is the volume of liquid that remained in your cell model. Repeat the tests in step 10 using the liquid from your cell model. Record in the table the substances that were present. You will be checking for the presence of the original substances in the liquid and for the movement of iodine into the liquid.

12. Dispose of the liquids and clean your equipment.

<u>Part II: Osmosis in a Living Cell</u>

1. Use a grease pencil to label one slide "Aquarium water", the second slide, "Salt water", and the third "Distilled water". Place several drops of the liquid named on the label in the center of the slide that bears that label.

2. Select three small *Elodea* leaves, and place each one in the liquid on the center of the slide. Add a coverslip.

3. Examine each slide under the microscope using low power first, then high power. In the spaces provided, draw and label a typical cell from each leaf as it appears under high power. Notice the size of the vacuole in each cell.

Part III: Analysis

1. Table II lists approximate molecular weights of the molecules dissolved in the liquids used in Part I. Use this information to explain the results of the laboratory. How is a substance's molecular weight related to the substance's diffusion rate?

____

____

Table II. Molecular weight

Substance	Approximate molecular weight
Water	18
Glucose	180
Iodine	250
Starch	1,000
Oil	1,000
Albumin	40,000

2. Did the amounts of liquid inside and outside the cell model change significantly? Explain why or why not.

____

____

3. In Part II, how did the three liquids affect the Elodea cells? Use the terms *osmosis, isotonic, hypertonic and hypotonic* to explain your results.

____

____

____

____

4. How does the structure of the *Elodea* cell protect the cell if the cell is placed in distilled water? What might happen to blood cells placed in distilled water? Explain your answer.

____

____

____

5. Kidney machines use dialysis tubing in a special bath to remove wastes from a patient's blood. What causes the waste products in the blood to pass through the tubing into the bath?

____

____

<u>Part IV: Going Further</u>

1. Use forceps to dunk the *Elodea* leaf that was in salt water into a beaker of aquarium water. Then, using aquarium water, make a wet mount of the leaf. After about ten minutes, observe the leaf cells under low power and then high power. Draw some of the leaf cells. Compare your drawing to the drawings that you did in step 3 of Part II. If the cell changed in appearance, explain why.

2. Repeat the above procedure with the leaf that was placed in distilled water. Again, draw the leaf cells, and explain any changes that you observe.

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #6--MEASURING LOSS FROM TRANSPIRATION

Name____ Score__________________________

I. Materials needed

A. A growing plant in a pot, bucket or other container or a plant growing in a convenient location

B. Plastic bag or sheet of clear plastic that will cover the plant or a branch of the plant containing 10 to 12 leaves

C. String, rubber bands or other suitable tie materials

D. Stake to support the weight of the plastic

E. Plastic straw or other suitable tubing for a drain

F. Measuring cup or beaker

II. Procedure (Figure 1)

A. Be sure plant has been watered

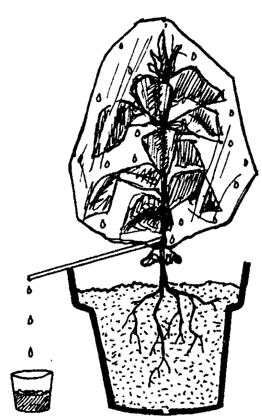
B. Cover the entire vegetative portion of the plant or a section with plastic material

C. Locate tubing at bottom of plastic covering to serve as a water drain

D. Place plant in sunny location for an entire day; measure the water collected; empty container

E. Measure water collected during dark period of the day

F. Compare differences in the amount of water collected



III. Questions

a. Which period produced the most water in the container? Why?

b. Does temperature have an effect on transpiration rates? Does light? Air humidity?

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #7--MEASURING RATES OF PHOTOSYNTHESIS IN DIFFERENT ENVIRONMENTS

Name____ Score ______________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

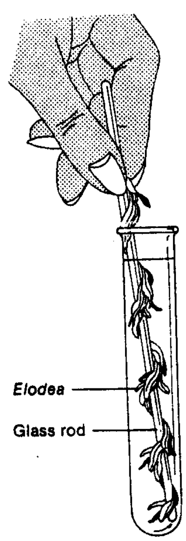
Plants grow in many different environments. Dandelions grow in cracks in a sidewalk; pine trees grow high on mountainsides; water lilies grow from shallow lake bottoms. Though plants flourish in vastly different environments, most plants have one thing in common: they need light to survive. Unlike certain animal species, no species of green plant can survive for long in total darkness. To make glucose, plants capture light energy in the process of photosynthesis. In this laboratory you will observe how both light intensity and temperature affect the rate of photosynthesis of an *Elodea* plant.

Materials needed

Metric ruler
Scissors or scalpel
Clock or timepiece
Sodium bicarbonate
Spoon
Masking tape
Marking pen
Ice
Thermometer
4 300-ml beakers
Elodea sprigs
Tap water
4 test tubes
4 glass stirring rods, each about 5 cm long

Part I: Comparing Rates of Photosynthesis Under Different Light Conditions

1. Place four test tubes in a test-tube rack. Fill each test tube to within 4 cm of the rim with aquarium water.



a. *Elodea* sprig in test tube

2. Cut four healthy sprigs from an *Elodea* plant. Each sprig should be approximately 8 cm long. Use sharp scissors or a scalpel to make a clean diagonal cut across the bottom of each sprig.

3. Obtain four glass rods. Wrap each *Elodea* sprig around a glass rod. Place each glass rod with an Elodea sprig in a test tube, as shown in a. The cut end of the *Elodea* should be in the bottom of the test tube. Add about 1 g of sodium bicarbonate to each test tube. Sodium bicarbonate supplies carbon dioxide needed for certain reactions in photosynthesis.

4. Make masking tape labels for each test tube. On one label, write "bright light"; on a second label, write "daylight"; on a third, write "shade"; on the fourth, write "darkness". These are the four different light environments for this part of the laboratory.

5. Place each test tube in the type of light indicated on its label. Make sure that the temperature in each different light environment varies no more than 5°C. On a separate piece of paper, copy Table I below.

6. After 15 minutes have passed, observe the bubbles rising from the cut ends of each *Elodea* plant. These bubbles are oxygen gas given off as a by-product of photosynthesis. What is the relationship between the number of bubbles given off and the rate of photosynthesis?

   (a) ____

7. Count the number of bubbles given off by each plant in three minutes. Record your results in your Table I. Compute the average number of bubbles given off by each sprig in one minute. Record these averages in Table I.

<u>Part II: Comparing Rates of Photosynthesis Under Different Temperature Conditions</u>

1. Repeat steps 1-3 of Part I.

2. Prepare masking tape labels for your test tubes. Label one tube "0°C"; a second, label "15°C"; label a third test tube "30°C"; label the fourth "45°C". These are the four different temperature environments for this part of the laboratory. On a separate piece of paper, copy Table II.

3. Obtain four beakers. Fill one beaker three-quarters full of ice. Half fill the other beakers with cool, warm and hot water respectively. Measure the temperature of each water bath. Add warmer or cooler water to each to bring the temperature of the cool water bath to 15°C, the warm water bath to 30°C, and the hot water bath to 45°C. In each water bath, place the test tube with the corresponding label.

4. Count and record the number of bubbles released during three minutes from the cut ends of each *Elodea* sprig. Compute the average number of bubbles released by each sprig in one minute, and record these averages in Table II.

5. Clean up your work area and put away your equipment.

Table I. Light intensity

Light conditions	Bubbles released in three minutes	Average number of bubbles released per minute
Bright light		
Daylight		
Shade		
Darkness		

Table II. Temperature

Water bath temperature	Bubbles released in three minutes	Average number of bubbles released per minute
0° C		
15° C		
30° C		
45° C		

Part III: Analysis

1. Using your results from Part I as evidence, how does light intensity affect the rate of photosynthesis of an *Elodea* plant?

 ____

 ____

2. How can you explain the effects of light intensity on photosynthesis? Review the photosynthesis reactions to formulate your answer.

 ____

 ____

3. How does temperature affect the rate of photosynthesis in an *Elodea*? Explain using the results from Part II.

 ____

 ____

BASIC PLANT PROCESSES

AG 510 - E

LABORATORY EXERCISE #8--WATER MOVEMENT THROUGH PLANTS

Name____ Score___________________________

Materials needed

Tulip, Trandescantia or Geranium leaves
6 coleus or periwinkle cuttings, 15-20 cm in length
1 healthy geranium plant
Slide, cover glass
Microscope
Paper toweling
10% salt solution
2 sandwich bags
Cobalt paper
Paper clips
Cellophane tape
250-ml beaker
Eosin powder or red ink
Single-edged razor blade

Part I: The Structure of the Stomata

In addition to providing for the movement of gases in and out of a leaf, the stomata have the function of regulating the movement of water through the plant.

Remove a small piece of the lower epidermis from a tulip or geranium leaf by tearing with the blade, twisting as you tear. The epidermis appears as a thin, transparent skin. Prepare a wet mount of a piece of the epidermis. Be careful not to wrinkle the tissue. Examine the tissue under low power. Note the shape and arrangement of the *epidermal cells* and the number and arrangement of the *stomata* (singular stoma).

a. Are chloroplasts present in the epidermal cells? ____

Locate the bean-shaped *guard cells* on either side of the stoma. Study the walls of the *guard cells* under low power.

b. What variation in thickness can be observed in the inner and outer walls?

____

c. What structure can you observe in the guard cells?

____

The *stoma* is a pore opening into the air spaces of the leaf. Only a small percentage of the water absorbed by a plant is used in photosynthesis and other plant processes. The remainder is lost from the tissues of the leaf through the stomata. The guard cells regulate the size of the stomata by changing shape.

d. Why is this important to the leaf and the plant?

____

To observe the opening and the closing of the stoma, prepare a fresh wet mount of the lower epidermis and examine under low power.

e. Are the stomata open?____

____

Remove the water from the preparation by placing paper toweling at the left edge of the cover glass to soak up the water. Add a 10% salt solution to the right side of the cover glass. *Observe quickly*.

f. Describe what happened to the guard cells and the stoma.

____

____

g. How can you explain the changes that occurred?

____

____

h. Explain what natural activity of a leaf might cause the stomata to close.

____

____

____

____

In the space provided, draw the lower leaf epidermis. Label: **stoma, guard cells, chloroplasts, epidermal cells.**

<u>Part II: Transpiration</u>

Transpiration is essentially the loss of water from a plant through evaporation from leaf tissues.

Remove a leaf from a vigorously growing geranium plant. Fasten a strip of blue cobalt paper to the lower surface and upper surface by clipping the paper at both ends to the leaf. Do not damage the leaf unnecessarily. Blue cobalt paper turns pink in the presence of moisture. Place the leaf in a small plastic sandwich bag and seal it with tape. Place a strip of cobalt paper in a bag by itself and seal it.

a. What is the purpose of this second bag?

____

Observe the leaf after 10 minutes.

b. What is the color of the cobalt paper on the upper surface? ____________________

____

c. The color on the lower surface?______________________________

d. What is the color of the cobalt paper in the empty bag?

____

e. How do you account for the difference in the color of the cobalt paper?

____

____

f. Why is it necessary to seal the bag?

____

____

g. Are the leaves wet?______________________________________

h. From what part of the leaf did the moisture come?

____

i. Why is a control bag needed?

____

____

j. Originally, how did the water get to the leaf?

____

____

Part III: The Path of Rising Water in a Stem

In the examination of the structure of roots and stems, it may be observed that certain tissues are responsible for the conduction of substances up and down the stem.

a. Which tissue is responsible for the conduction of water?

____

Fill a 250-ml flask about one third full of water which as been colored with powdered eosin or red ink. Place a *freshly* cut stem of coleus in the flask. Leave the stem in the solution at least 30 minutes. Remove the stem and split it lengthwise with a razor blade.

b. What evidence do you see of the rise of dye in the stem?

____

c. In the stem, locate where the water seems to have risen.

____

____

Make a cross section of a lower portion of the stem and prepare a wet mount. Examine the stem under low power of the microscope.

d. In what tissue of the stem is there evidence that water has risen?

____

Part IV: Summary

a. On the basis of what you have learned about transpiration, account for the fact that leaves often wilt on a hot summer day, but return to normal at night.

____

____

____

b. List as many factors as you can think of that might affect the loss of water from a plant.

____

____

The following events trace the movement of water from the soil, through a plant to the atmosphere. Using your knowledge of plant structure, unscramble the pathway and write the events in order of occurrence in the space provided. The first and last are done for you.

WATER

*enters the petiole of the leaf	1.	water in the soil
*moves across the cortex of the root	2.	______________________________
*absorbed by mesophyll cells	3.	______________________________
*enters vascular cylinder	4.	______________________________
*enters veins of leaf	5.	______________________________
*absorbed by root hairs	6.	______________________________
*leaves leaf through stomata	7.	______________________________
*moves into xylem cells of stem	8.	______________________________
*evaporates into air spaces of leaf	9.	______________________________
*moves up xylem of stem	10.	______________________________
	11.	______________________________
	12.	water escapes to atmosphere

BASIC PLANT PROCESSES

AG 510 - E

ANSWERS TO LABORATORY EXERCISES

Lab #1:

Part I:

2. (a) Carbon dioxide dissolved in the water, forming carbonic acid.
4. (b) It is a control to show how the carbon dioxide content of water changes over time.
5. (c) Photosynthesis

Table I. Photosynthesis and respiration

Color of Liquid		
Test tube	Beginning of lab	After 30 minutes
Light	------------------------	------------------------
Elodea	Yellow or green	Blue
Liquid only	Yellow or green	Yellow or green
Dark	------------------------	--------------------------
Elodea	Yellow or green	Yellow
Liquid only	Yellow or green	Yellow or green

Part II:

1. (d) It is a control to show how carbon dioxide content of sucrose and water solution changes over time.

Table II. Fermentation

Color of liquid		
Minutes	Yeast	Water
0	Blue	Blue
10	Blue or turquoise	Blue
20	Turquoise or green	Blue
30	Green or yellow	Blue
40	Green or yellow	Blue

Part III:

1. Carbon dioxide. Brom thymol solution turns yellow as carbon dissolves in the water.

2. Carbon dioxide. Brom thymol solution changed from yellow to blue as CO_2 in water was used by the *Elodea.*

3. The change of brom thymol solution from yellow back to blue indicates plants carry on photosynthesis. The change in color of brom thymol blue to deep yellow indicates plants respire.

4. The change in color of brom thymol blue to a deep yellow and the odor of the liquid indicate yeast carry on fermentation, releasing CO_2 and alcohol.

<u>Lab #2</u>

Part I:

a. as color control test tubes.
b. tubes with brom thymol blue and *Anacharis* in the dark.
c. Carbon dioxide was produced resulting in a change from alkaline to acid.
d. respiration

Part II:

a. one bottle
b. The yeast cells fermented and released heat energy.
c. no change in control bottle; brom thymol blue in experimental bottle turned from blue to yellow
d. yes
e. The carbon dioxide produced during fermentation caused brom thymol to change color.
f. Alcohol
g. anaerobic

Answers in table will vary.

Part III:

a. Carbon dioxide was produced.
b. to be certain that a change has taken place due to respiration
c. Living yeast cells were only in one thermos.
d. by smelling the product (alcohol)

<u>Lab #3</u>

Part I:

a. provides the carbon dioxide that is needed for photosynthesis
b. They indicate how rapidly it is taking place.
c. under the brightest light
d. under the least light
e. The rate of photosynthesis is directly proportional to the amount of light available.

Answers in the table will vary.

f. Oxygen is a by-product of photosynthesis. When the light intensity is reduced or light is not available, the rate of photosynthesis is slowed down or stops.

Part II:

a. yellow
b. addition of carbon dioxide
c. acts as a control
Answers in the table will vary.
d. The indicator (brom thymol blue) changes color as CO_2 concentration varies.
e. carbon dioxide
f. blue or red
g. green
h. creates an acid environment where brom thymol blue is yellow in color
i. yellow
j. control

Part III:

a. by observing the rate of release of oxygen
b. provided the necessary carbon dioxide
c. the best light source
d. darkness
e. The rate of photosynthesis is dependent on the amount of light.
f. carbon dioxide
g. blue or red
h. More carbon dioxide was absorbed.

Lab #4

Part I:

a. They appear soft and limp.
b. appear crisp and firm
c. increased
d. Water entered the cells due to osmotic pressure.
e. soft and limp
f. less turgidity
g. Turgidity was lost when water left the cells.
h. yes

Part II:

a. The cell wall and chloroplasts should be visible.
b. The cell membrane is pressed firmly against the wall; the chloroplasts are found through the cytoplasm.
c. 3-5 drops
d. out of the cell
e. The salt solution has a lower water concentration than the cell content.
f. Most cells will show increased turgor and some may bulge slightly.

Part III:

a. yes
b. The water diffused from the cell to an area of lesser concentration.
c. Turgor pressure had been lost as water diffused out of the cells.
d. pressure exerted by water within a cell

e. enables the plant to be stiff
f. as a control

Lab #5

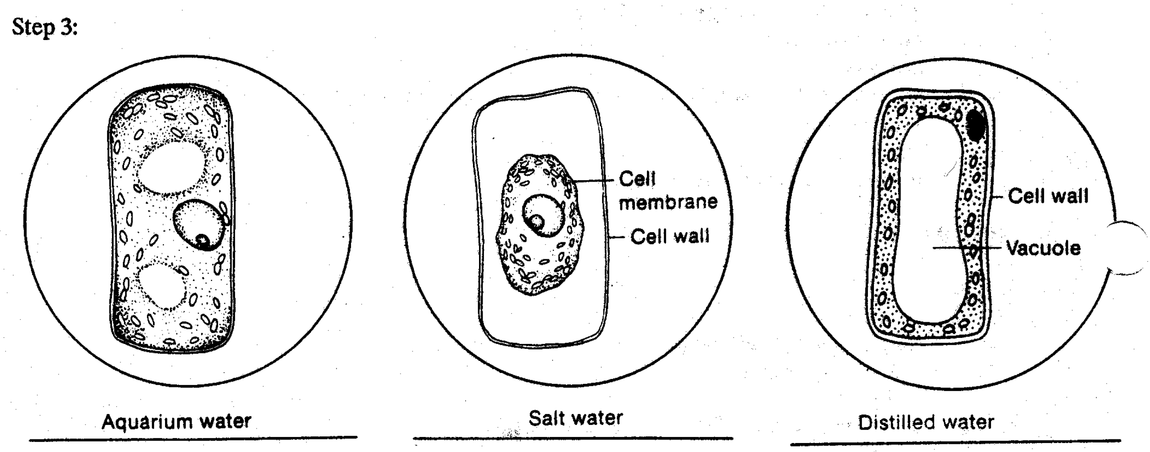
Part I:

(a) Approximately 33 ml
(b) Answers will vary, but should be around 15 ml
(c) Answers may vary, but should be about 200 ml
(d) Answers may vary, but may range between 0 and 25 ml

Table I: Glucose will probably diffuse out of the cell model. Iodine will probably diffuse into cell model. The volume of liquid inside and outside the cell model will probably remain relatively constant.

Part II:

Step 3:



Part III:

1. The larger the molecular weight, the slower the rate of diffusion.

2. No, because diffusion was taking place in both directions. About the same amount of water entered as left the cell.

3. Osmosis occurred in all slides. Because aquarium water is isotonic to the cell, the amount of water flowing in and out of the cell was equal. Salt water is hypertonic to the cell, so water flowed out of the cell and the cell shrank. Distilled water is hypotonic to the cell, so the net flow of water into the cell caused the vacuole to enlarge. (Excess water is stored in the vacuole.)

4. The rigid cell wall prevents the cell membrane from expanding to the bursting point in a hypotonic solution. A blood cell, which lacks a cell membrane, will burst in a hypotonic solution.

5. Wastes move from a region of high concentration (in the blood) to a region of low concentration (into the bath) by diffusion.

Lab #6

Part III:

a. Most water into container during the daylight period

Why? Stomata are open during the day, allowing water to escape

b. Temperature - as temperature increases, transpiration increases

Light - light increases temperature, which increases transpiration

Air humidity - as humidity increases, it lowers transpiration

Lab #7

Part I:

(a) The more bubbles, the faster the rate of photosynthesis.

Part III:

1. The stronger the light, the more oxygen was released by the plant. This indicates photosynthesis was occurring at a fast rate.

2. The more light energy, the more chlorophyll can undergo chemical changes that result in the splitting of water into hydrogen and oxygen. Thus, the more light energy, the more oxygen produced during photosynthesis.

3. More oxygen bubbles were released from the plant in the 30^{o}C environment. Thus, a warm temperature best promotes photosynthesis.

Lab #8

Part I:

a. No
b. The inner wall is considerably thicker than the outer wall.
c. Chloroplasts
d. This regulates water loss.
e. If the plant has been exposed to bright light, the stomata will be open.
f. The guard cells changed shape, resulting in the closing of the stomata.
g. The salt concentration outside the cell caused the guard cells to lose water, and the stomata were closed.
h. In the synthesis of carbohydrates, carbon dioxide is used up and the acid content of the guard cell decreases. More starch is converted to sugar; water diffuses into the guard cells and the stomata close.

Drawings will vary. Complete to instructor's satisfaction.

Part II:

a. To serve as a control
b. Less blue, slightly pink
c. Pink

d. Blue
e. The papers attached to the leaves respond to moisture transpiration from the leaves and turned pink. Those by themselves remained blue.
f. To insure that the only moisture affecting the cobalt paper is coming from the leaf.
g. No
h. From the air spaces and through the stomata
i. To demonstrate that the water came only from the leaf.
j. It was carried to the leaf through the vascular tissue of the roots and stem and of the leaf itself.

Part III:

a. Xylem
b. The water colored red by the dye has moved up the stem and the stem tissues appear red.
c. Toward the interior where the xylem tissue is located.
d. Xylem

Part IV:

a. The atmosphere becomes cooler and absorption makes up the water deficiency. The stomata remain closed for longer periods of time at night, thus reducing the evaporation rate.

b. Air currents, humidity, temperature, light, soil factors, available water

 2. Absorbed by root hairs
 3. Moves across the cortex of the root
 4. Enters vascular cylinder
 5. Moves into xylem cells of stem
 6. Moves up xylem of stem
 7. Enters the petiole of the leaf
 8. Enters veins of leaf
 9. Absorbed by mesophyll cells
 10. Evaporates into air spaces of leaf
 11. Leaves leaf through stomata

BASIC PLANT PROCESSES

AG 510 - E

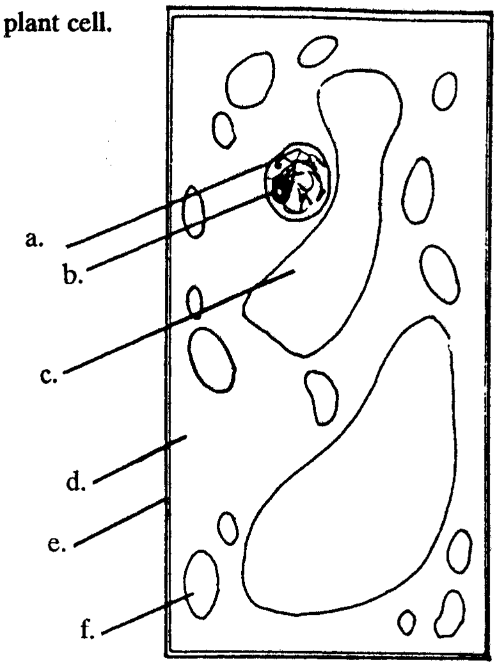
UNIT TEST

Name___________________________________ Score___________________________________

1. Match terms associated with basic plant processes to the correct definitions. Write the correct numbers in the blanks.

_____a.	A small opening in the epidermis of leaves and stems through which gases must pass	1.	Photosynthesis
		2.	Respiration
_____b.	The green pigment of plant cells; necessary for photosynthesis	3.	Osmosis
_____c.	The process of making sugars in green plants from water and carbon dioxide in the presence of sunlight	4.	Absorption
		5.	Stoma
_____d.	Food conducting tissue of plants	6.	Mesophyll
_____e.	The outermost layer of cells of the leaf and of young stems and roots	7.	Chlorophyll
_____f.	The evaporation of water vapor from the stoma on the leaves of a plant	8.	Chloroplast
		9.	Phloem
_____g.	A cellular organelle in which chlorophyll is contained; site of photosynthesis	10.	Root hairs
_____h.	Tissue through which most of the water and minerals of a plant are conducted	11.	Permeable membrane
_____i.	The photosynthetic tissue of a leaf; located between the layers of epidermis	12.	Epidermis
		13.	Cortex
_____j.	The process of using the stored foods of a plant in which energy is obtained or released	14.	Xylem
_____k.	A membrane through which liquid substances may diffuse	15.	Transpiration
_____l.	The taking in of water and mineral nutrients through the roots of a plant		
_____m.	Cells of a stem or root bound externally by the epidermis and internally by the vascular system		
_____n.	Outgrowths of the epidermal cells of the root; greatly increase absorption area of the root system		
_____o.	The diffusion of water through a selectively permeable membrane		

2. **Label the parts of a common plant cell.**



3. Match the parts of a common plant cell to the correct function.

_____a. Regulates passage of liquids and gases into and out of cell; provides surface for chemical reactions to take place	1. Cell wall
	2. Cell membrane
_____b. Controls cell activities; contains genetic material responsible for all inherited characteristics	3. Vacuoles
	4. Chloroplast
_____c. Supports and gives shape to cell	5. Nucleus
_____d. Transport system between cell parts	6. Mitochondria
_____e. Site of photosynthesis (food production)	7. Endoplasmic reticulum
_____f. Involved in carbohydrate metabolism	
	8. Plastids
_____g. Provide water storage space	
_____h. Site of respiration; involved in protein synthesis	

4. Name the four important plant processes in food manufacture and growth.

a. ____

b. ____

c. ____

d. ____

5. Select from the following list reasons photosynthesis is the most important process in the world. Write an "X" in the blank before each correct answer.

_____a. Produces food used directly by man

_____b. Releases carbon dioxide

_____c. It warms the soil

_____d. Produces food used indirectly by man

_____e. All life is dependent on photosynthesis

_____f. Releases moisture into the atmosphere

6. Explain the process of photosynthesis.

____

____

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____

7. Select from the following list factors that affect photosynthetic rate. Write an "X" in the blank before each correct answer.

_____a. Nutrient deficiency

_____b. Energy produced

_____c. Water supply

_____d. Absorption rate

_____e. Quality of light

_____f. Temperature

_____g. Intensity of light

8. Explain the process of respiration.

____

____

____

____

____

9. Classify the following characteristics as that of photosynthesis (X) or respiration (O). Write the correct letter in the blank before each statement.

_____a. Sugar is the end product

_____b. Carbon dioxide is given off

_____c. Requires light

_____d. A destruction process

_____e. Goes on day and night

_____f. A building process

_____g. Only takes place in cells containing chlorophyll

_____h. Carried on in all cells

_____i. Oxygen is given off

_____j. Sugars consumed

10. Match ways nutrients and water are absorbed by the plant to the correct definition. Write the correct numbers in the blanks.

_____a. Nutrients and water entering the plant through leaves and stems

_____b. Movement of gases or liquid from an area of high concentration to an area of low concentration

_____c. Movement of a substance from a place of greater concentration through a semi-permeable membrane to a place of lesser concentration

1. Diffusion
2. Osmosis
3. Non-root feeding

11. Explain the process of absorption by plant roots.

____

____

____

____

____

12. Explain the process of transpiration.

____

____

____

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____

13. Select from the following list factors affecting water loss by transpiration. Write an "X" in the blank before each correct answer.

_____a. Amount of available water

_____b. Number of root hairs

_____c. Presence of cuticle on leaf

_____d. Number of stoma on leaf

_____e. Soil fertility

_____f. Type of root structure

_____g. Climatic conditions

_____h. Amount of sunlight

BASIC PLANT PROCESSES

AG 510 - E

ANSWERS TO TEST

1.
a.	5	f.	15	k.	11
b.	7	g.	8	l.	4
c.	1	h.	14	m.	13
d.	9	i.	6	n.	10
e.	12	j.	2	o.	3

2.
a.	nucleus	e.	cell wall
b.	nucleolus	f.	chloroplasts
c.	vaculole		
d.	cytoplasm		

3.
a.	2	e.	4
b.	5	f.	8
c.	1	g.	3
d.	7	h.	6

4. Photosynthesis; Respiration; Transpiration; Absorption

5. a, d, e

6. Carbon dioxide (CO_2) enters the leaf from the surrounding air through the stoma; Water moves from the soil into the root, stems and leaves through the xylem tissue; The molecules of water (H_2O) and carbon dioxide (CO_2) are synthesized (put together) in the chlorophyll of a plant with energy from sunlight; The end result is the formation of sugar which is transported by the phloem tissue to the part of the plant where it is used

7. a, c, e, f, g

8. Sugar is broken down to produce energy for essential plant functions; Respiration consumes oxygen (O_2) and glucose ($C_6H_{12}O_6$); Respiration gives off carbon dioxide (CO_2) and water (H_20)

9.
a.	X	e.	O	i.	X
b.	O	f.	X	j.	O
c.	X	g.	X		
d.	O	h.	O		

.

10. a. 3 b. 1 c. 2

11. The soil solution enters the root hairs by the process of osmosis; After the soil solution is absorbed by the root hairs, it moves through the epidermal cells, cortex and phloem to the xylem; The xylem conducts the solution to other parts of the plant

12. Water enters plant through root hairs; Water passes to xylem and up the stem to the leaves; A small amount of water is used in photosynthesis; The remainder is lost by transpiration

13. a, c, d, e, g

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

UNIT OBJECTIVE

After completion of this unit, students should be able to match terms and definitions, identify the parts of a plant and match functions and plant parts. Students should also be able to select requirements for good seed germination and list factors that cause poor germination. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with plant growth and development to the correct definitions.
2. Name the three stages of plant growth and development.
3. Name three requirements for good seed germination.
4. Label a drawing showing the parts of a monocot and dicot seed.
5. Arrange in order the stages of germination for a monocot and dicot seed.
6. Select factors that cause poor seed germination.
7. Label a drawing showing the four primary parts of a plant.
8. Match functions of plant parts to the correct part.
9. Name two types of root systems.
10. Label a drawing showing the parts of a stem.
11. Label a drawing showing the plant tissues in a monocot and dicot stem.
12. Match stem modifications with the correct description.
13. Select conditions affecting the vegetative growth of crop plants.
14. Name the three vegetative growth stages of small grains.
15. Name the four vegetative growth stages of corn.
16. Describe sexual reproduction in plants.
17. Describe asexual reproduction in plants.
18. Arrange in order the life cycle of a flowering plant.
19. Label a drawing showing the parts of a complete flower.

20. Match the type of flower to the correct description.
21. Match the types of pollination to the correct description.
22. Name three ways pollen is moved.
23. Explain the process of fertilization in plants.
24. Define the two basic types of plant tissue.
25. Identify the correct types of meristematic and permanent tissues when given a description of each.
26. Study cells.
27. Study cell parts.
28. Describe how animal cells differ from plant cells.
29. Discuss how monocot stems differ from dicot stems.
30. Examine roots and stems.
31. Examine root growth.
32. Observe the structure and function of flowers.
33. Study flower functions in reproduction.
34. Observe the development of seed parts into young plants.
35. Observe plant growth.
36. Study plant reproduction without seeds.
37. Grow a bean plant.
38. Grow plants from seeds.
39. Produce rooted cuttings.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Agronomy Curriculum Materials Packet*, 232 pages; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $10.00; order no. 214.

b. *Crop Production*, 15 transparency masters; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $2.25; order no. 517.

2. Filmstrips, slideshows, etc.

a. *Agronomy,* computer program; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $15.00; order no. 902.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information sheets and laboratory exercises.

E. Discuss information sheets and demonstrate procedures outlined in laboratory exercises.

F. Review and give test.

G. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--A Corn Grain and Its Parts

2. TM 2--A Bean Seed and Its Parts

3. TM 3--Stages in Germination and Emergence of Corn
4. TM 4--Stages in Germination and Emergence of a Bean Seed
5. TM 5--Primary Parts of a Plant
6. TM 6--Functions of Leaves, Stems, Roots and Flowers
7. TM 7--Types of Root Systems
8. TM 8--Parts of the Stem
9. TM 9--Arrangement of Tissue in Stems
10. TM 10--Above Ground Stem Modifications
11. TM 11--Below Ground Stem Modifications
12. TM 12--Conditions Affecting the Vegetative Growth of Crop Plants
13. TM 13--Comparison of Utilization of Sunlight by Crop Plants
14. TM 14--Plant Growth Variance With Temperature Change
15. TM 15--Rate of Photosynthesis and Respiration as Affected by Temperature
16. TM 16--Approximate Pounds of Water Required to Produce One Pound of Dry Matter
17. TM 17--Vegetative Growth Stages of Wheat
18. TM 18--Vegetative Growth Stages of Corn
19. TM 19--The Life Cycle of a Flowering Plant
20. TM 20--Parts of a Complete Flower
21. TM 21--Self-pollination and Cross-pollination
22. TM 22--Plant Meristems
23. TM 23--Epidermal Cells
24. TM 24--Parenchyma Tissue
25. TM 25--Collenchyma Tissue
26. TM 26--Schlerenchyma Tissue
27. TM 27--Phloem Tissue

E. Instructor notes for laboratory exercises

F. Laboratory exercises

1. LE 1--What Are Cells?
2. LE 2--Studying Cell Parts
3. LE 3--Animal and Plant Cell Differences
4. LE 4--How Monocot Stems Differ From Dicot Stems
5. LE 5--Examining Roots and Stems
6. LE 6--Root Growth
7. LE 7--Observing the Structure and Function of Flowers
8. LE 8--Flower Functions in Reproduction
9. LE 9--Development of Seed Parts into Young Plants
10. LE 10--Plant Growth
11. LE 11--Plant Reproduction Without Seeds
12. LE 12--Growing a Bean Plant
13. LE 13--Plant Propagation From Seed
14. LE 14--Produce Rooted Cuttings

G. Answers to laboratory exercises

H. Test

I. Answers to test

III. Unit references

A. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

B. Delorit, R.J., et al., *Crop Production*, 5th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

C. Fridline, C.R., *Plant Growth and Development*, Ohio State University, Ohio Agricultural Education Curriculum Materials Service, Columbus, Ohio, 1980.

D. Fridline, C.R., *Seed Production of Corn, Small Grains and Soybeans*, Ohio Agricultural Education Curriculum Materials Service, Columbus, Ohio, 1977.

E. Hartmann, Hudson T., et al., *Plant Science - Growth, Development, and Utilization of Cultivated Plants*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

F. Janick, J., et al., *Plant Science*, 2nd edition, W.H. Freeman and Co., San Francisco, California, 1974.

G. Otto, James H., Towle, Albert, *Modern Biology*, Holt, Rinehart and Winston, New York, 1985.

H. Raven, P.H., et al., *Biology of Plants*, 3rd edition, Worth Publishers, Inc., New York, New York, 1981.

I. Slesnick, Irwin, L., et al., *Biology*, Scott, Foresman and Company, Glenview, Illinois, 1985.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

INFORMATION SHEET

I. Terms and definitions

A. Node--The part of a stem where a leaf is attached

B. Internode--The part of a stem between two nodes

C. Bud--An embryonic shoot of a plant

D. Leaf scar--A scar left on the stem when a leaf falls

E. Vascular bundle scar--A spot within a leaf scar left by the vascular bundles when a leaf falls

F. Monocot--Plant having one seed leaf (cotyledon) as in cereals and corn

G. Dicot--Plant having two seed leaves (cotyledons) as in beans and peas

H. Vascular bundle--A strand of tissue containing xylem and phloem enclosed by a sheath of cells

I. Xylem--Vascular tissue that transports water and minerals from the root system to the leaves

J. Phloem--Vascular tissue that conducts food from the leaves to regions of growth or storage

K. Pistil--Seed bearing organ of a flower, composed of the ovary, style and stigma

L. Stamen--Part of the flower which produces the pollen; composed of the filament and anther

M. Fertilization--Union of the male (pollen) nucleus with the female (egg) cell

N. Pollination--Transfer of pollen from the anther to the stigma

O. Embryo--The young plantlet within the seed; the germ

P. Radicle--The embryonic root

Q. Hypocotyl--The part of an embryo between the cotyledons and the radicle

R. Epicotyl--The part of the embryo above the cotyledons and below the next leaves

II. Stages of plant growth and development

A. Seed germination and seedling growth

B. Vegetative

C. Reproduction

III. Requirements for good seed germination

A. Proper temperature

(Note: This requirement varies for different crops. Cereals will show some germination at $32^{o}F$, while corn will not show any germination until $48^{o}F$.)

B. Sufficient moisture

(Note: This requirement varies for different crops. Cereals will germinate when their moisture content is about 50%. Soybeans will not germinate until their moisture content is about 75%. The range is 26% to 75% for most agronomic crops.)

C. Ample supply of oxygen

(Note: Germination will not occur if oxygen is not available for crops like small grains and peas. Rice seed can germinate in the absence of oxygen.)

IV. Parts of the seed

A. Monocot (Transparency 1)

1. Epicotyl
2. Hypocotyl
3. Radicle
4. Cotyledon
5. Coleoptile
6. Endosperm
7. Seed coat

B. Dicot (Transparency 2)

1. Epicotyl
2. Hypocotyl
3. Radicle
4. Cotyledons

5. Seed coat

V. Stages of germination

A. Monocot (corn, small grains) (Transparency 3)

1. Absorption of water and oxygen into the seed

2. The seed coat ruptures and the primary root (radicle) begins to grow downward

3. The epicotyl elongates, the coleoptile piercing the soil as it grows upward

(Note: The leaves of the coleoptile are rolled into tight pointed buds.)

4. The coleoptile emerges

(Note: When the coleoptile emerges, the first node on the stem is still underground. It is from this node that the secondary root system develops.)

5. The coleoptile unfolds

(Note: When the leaves of a seedling emerge above the soil surface and unfold, the plant is then capable of manufacturing its own food.)

B. Dicot (beans, peas) (Transparency 4)

1. Absorption of water and oxygen into the seed

2. The seed coat ruptures and the primary root (radicle) begins to grow downward

3. The hypocotyl curves into a loop and pushes through the soil, pulling the cotyledons toward the soil surface

4. Emergence of seedling occurs

(Note: The curve in the hypocotyl straightens out immediately after emergence so the plant will stand correctly.)

5. The cotyledons spread apart and the stem tip is exposed to air and sunlight

(Note: When the first pair of leaves has emerged, the plant is then capable of manufacturing its own food.)

VI. Factors that cause poor seed germination

A. Mechanical injury to seed (cracked grain)

B. Disease

C. Storage conditions

(Note: Temperature and humidity are important considerations for storage of crop seeds.)

D. Age of seed

(Note: Germination percentages will decrease as the age of the seed increases.)

E. Soil temperature too cold

F. Hard seed coat

(Note: Some plants (hard-seeded legumes) produce seeds with a hard seed coat. The seed coat will not allow moisture and oxygen to enter the seed and bring about germination.)

G. Soil moisture insufficient

H. Planting too deep

I. Chemical damage

(Note: Reduced germination percentages may result if seeds come in contact with chemicals such as fertilizers.)

J. Crusting of soil

VII. Primary parts of a plant (Transparency 5)

A. Roots

B. Stem

C. Leaves

D. Flowers

VIII. Functions of plant parts (Transparency 6)

A. Roots

1. Absorb water and nutrients

(Note: Most of absorption takes place through root hairs. The rate at which water is absorbed depends on (1) the rate at which water is lost from leaves (transpiration), (2) the amount of water in the soil, and (3) the amount of root surface in contact with soil particles.)

2. Anchor and support plants

(Note: The roots must anchor the plant to the extent that wind, etc., cannot knock it down.)

3. Store food

   (Note: Some plants store foods they have manufactured in the roots. Examples are radishes, carrots, sweet potatoes and sugar beets.)

B. Stem

1. Supports leaves, flowers, fruit and seeds

2. Conducts water, nutrients and food

   (Note: The stem conducts water and minerals in solution from the root system through the xylem tissue to the leaves. It also conducts food made in the leaves through the phloem tissue to the parts of the plant where it is growing or food is being stored.)

3. Stores food

   (Note: Examples of plants that store food in the stem include potatoes and asparagus.)

C. Leaves

1. Manufacture food for the plant

   (Note: Photosynthesis is the process by which leaves make food from carbon dioxide and water in the presence of sunlight.)

2. Necessary for transpiration

3. Store food

   (Note: Examples of plants that store food in the leaves include lettuce, cabbage, celery, rhubarb and onions.)

D. Flowers

1. Serve as site of reproduction

2. Store food

   (Note: Examples of plants that store food in flowers include grains, fruits, nuts, berries, broccoli and cauliflower.)

IX. Types of root systems (Transparency 7)

A. Tap root system

   (Note: In this system, one root is larger than the rest. Examples of plants with tap root systems include alfalfa, sugarbeets, beans, carrots and radishes.)

B. Fibrous root system

(Note: In this system, all roots are approximately the same size. Examples of plants with fibrous root systems include all the grasses and cereal grains.)

X. Parts of the stem (Transparency 8)

A. Node

B. Internode

C. Terminal bud

D. Lateral bud

E. Leaf scar

F. Vascular bundle scar

XI. Tissues in a stem (Transparency 9)

A. Monocots

(Note: Vascular tissue, which consists of the xylem and phloem, is evenly distributed throughout the pith. With some monocots, the stem is hollow. Examples include wheat and oats.)

1. Epidermis

2. Pith

3. Vascular bundles

B. Dicots

(Note: Vascular tissue forms in a single ring near the outside of the stem.)

1. Epidermis

2. Cortex

3. Vascular bundles

4. Pith

XII. Stem modifications (Transparency 10)

A. Above ground

1. Crown--Appears just above or just below ground level from which modified stems grow. This type of growth is common in small grains

2. Stolon--Runners that grow along top of soil surface. This type of growth is common in strawberry plants and clover

3. Spur--Modified stem growth that appears laterally on branches of fruit trees and bears fruit

B. Below ground (Transparency 11)

1. Rhizome--Underground stems that grow horizontally below soil surface. This type of growth is common to bluegrass, brome grass, quackgrass and canada thistle

2. Tuber--Enlarged fleshy parts found at the tip of a rhizome. This type of growth is common to potatoes

3. Corm--Fleshy, short underground stems with very few buds. This type of growth is common to timothy and gladiolus

4. Bulb--Short disc-shaped stem surrounded by leaf-like scale structures. This type of growth is common to onion and garlic

XIII. Conditions affecting the vegetative growth of crop plants (Transparency 12)

A. Climate

1. Sunlight (Transparency 13)

(Note: Sunlight is the energy source for photosynthesis. More efficient use of sunlight by a crop plant will result in higher yields, if other factors are not limiting.)

2. Temperature (Transparencies 14, 15)

(Note: The temperature of both air and soil affects the rates at which the different plant processes take place. Air temperature affects the rate of photosynthesis, respiration and transpiration. Soil temperature has an effect on respiration and absorption by the roots.)

3. Water (Transparency 16)

(Note: Water can be a severe limiting factor in the growth of crop plants. The availability of water, either by precipitation or irrigation, influences crop yield more than any other factor. Water is a requirement for food manufacture, a solvent for mineral nutrients and a part of the transpiration process.)

B. Soil features

1. Nutrient availability

2. Moisture storage

3. Soil compaction

   a. Reduced water infiltration

   b. Reduced root penetration

4. Amount of erosion

C. Crop pests

1. Disease

2. Insects

3. Weeds

D. Crop being produced

E. Economics

(Note: Economics is the least controllable of all variables affecting crop production. In many cases the point of maximum yield is not the same as maximum profit point. Crops should be managed to reach the point of maximum profit.)

XIV. Vegetative growth stages of small grains (Transparency 17)

A. Tillering

B. Jointing

C. Boot

XV. Vegetative growth stages of corn (Transparency 18)

A. Two-leaf stage

B. Six-leaf stage

C. Ten-leaf stage

D. Fourteen-leaf stage

XVI. Sexual reproduction in plants

A. Reproduction by seed

1. Involves the combination of two different sets of genes to create offspring with a new genetic makeup

2. Often the most efficient and economical method for reproducing annual bedding plants and some biennials and perennials

3. The function of the seed is to produce a new plant

   a. A seed is produced by the combination of nuclear material in the process of fertilization

   b. Results in zygote formation

B. Sexual reproduction usually used for annuals and on plants which grow quickly from seed and produce a plant similar to the parents

(Note: The end result of sexual reproduction in plants is the seed. Seeds are of importance in production of a new crop and as food for both people and livestock.)

XVII. Asexual reproduction

A. Reproduction by vegetative propagation

1. Uses plant parts such as leaves, roots and stems to start new plants

2. No new genetic material introduced--the offspring will be identical to parents

B. Methods

1. Cuttings

   a. Stem cuttings using a tip (straight) cutting

   b. Leaf cuttings using a leaf section, leaf petiole or by cutting the veins

   c. Root cuttings using a cutting of the root and planting it

2. Layering--Rooting a stem at the node

   (Note: Grape layering to replace a vine or strawberries' natural runners are examples of layering.)

3. Separation--Removing corms or bulbets from the parent bulb plant (for example: an iris)

4. Division--The removal of new shoots with some root from below

   (Note: This is used on dahlias.)

5. Grafting--Involves the transfer of wood with buds from one plant and matching up its cambium layer to another plant. The ends then grow together, resulting in a plant having desirable qualities of both parent plants

XVIII. The life cycle of a flowering plant (Transparency 19)

A. Seed germination and seedling growth

B. Vegetative growth

C. Flower formation

D. Pollination

E. Fertilization

F. Seed development

XIX. Parts of a complete flower (Transparency 20)

A. Pistil--Female part where egg cell originates

1. Stigma--Upper part of pistil that catches pollen

2. Style--Supports stigma

3. Ovary--Produces ovules which develop into seeds

B. Stamen--Male part of flower

1. Filament--Supports anther

2. Anther--Bears the pollen

C. Accessory organs

1. Corolla--Petals of the flower

2. Calyx--Sepals of the flower

3. Pedicel--Stalk of an individual flower

XX. Types of flowers

A. Complete--Has stamens, pistils, petals and sepals on same flower; common to dicots

B. Incomplete--Has stamens and pistils, but no petals or sepals; common to monocots

C. Perfect flower--Has both stamens and pistils on the same flower

D. Imperfect flower--Has either stamens or pistils, but not both on the same flower

E. Staminate--Has only male flower parts

F. Pistillate--Has only female flower parts

G. Monoecious--Staminate and pistillate flowers found on the same plant (Examples: Corn, cucumbers, squash, melons and pumpkins)

H. Dioecious--Staminate and pistillate flowers found on separate plants (Examples: Holly, date, palm, spinach and asparagus)

XXI. Types of pollination (Transparency 21)

A. Self-pollination--Transfer of pollen from the anthers to the stigma of the same flower on the same plant

B. Cross-pollination--Transfer of pollen from the anthers of one plant to the stigmas of another plant

(Note: Cross-pollination usually requires an insect or bee to transfer the pollen from one plant to the other.)

XXII. Pollen is moved by

A. Gravity

B. Wind

C. Insects

D. Birds

E. Man

XXIII. Fertilization--After a pollen grain alights on the surface of the stigma, it forms a pollen tube. The pollen tube grows down the style to the ovary. It penetrates the ovary and the male cell unites with the ovule. This is called fertilization, the union of the male and female cells. The result is a zygote. Cell division takes place and the zygote becomes the embryo of the seed

XXIV. Plant tissues

A. Large groups of organized cells of similar structure that perform a collective function

B. Basic types

1. Meristem (meristematic tissue)

a. Comprised of actively dividing cells that develop and differentiate into other tissues and organs

b. Cells have thin walls and dense protoplast

2. Permanent

a. Develops from the meristems

b. Non-dividing differentiated cells

XXV. Meristematic tissue (Transparency 22)

A. Apical meristems

1. Shoot meristems

a. Found in the tops of the shoots

b. Responsible for producing new buds and leaves in a uniform pattern at the end of the stem and laterally along stems

2. Root meristems

a. Growing points for the root system

b. Found at the various ends of the roots

B. Lateral meristems

1. Account for girth and growth of woody stems

2. Composed of cellulose and pectin

3. Provide mechanical support for plant

4. Vascular cambium--Produces new xylem and phloem

5. Cork cambium--Produces bark (the protective covering of old stems and roots)

6. Number of growth rings indicates tree's age

C. Intercalary meristems

1. Active tissues that have been separated from the shoot terminal meristem by regions of more mature or developed tissue

2. Found near the nodes of grasses

3. Reason for continuous growth after mowing grasses

XXVI. Permanent tissues

A. Simple tissue--Uniform, composed of only one type of cell

1. Epidermis tissue (Transparency 23)

a. Single, exterior layer of cells that protects stems, leaves, flowers and roots

b. Outside surface of epidermal cells usually covered with cutin--a waxy substance that reduces water loss

2. Parenchyma tissue (Transparency 24)

   a. Living, thin-walled cells with large vacuoles and many flattened sides

   b. Most common and abundant plant tissue making up the fleshy part of the in food and water

3. Collenchyma tissue (Transparency 25)

   a. Elongated cells with unevenly thickened primary walls

   b. Gives support to young stems, petioles and leaf veins

4. Schlerenchyma tissue (Transparency 26)

   a. Thick-walled cells

   b. Common in stems and bark

   c. Found as stone cells in pear fruits and walnut shells

   d. Nonliving when mature

5. Cork tissue

   a. Bark of maturing stems, tree trunks and potato skins

   b. Cells walls are waterproofed with suberin (waxy material)

   c. Die soon, but retain shape

B. Complex tissue--Composed of combinations of simple and specialized cells and tissues

1. Xylem

   a. Constitutes the majority of wood

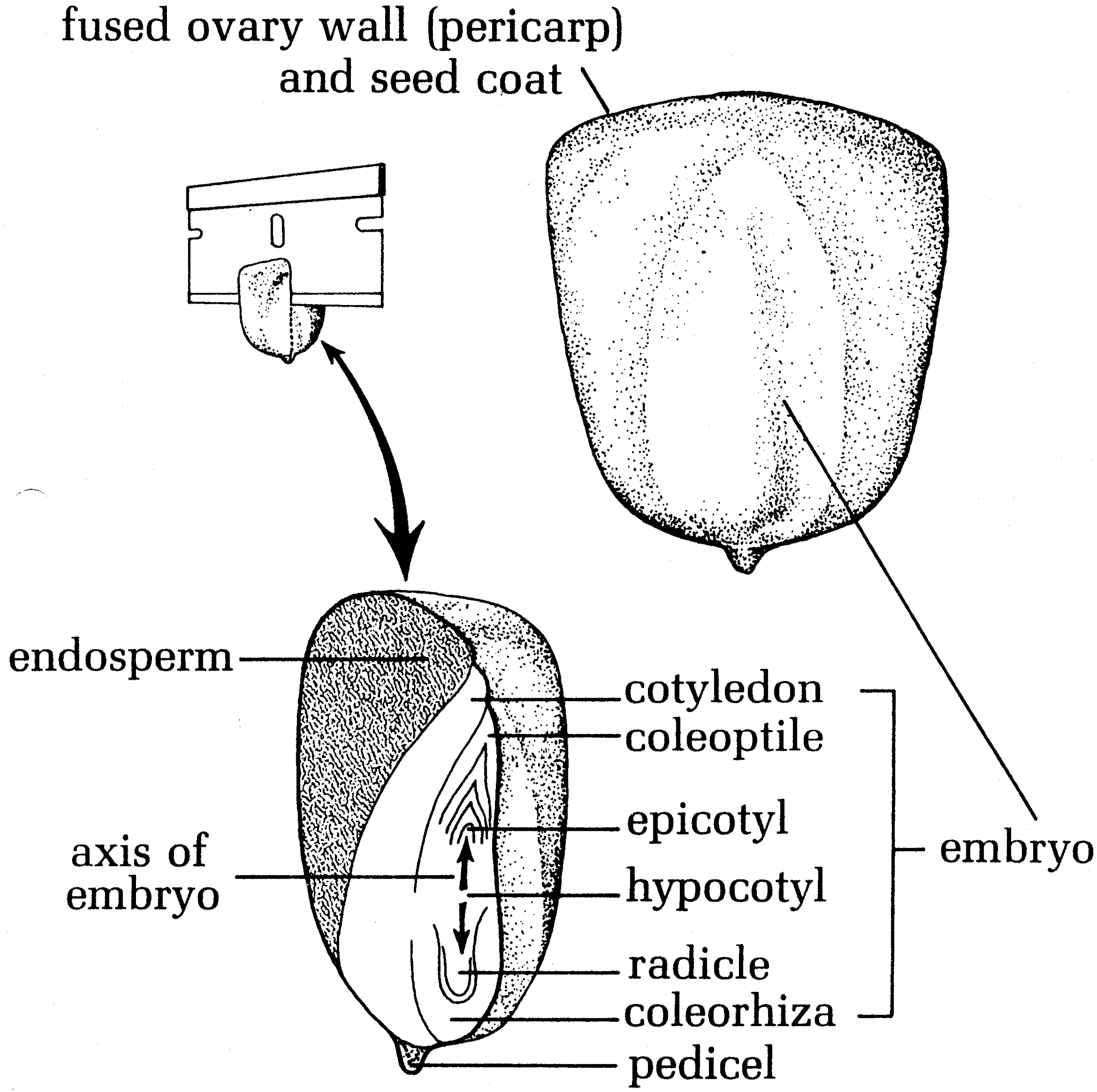
   b. Principal conductor of water and dissolved nutrients

2. Phloem (Transparency 27)

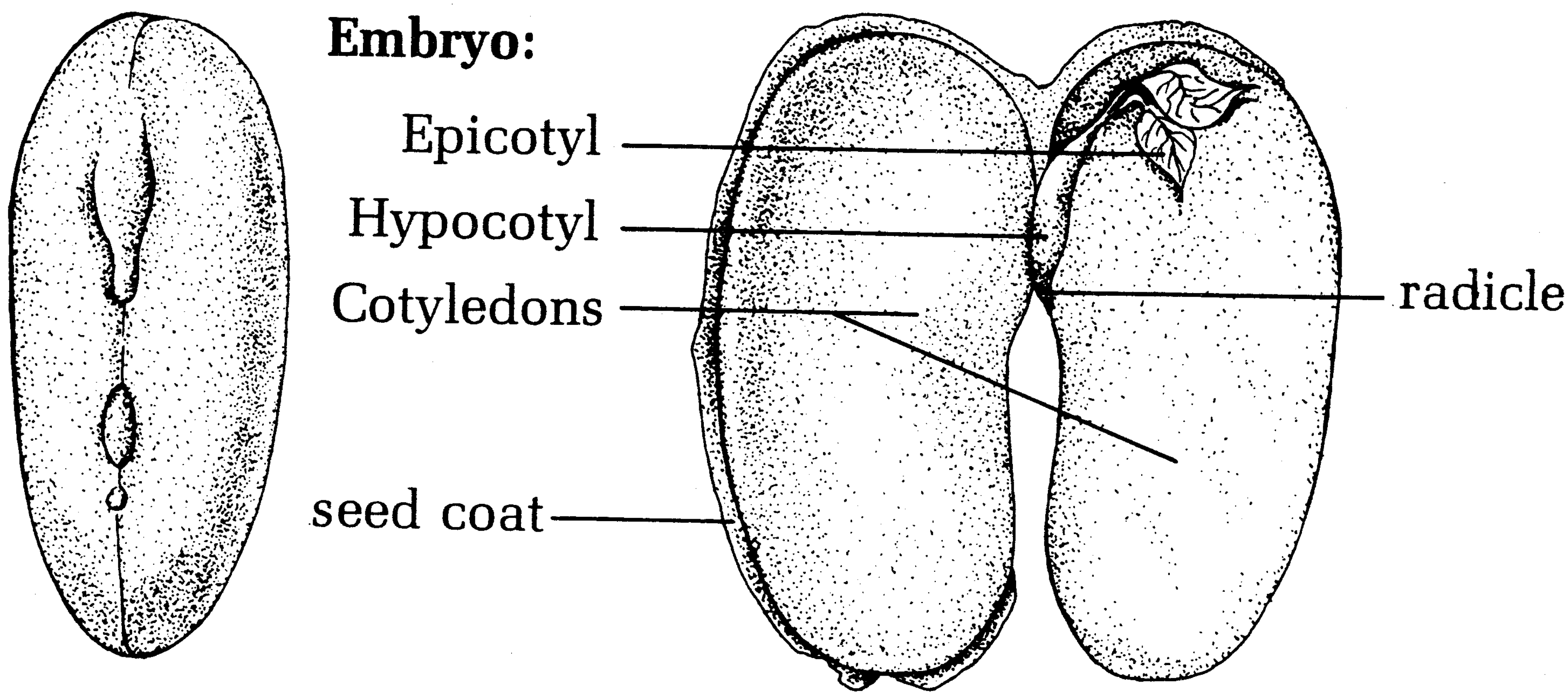
   a. Main conducting tissue for dissolved food material

   b. Basically composed of cells called sieve elements arranged into sieve tubes

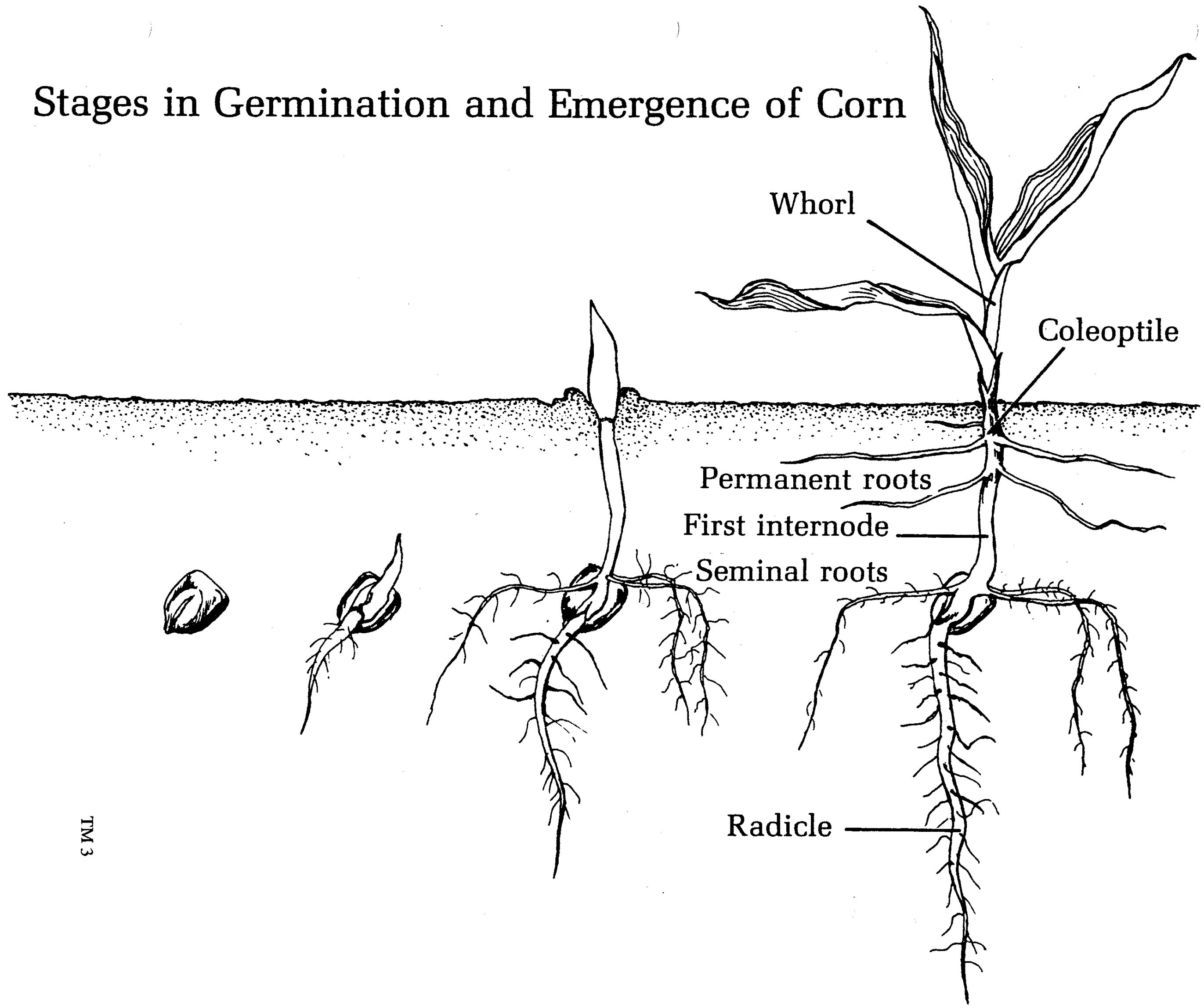
A CORN GRAIN AND ITS PARTS



A BEAN SEED AND ITS PARTS

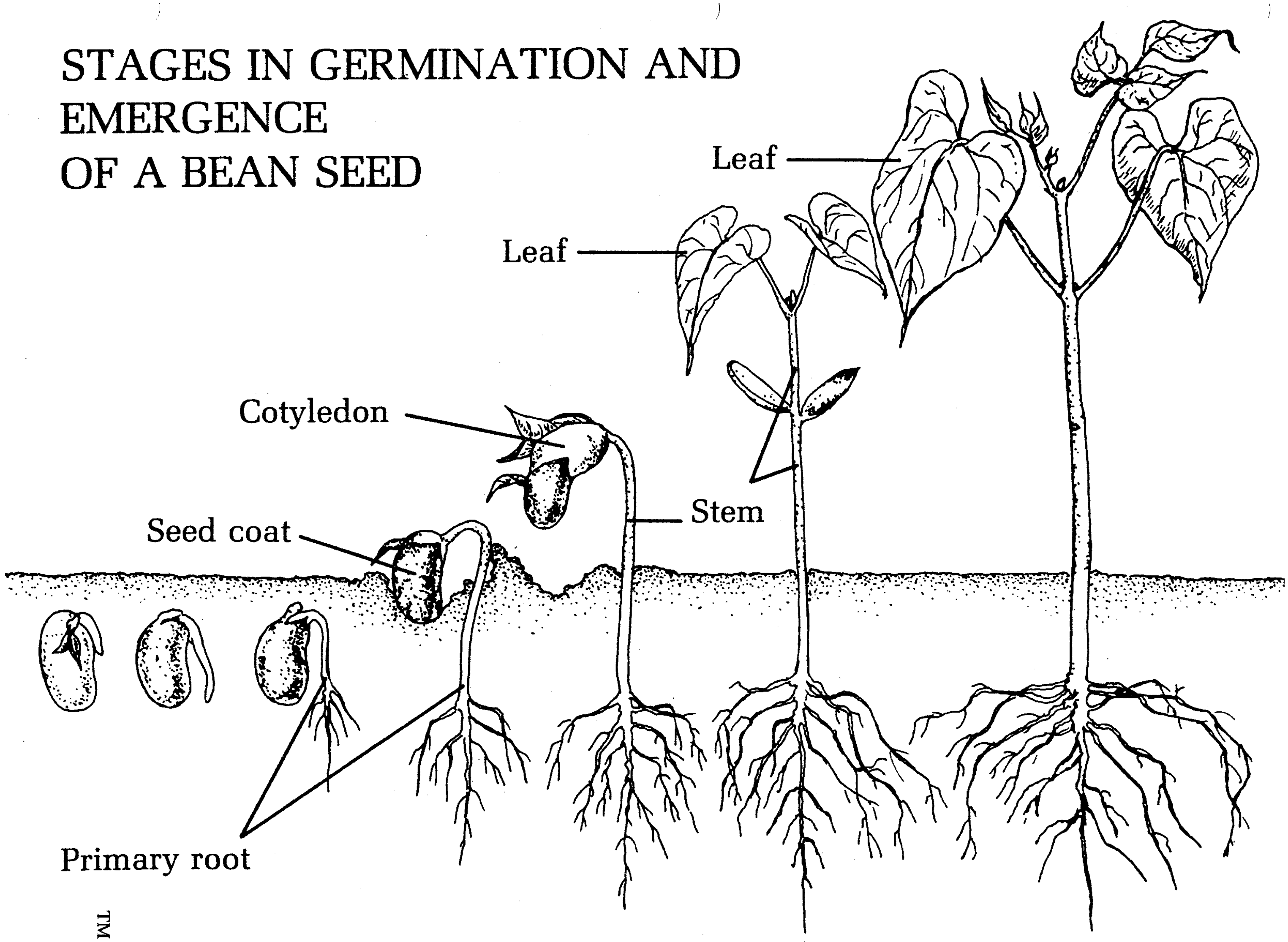


Stages in Germination and Emergence of Corn



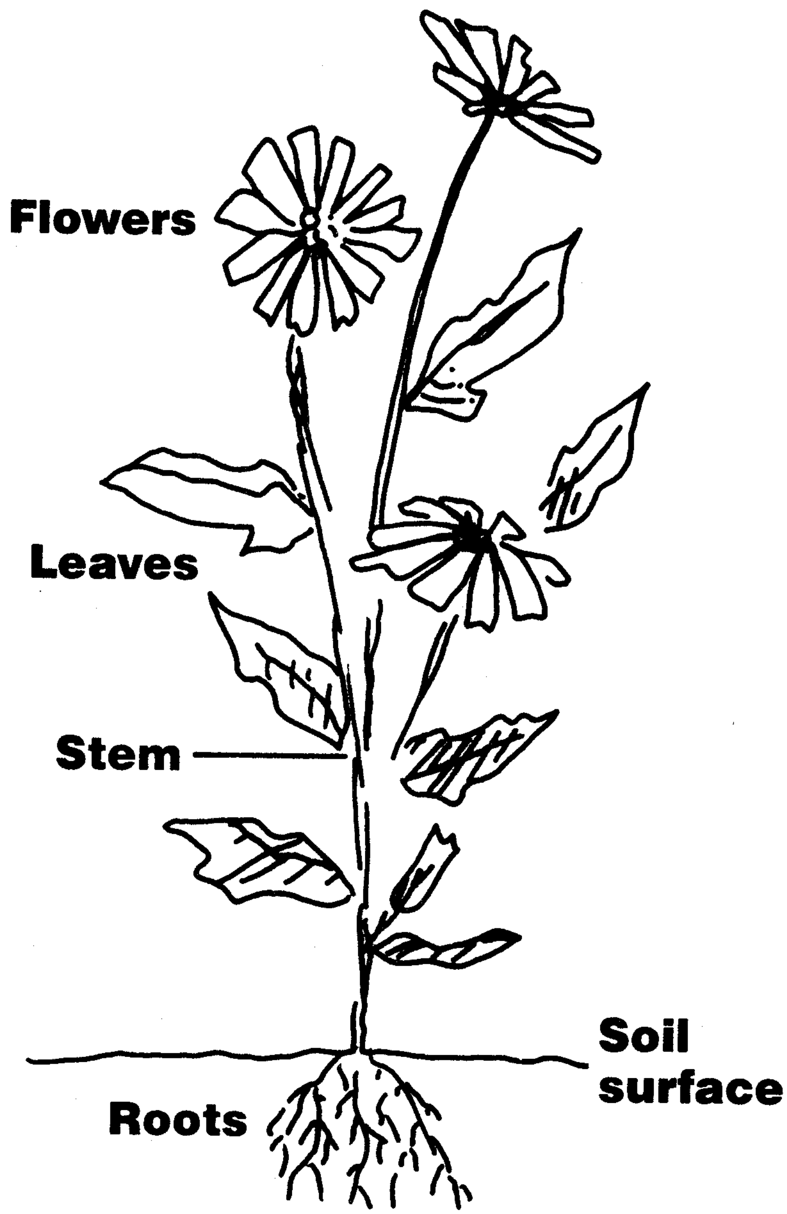
TM 3

STAGES IN GERMINATION AND EMERGENCE OF A BEAN SEED

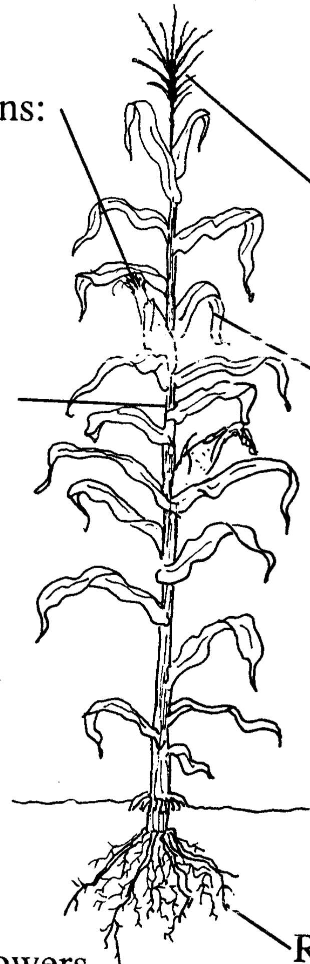


TM 4

Primary Parts of a Plant



Functions of Leaves, Stems, Roots, and Flowers



Female Flower Functions:

a. Reproduction
b. Store food - in seeds and fruits

Stem Tissue Functions:

a. Conducts water and raw minerals from soil to leaves
b. Conducts manufactured food from leaves to other plant parts
c. Produces leaves and displays them to light
d. Supports leaves, flowers, and fruit
e. Stores food reserves in some plants - Irish potato, asparagus, cabbage hearts, etc.

Male Flower Function:

a. Pollination

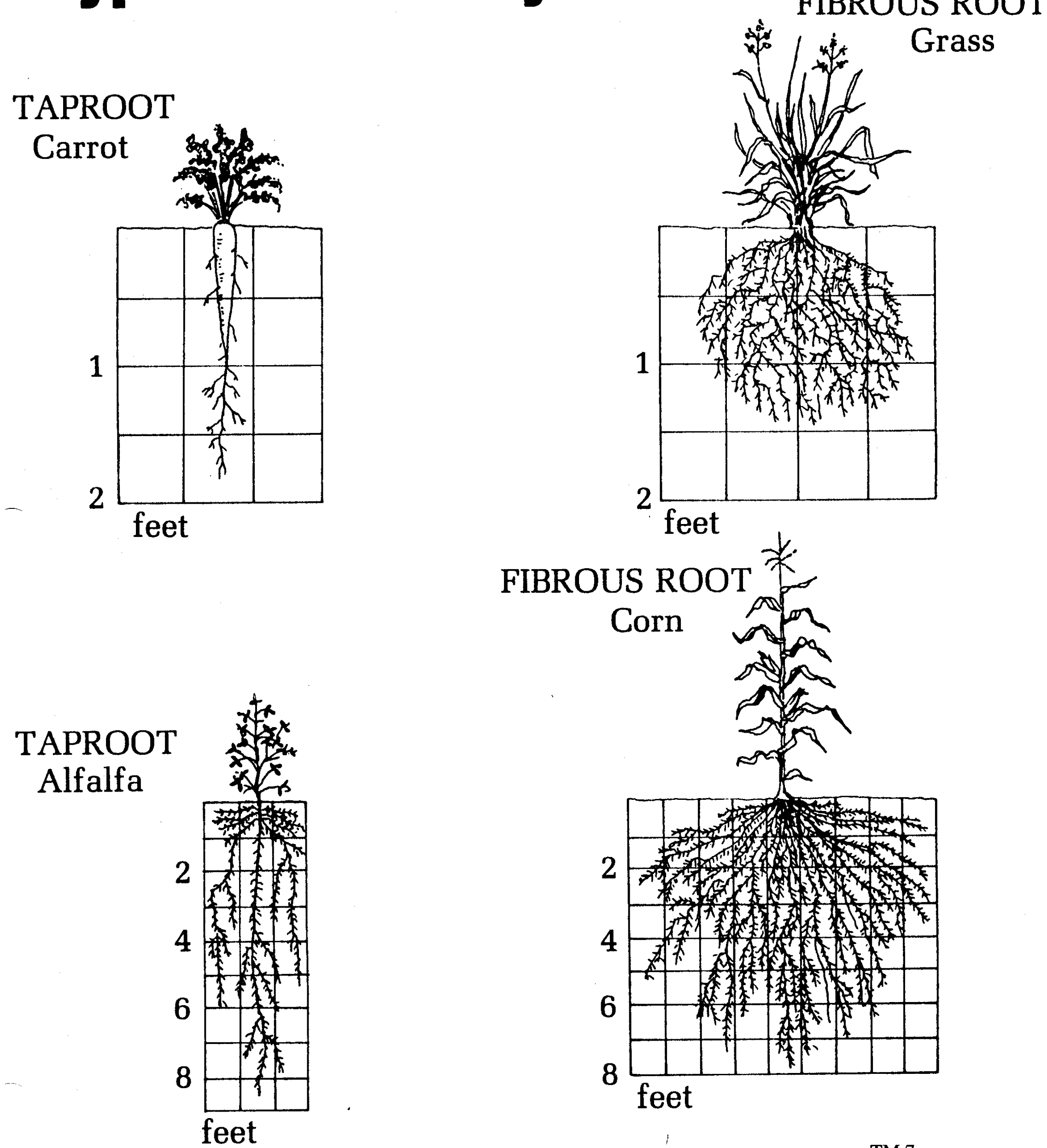
Leaf Functions:

a. Photosynthesis
b. Transpiration
c. Food storage in some crops, i.e. lettuce, cabbage

Root Functions:

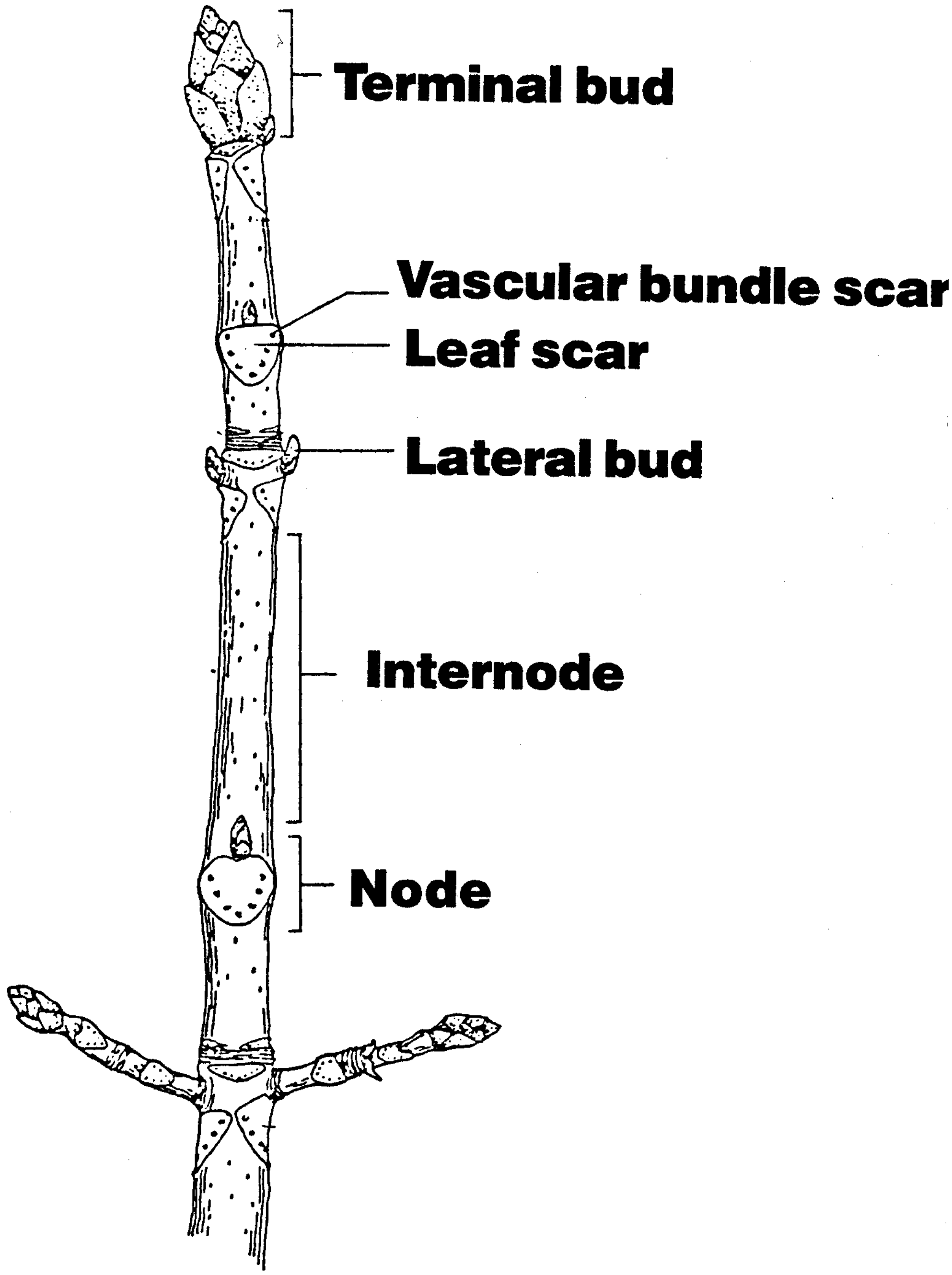
a. Absorb water and raw minerals
b. Anchor plant
c. Store food reserves - in some crops carrots, beets, turnips

Types of Root Systems

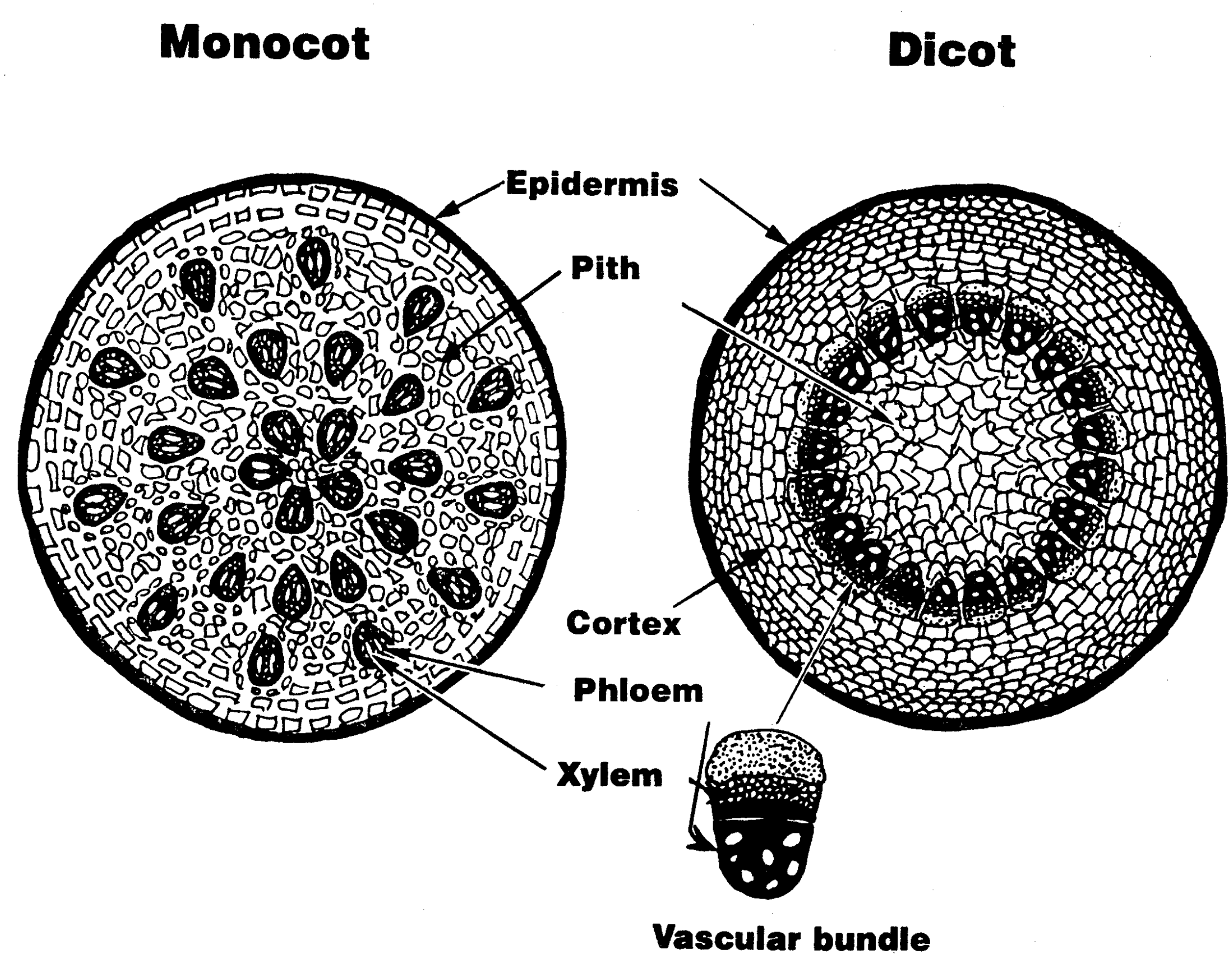


TM 7

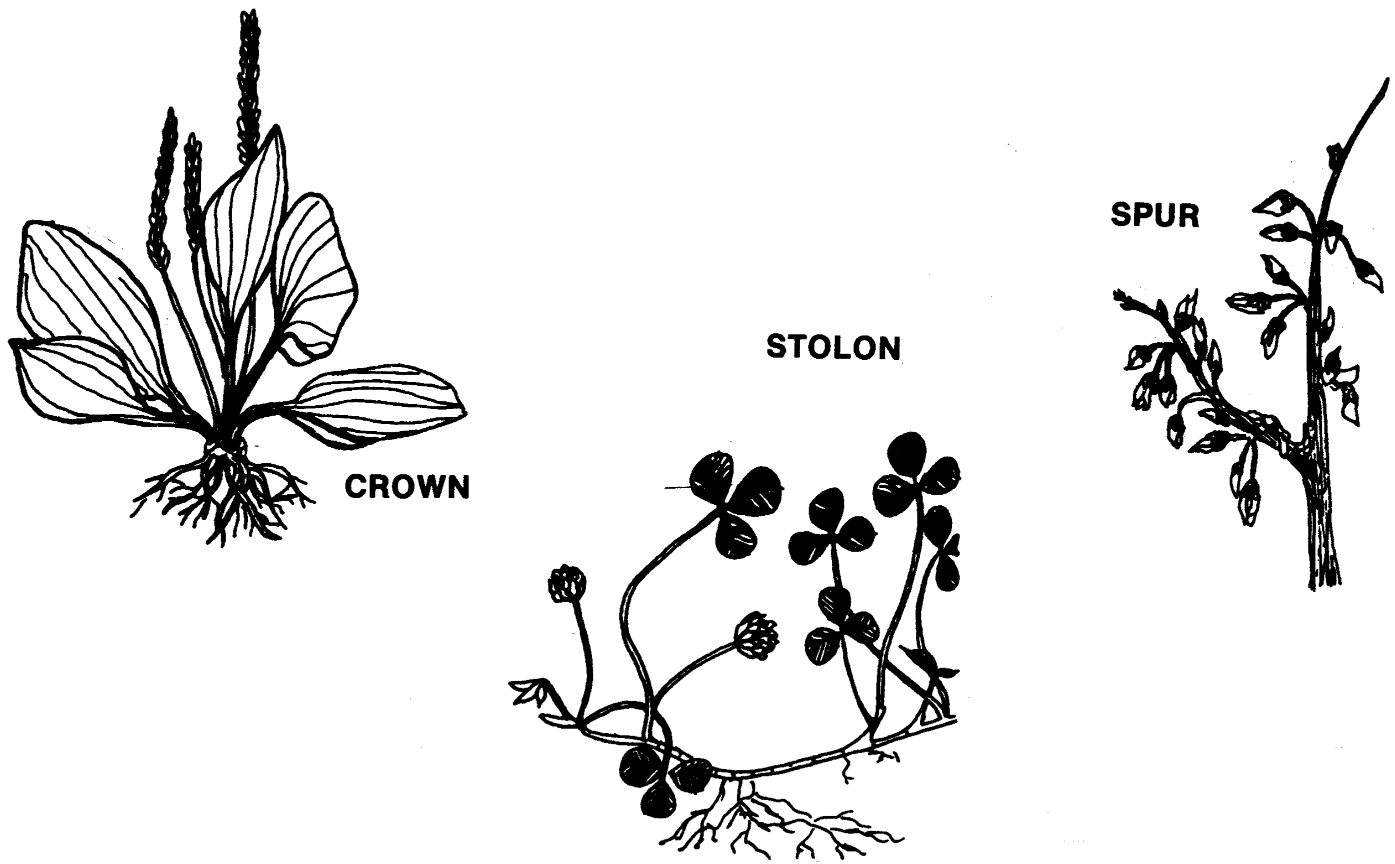
Parts of the Stem



Arrangement of Tissue in Stems

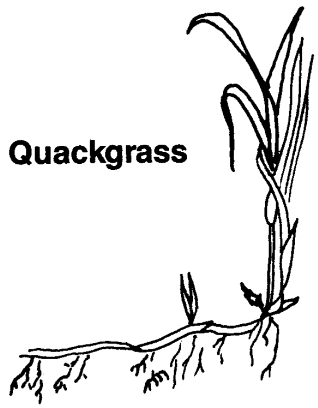


ABOVE GROUND STEM MODIFICATIONS



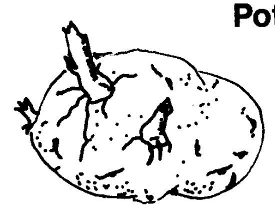
Below Ground Stem Modifications

Quackgrass



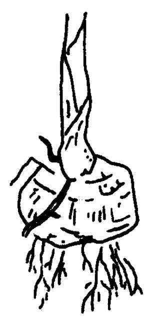
Rhizomes

Potato



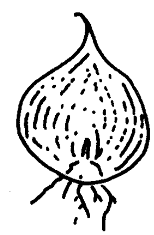
Tuber

Gladiolus



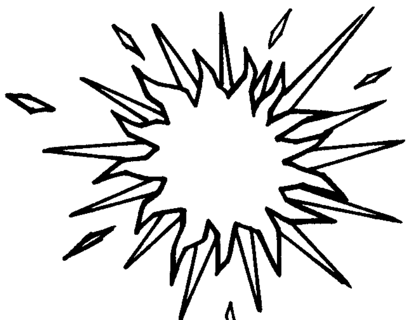
Corm

Onion

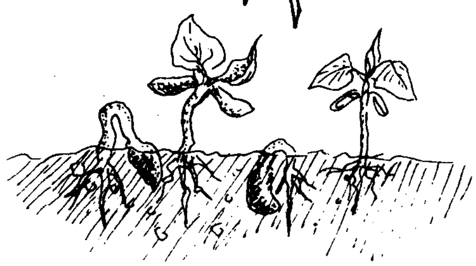


Bulbs

Conditions Affecting the Vegetative Growth of Crop Plants



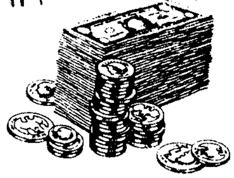
1. Climate



2. Soil features

3. Crop pests

4. Crop being produced



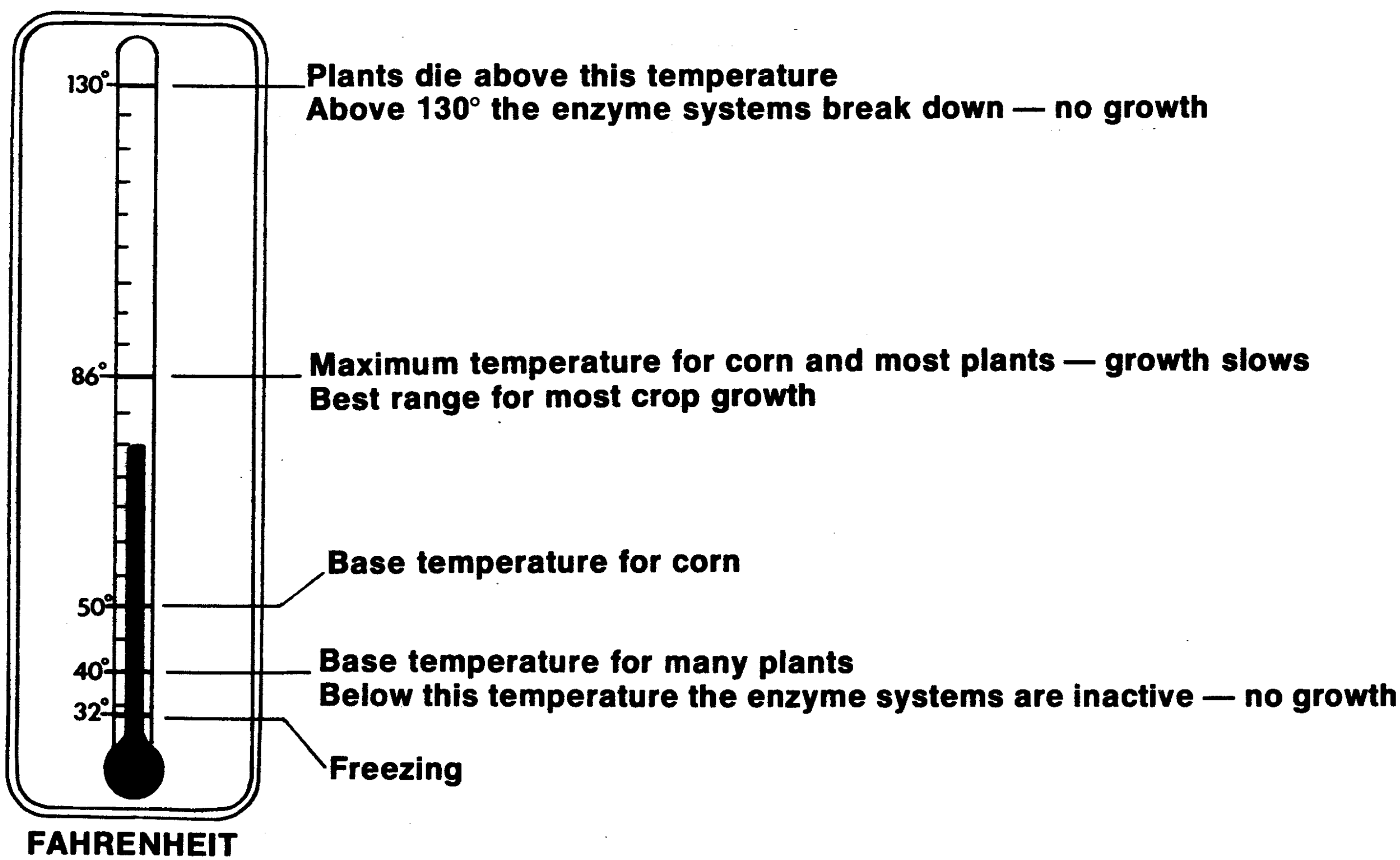
5. Economics

Comparison of Utilization of Sunlight by Crop Plants.*

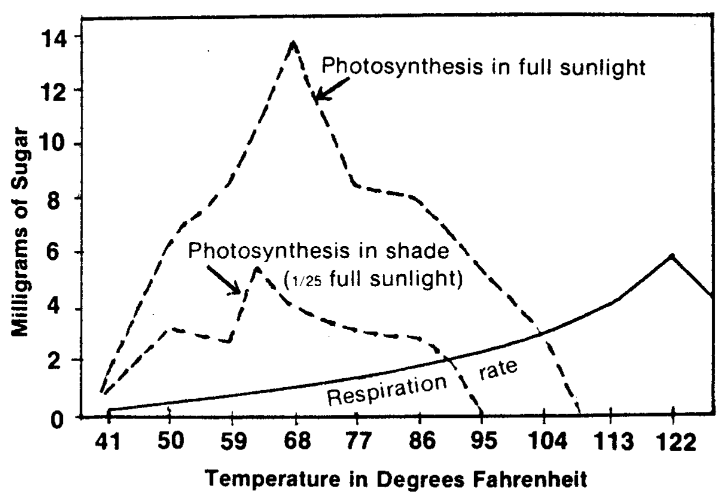
Crop	Yield	Total Dry Matter
Corn	150 bu.	19,500
Soybeans	45 bu.	5,700
Wheat	50 bu.	6,000
Oats	80 bu.	6,560
Alfalfa	6 tons	12,000
Red Clover	3 tons	6,000
Mixed hay (50% legume)	5 tons	10,000
Pasture	—	6,000

*More efficient use of sunlight by a crop plant will result in higher yields, if other factors are not limiting.

PLANT GROWTH VARIANCE WITH TEMPERATURE CHANGE



Rate of Photosynthesis and Respiration as Affected by Temperature

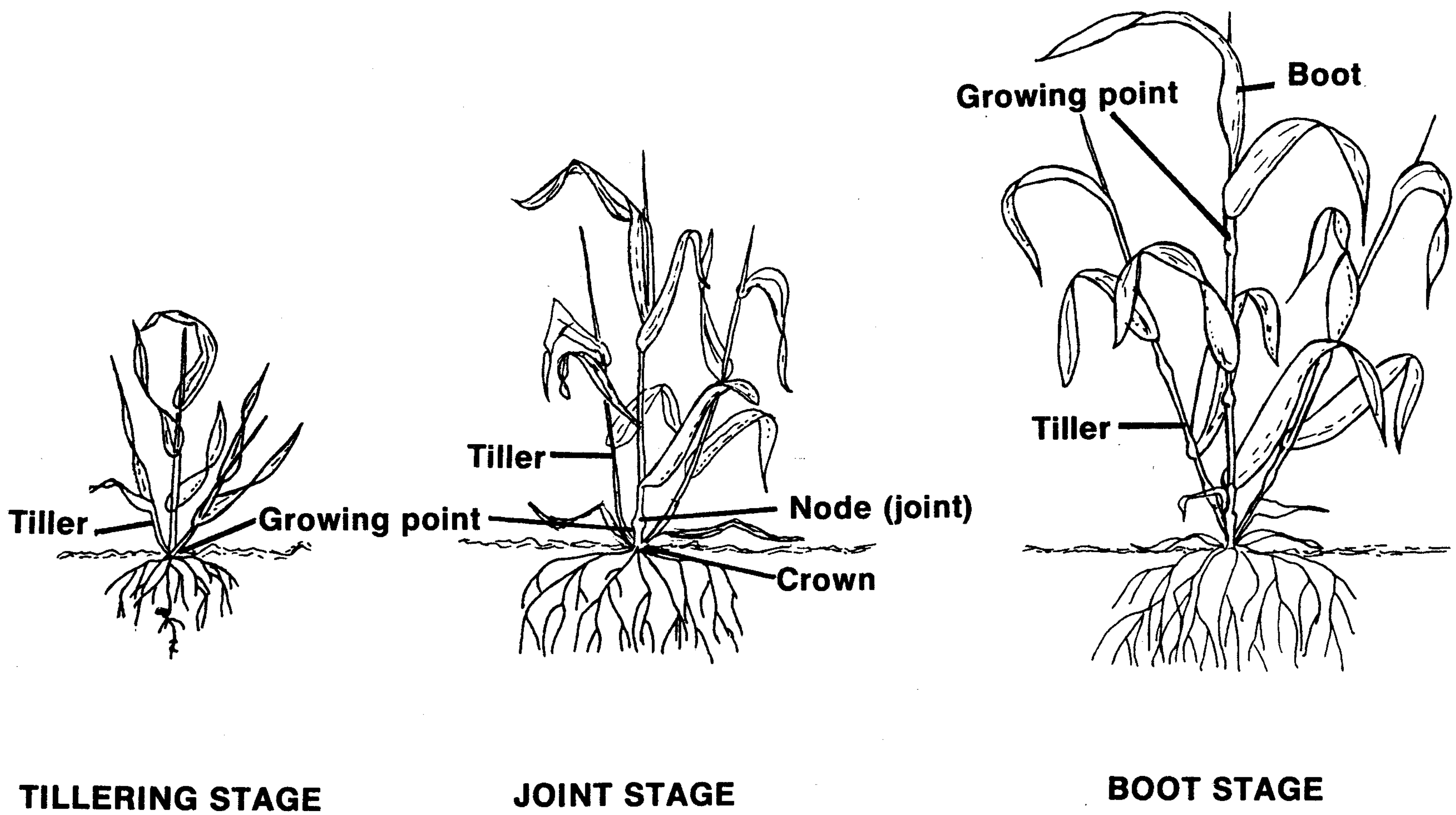


Approximate Pounds of Water Required to Produce One Pound of Dry Matter*

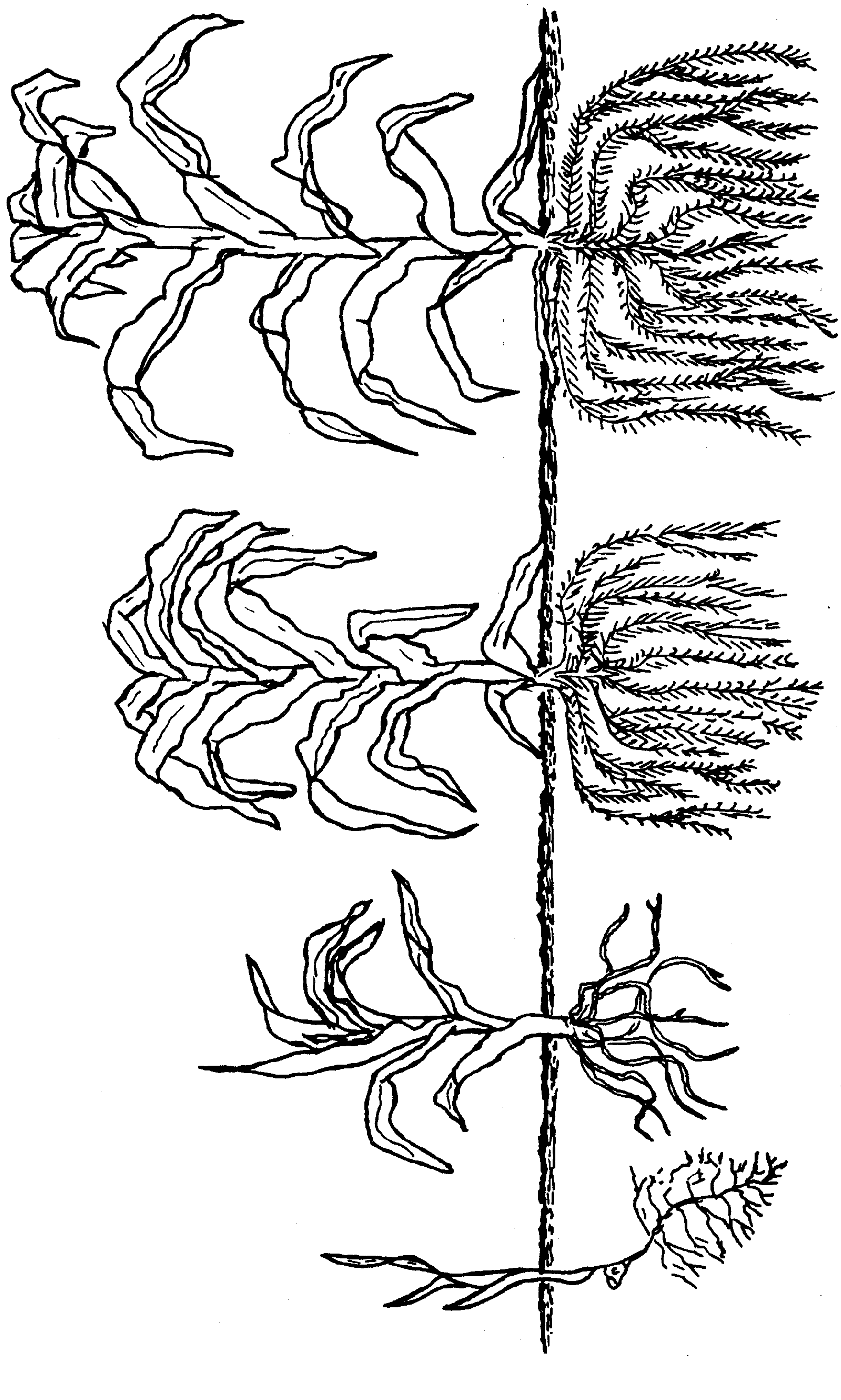
Crop	Pounds of Water
Corn	350
Soybeans	650
Wheat and Oats	550
Alfalfa	850
Red Clover	650

*The availability of water, either by precipitation or irrigation, influences crop yield more than any other factor.

VEGETATIVE GROWTH STAGES OF WHEAT

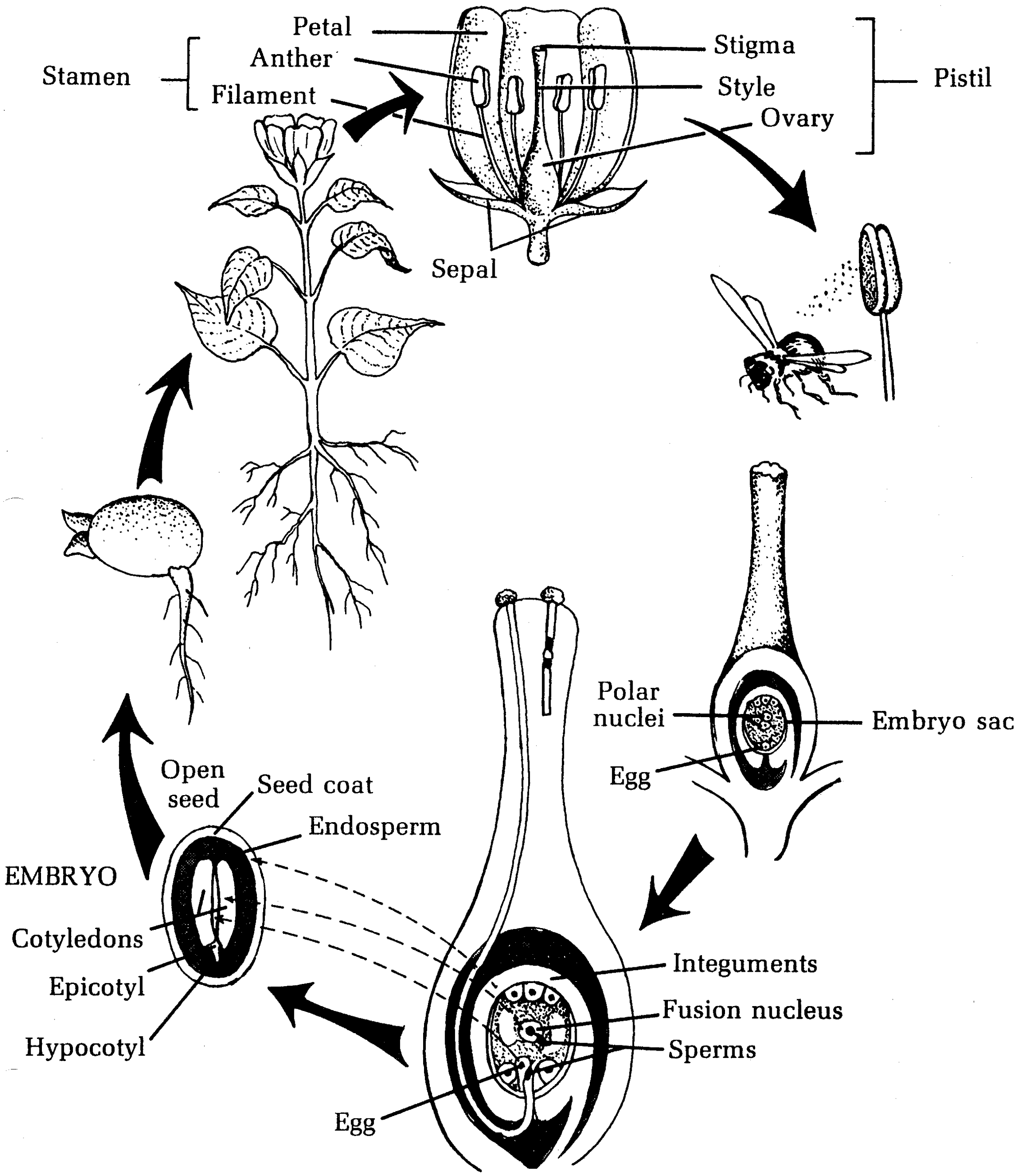


VEGETATIVE GROWTH STAGES OF CORN



TWO-LEAF STAGE | SIX-LEAF STAGE | TEN-LEAF STAGE | FOURTEEN-LEAF STAGE

The Life Cycle of a Flowering Plant



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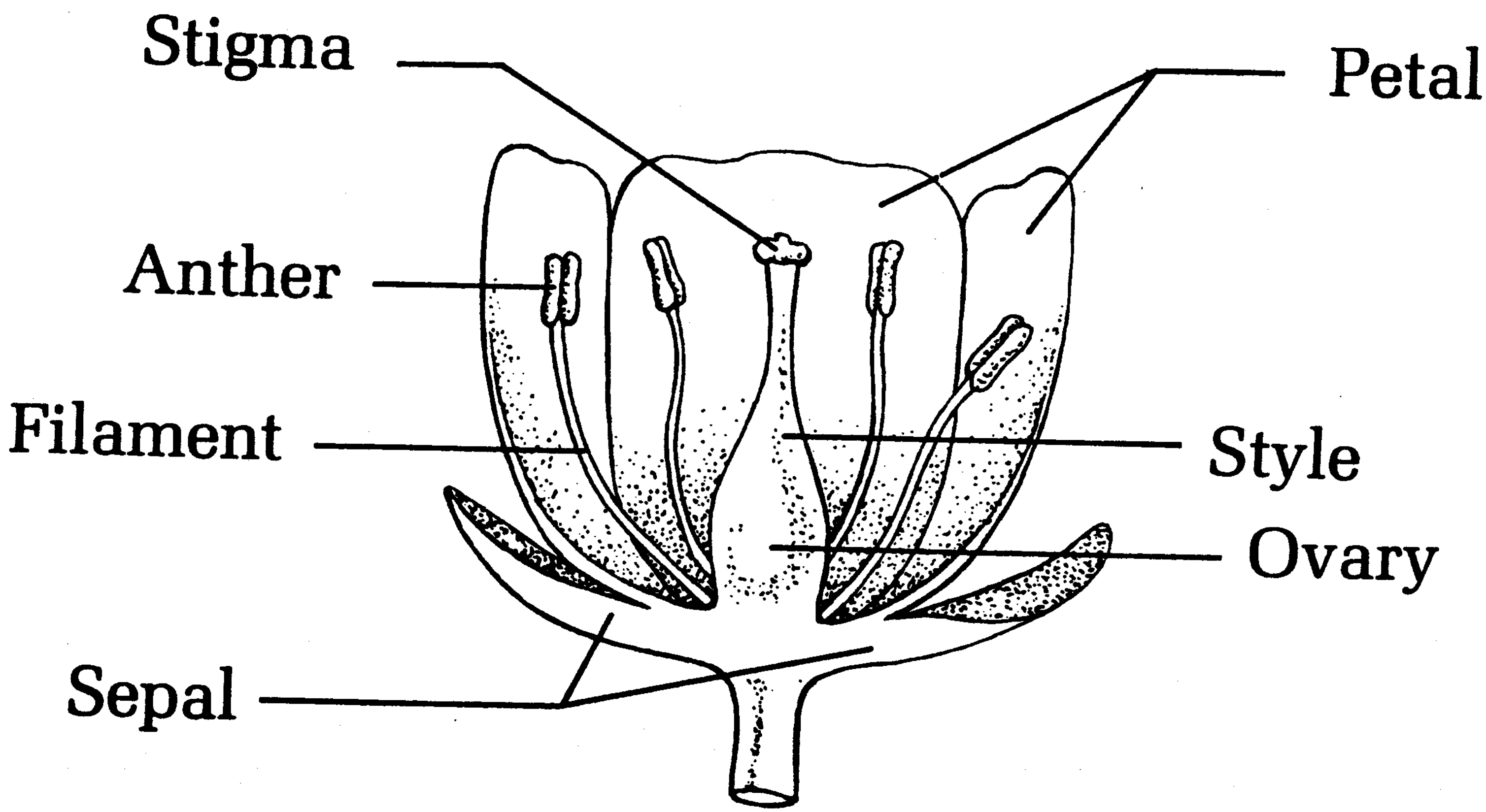
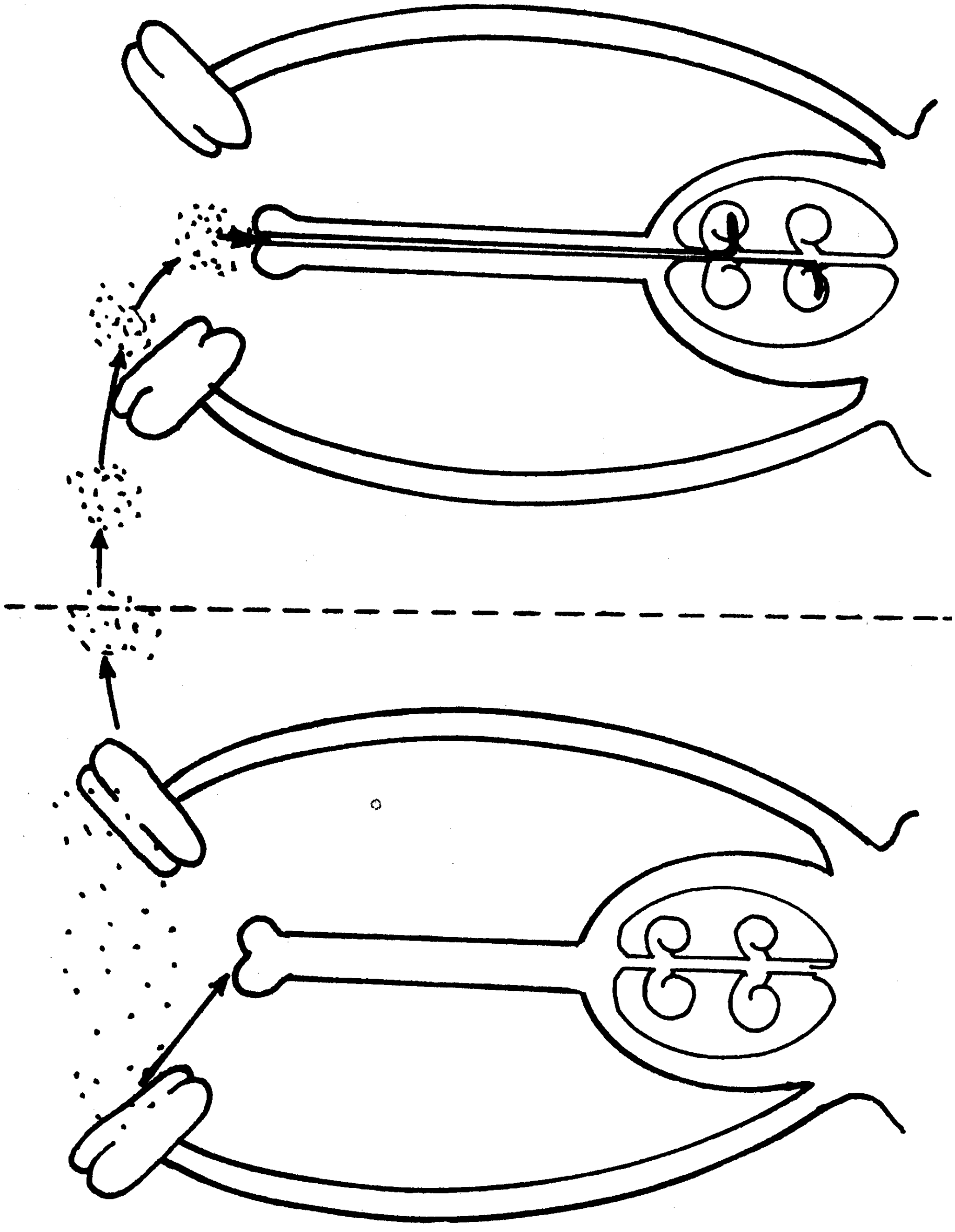
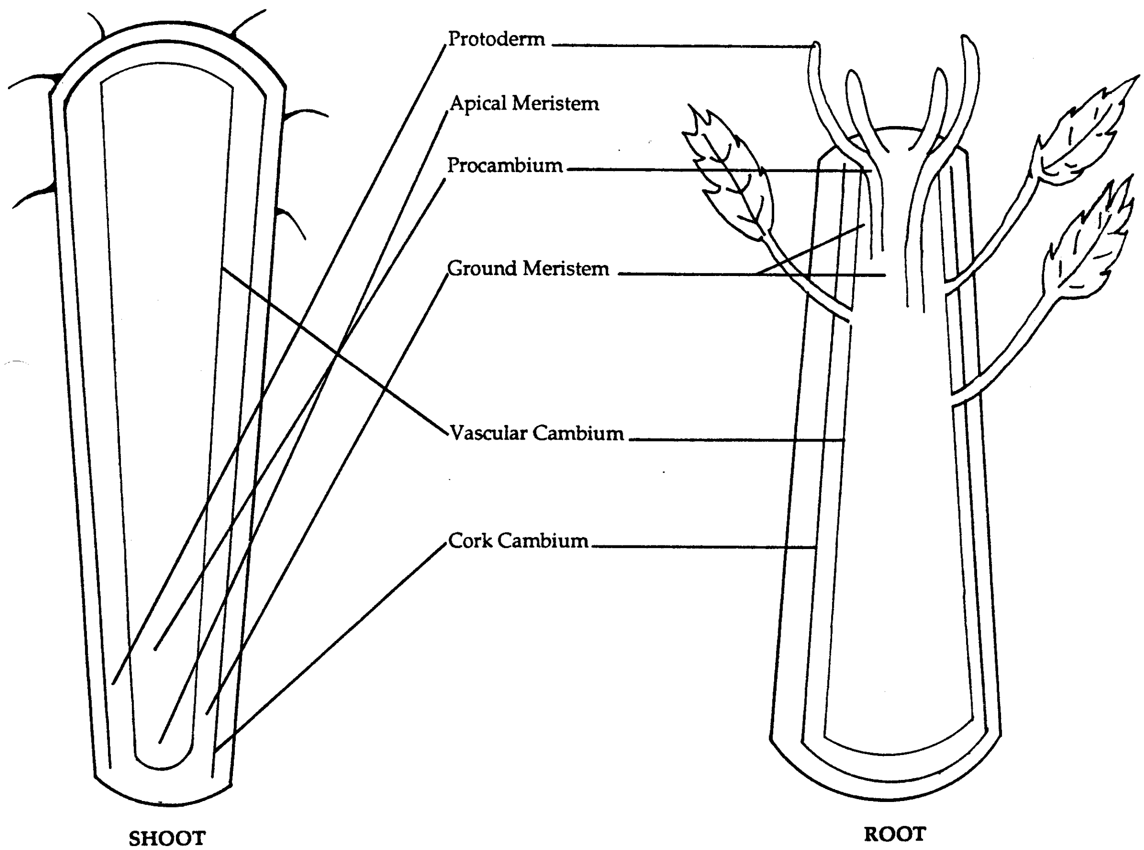
Parts of a Complete Flower



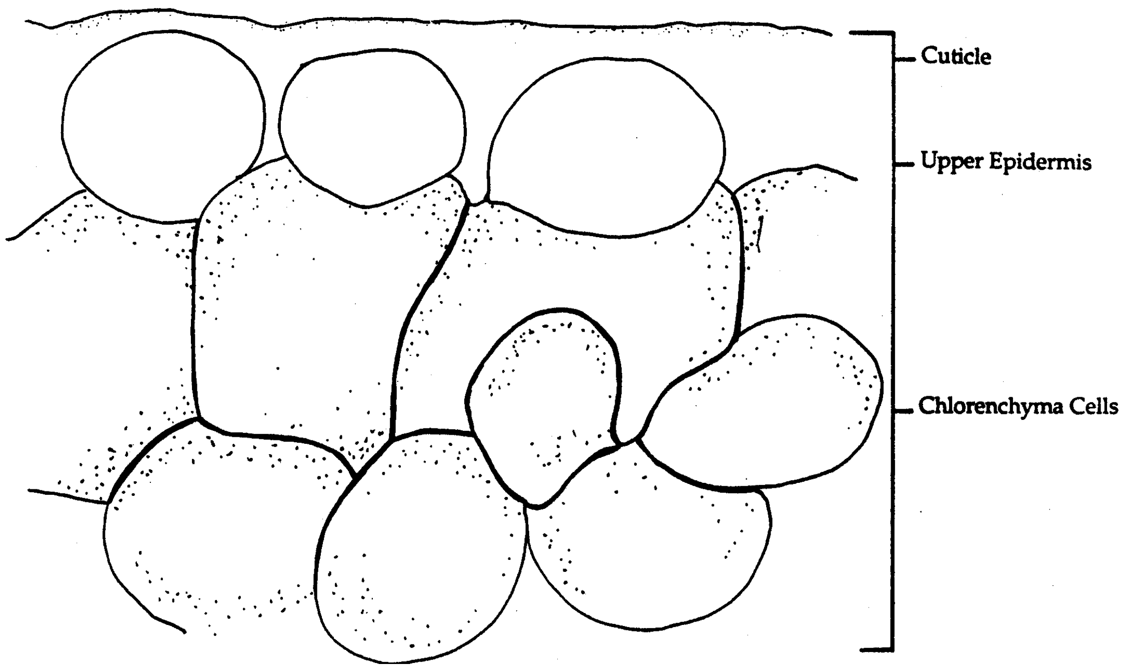
SELF-POLLINATION AND CROSS-POLLINATION



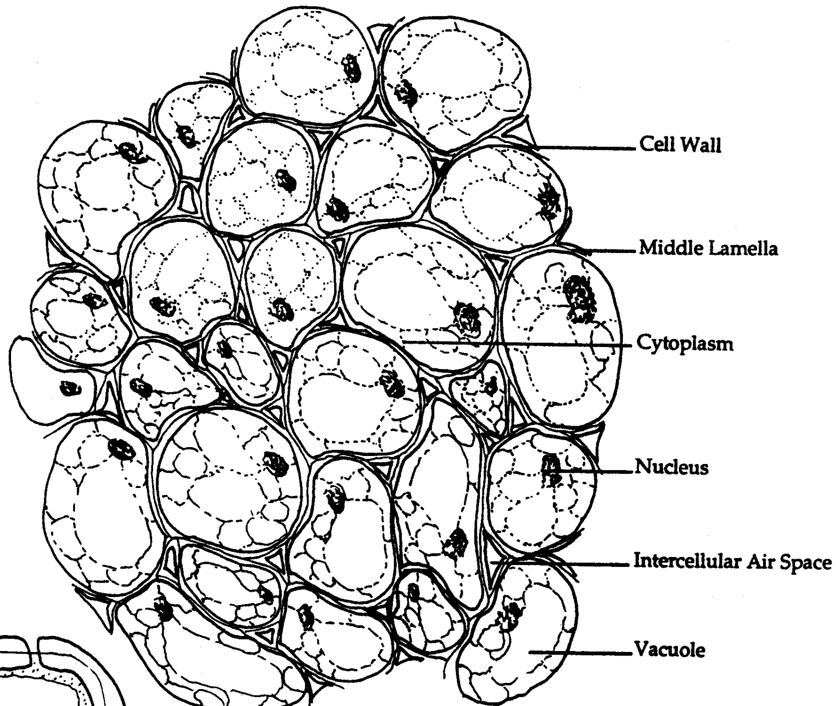
Plant Meristems

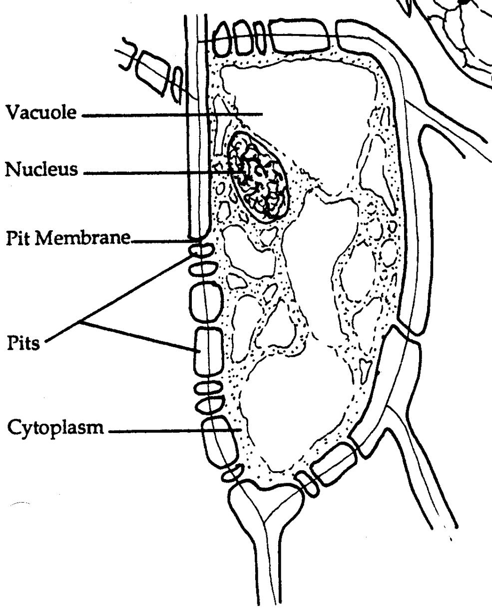


Epidermal Cells



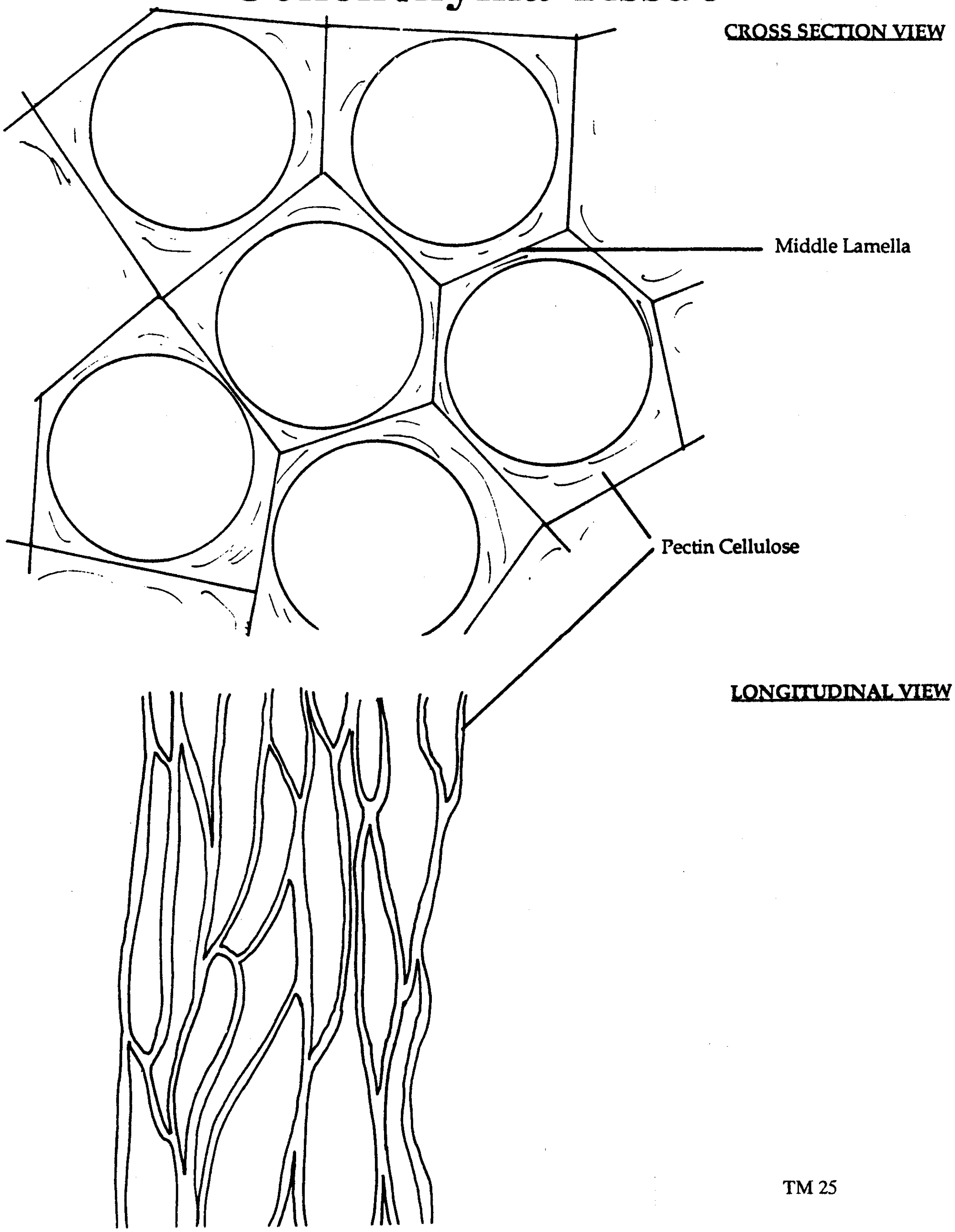
Parenchyma Tissue





A. Aerenchyma type: contains air spaces.
B. Woody type.

Collenchyma Tissue



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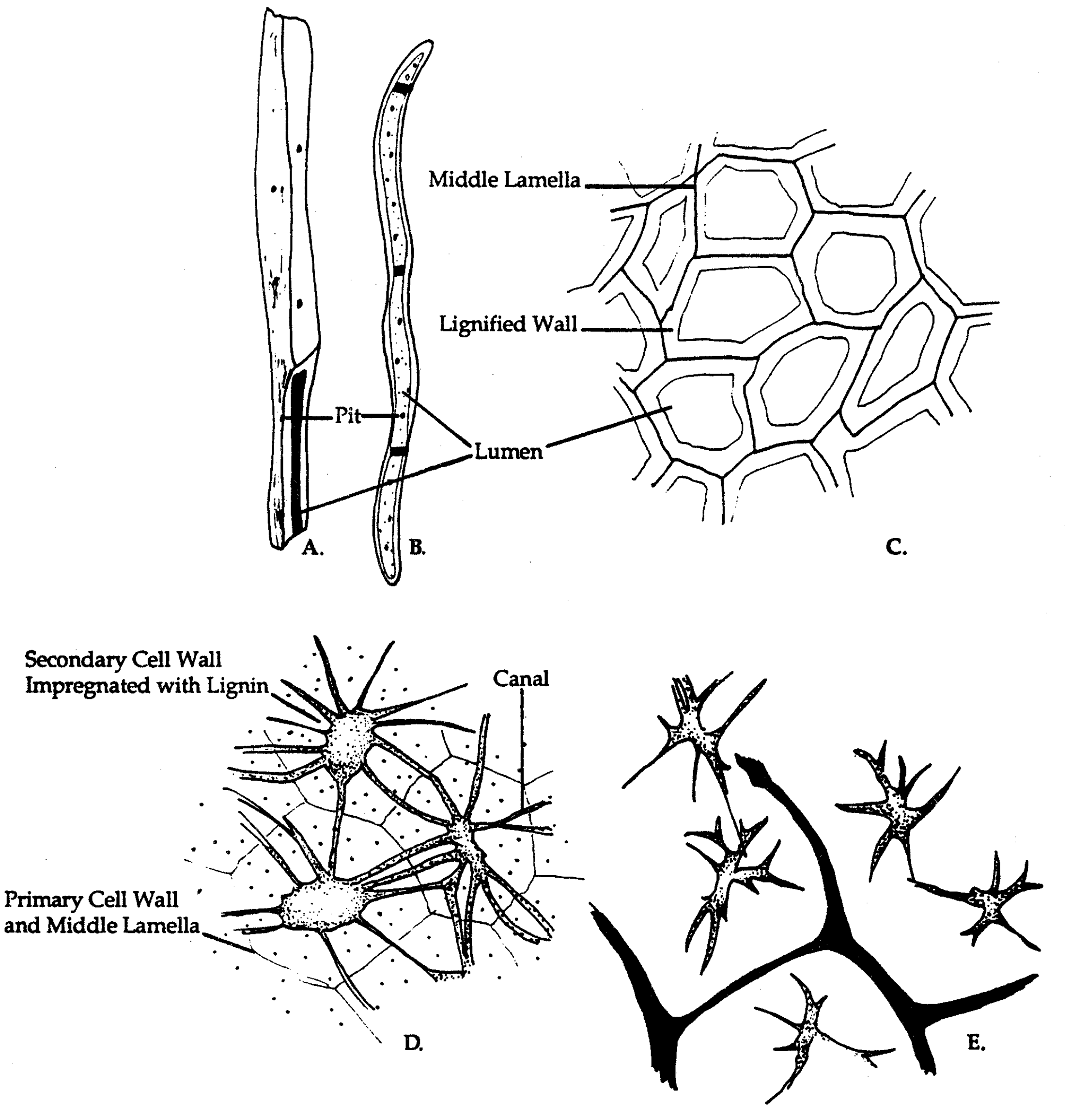
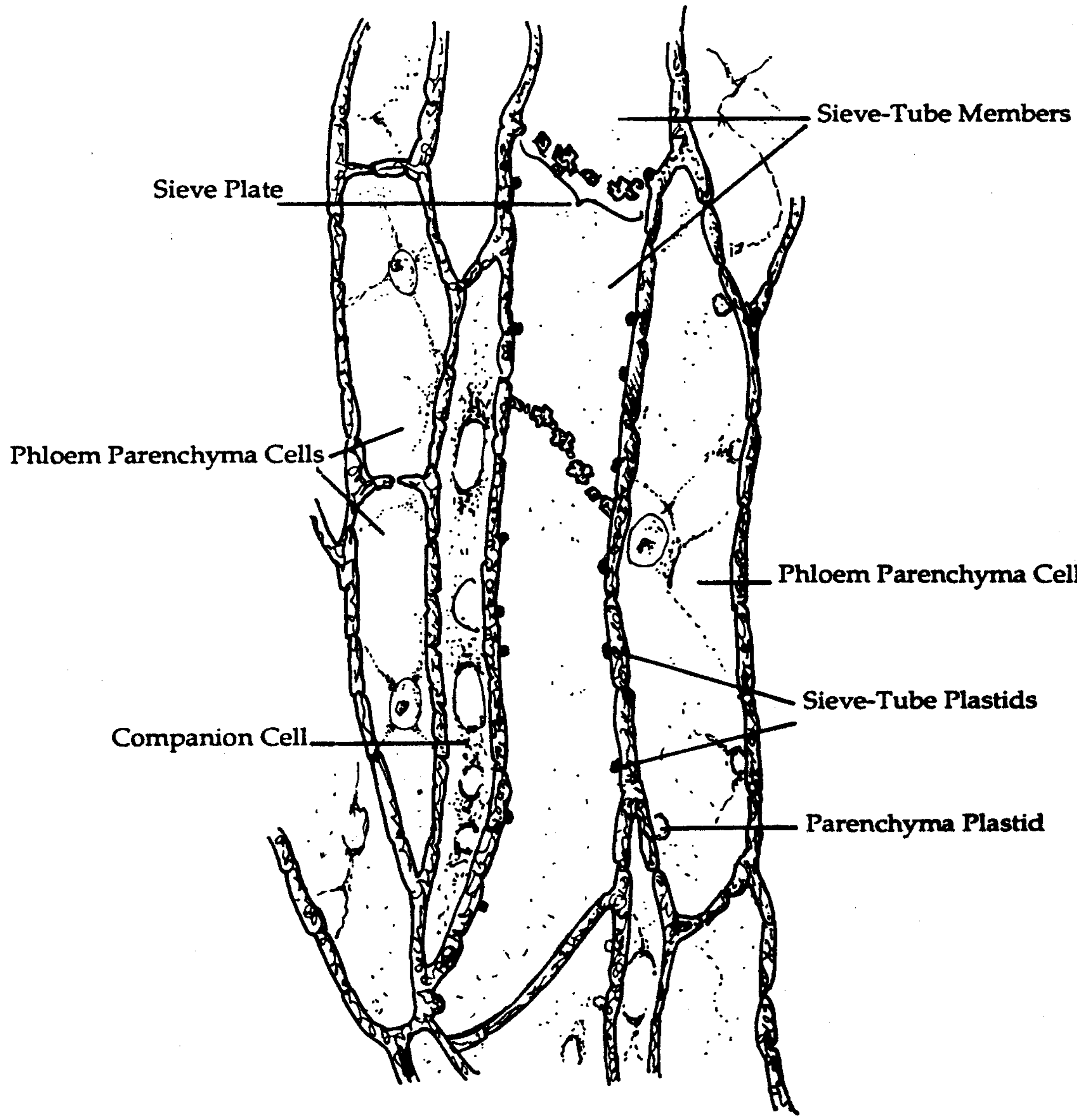
Sclerenchyma Tissue



A. and B. — Fibers in longitudinal view; C. — Fibers in cross section; D. — Stone cells of pear; E. — Sclereid in wheat leaf

Phloem Tissue



Phloem tissue from the stem of tobacco (*Nicotiana*).

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

INSTRUCTOR NOTES FOR LABORATORY EXERCISES

Lab #1

Point out to students that the cell theory was not generally accepted in Hooke's time.

Cork cells are excellent for use in observing the cell wall structure. Ask students to think about whether cork cells are living or nonliving.

Students may have to make several attempts before slicing the cork thin enough for observation. It is easier to use large corks when cutting.

Part I:

Step g: It is important that students understand that the cork cells are not living and therefore are lacking cellular structures.

Part II:

Caution students to avoid using too much water in the preparation of the slide. The drop of water should come to the edge of the cover glass.

Step d: Point out to students that iodine will enable them to see the parts of the cell more clearly.

Part III:

Point out to students that the chromosomes are only visible when the cell is dividing.

Lab #2

Sugar helps prevent the exploding of the nuclei and chloroplasts. Make a .58 M sucrose solution as directed below. Buffering this solution will also prevent the explosion of the cell parts. To buffer the solution add 0.1 g of potassium bisulphate (KH_2PO_4). The pH should be about 5.7.

Solution preparation:

The following general instructions apply for the preparation of most solutions: Solvents should be added to solutes. Use distilled water, not tap water, for all reagents. When preparing an acid or base solution, slowly add the acid or base to the water. Never add water to a concentrated acid or base.

To make percentage solutions measure 1 ml of solute per percentage. Add the solute to enough solvent to make 100 ml of solution. When dissolving a solid in water, measure 1 g of solute per percentage and mix the solute with enough water to make 100 ml of the solution.

Iodine solution (also available ready-made)

Dissolve 5.0 g of potassium iodide [KI] and 1.5 g of iodine crystals in 500 ml of distilled water. Store in brown bottle or other glass container that shields the liquid from light. *CAUTION: Iodine dust* *and vapors are toxic and irritating. Avoid body contact and inhalation of fumes. Should body contact occur, flush immediately with water.*

Sucrose solution

0.58 M: Put 99.5 g of sucrose in a flask. Add enough distilled water to make exactly 500 ml of solution. Stir until sucrose is dissolved, heating if necessary. Refrigerate. Quantity is enough for 50 students.

Part I:

You may wish to prepare the pea mixture ahead of time and give 30 to 50 ml to each student for filtration.

If time and availability of centrifuge are limited, prepare the filtrate and centrifuge it ahead of time for the students. The layers will remain separated and intact for over 24 hours. (Longer if refrigerated.)

Supervise the students' placement of test tubes in the centrifuge so that the centrifuge is balanced.

Lab 3:

Students will specifically observe the cell walls of plant cells and the plasma membranes of animal cells. They will also observe the food-producing organelles of plants--the chloroplasts.

Part I:

Point out to students that such movement (cyclosis) often requires observing one cell for several minutes.

On diagram: Students can stain the *Elodea* with iodine and observe one of the spike cells. The nucleus should become more clearly defined with iodine stain.

Part II:

Human cheek cells are excellent for the observation of cell membranes as well as cytoplasm.

Part III:

On diagram: Stress to students that although they appear different, both cork and cheek cells are the basic units of life.

Lab #4

Part I:

Have available several examples of herbaceous dicot stems for students to observe. It would be helpful to give a brief explanation on the fundamental differences between herbaceous and woody dicots.

Large sections cut from fireplace-size logs can be used. The sections should be approximately 6 cm in thickness and can be cut in the wood shop. Oak logs make outstanding specimens although other species are suitable. You may wish to demonstrate and explain the difference between heartwood and sapwood, the vessels and how they determine whether the wood is diffuse or ring porous.

Part II:

Make available several dried corn stalks for students to observe. Have on hand several other specimens of monocot stems to allow students to observe these macroscopically.

Lab #5

You will need to provide dormant twigs 3 years old or older. Collect these twigs from fallen wood if possible.

To sprout seeds, place them on moist filter paper in covered dishes for 30-40 hours. Lawn-grass seedlings are also excellent for viewing root hairs; they require 10-14 days for germination.

Part I:

Remind students of the differences between taproots and fibrous roots. Remind them that the root they are looking at is a dicot root, thus it may be a taproot.

Extension: Compare fibrous roots and taproots of different plants.

Step 3: If photosynthesis has not been allowed to occur, such cortex cells will not have starch stored in them.

Some slides may show roots developing from the pericycle of the main root. Suggest that students compare their slides to those of other students to note how root branches develop.

Part II:

Point out to students that the twig is an example of a dicot stem.

Step 1: Students may need to use hand lenses to see bundle scars and lenticels.

Step 2: Examine the meristem of the shoot apex under a microscope. Guide students to notice the dividing cells.

If prepared slides of longitudinal and transverse cross sections of woody stems are available, allow students to examine them and compare them to their twigs.

Review the function of parenchyma cells with the students.

Part III:

Number 4: The region of the root that contains the root hair does not move in order to grow. If this region did move, as the root tip does, the delicate root hairs would be stripped from its surface.

Part IV:

Students should be able to recognize all structures identified in Part I.

Lab #6

Begin this lab, as indicated, by planting the seeds a week in advance. The roots should emerge within 4-5 days and be ready for examination soon thereafter.

Lab #7

Complete flowers such as the snapdragon, tulip or lily are preferred for Parts I-III, but show students examples of pistillate, staminate, regular, irregular and composite flowers.

Solution preparation

The following general instructions apply for the preparation of most solutions: Solvents should be added to solutes. Use distilled water, not tap water, for all reagents. When preparing an acid or base solution, slowly add the acid or base to the water. Never add water to a concentrated acid or base.

To make percentage solutions measure 1 ml of solute per percentage. Add the solute to enough solvent to make 100 ml of solution. When dissolving a solid in water, measure 1 g of solute per percentage and mix the solute with enough water to make 100 ml of the solution.

Methylene blue stain

Dissolve 0.75 g of methylene blue in 50 ml of 95% ethyl alcohol. Dilute 5 ml of the alcohol and methylene blue solution with 45 ml of distilled water. This diluted solution is the stain. Bottle and store the remaining methylene blue and alcohol solution. *CAUTION: Ethyl alcohol is flammable. It is also irritating to the eyes. Flush spills with water. Do not ingest ethyl alcohol.*

10% Sucrose solution

Dissolve 15 g of sucrose in 135 ml of distilled water. Refrigerate.

Part I:

You may want to begin Part II early in the lab to allow time for completion.

Part III:

Staining helps to emphasize the nuclei. If the ovules are not flattened or well stained, have students repeat the slide preparation.

Part V:

Ray flowers: sepals, petals
Tube flowers: sepals, petals, stamen, carpel, ovary, ovule

Ray and tube flowers have different flower parts and the ray flowers have colorful, showy petals.

Sunflowers are composed of different types of flowers so they are composites.

Lab #8

Flowers as suggested are often donated upon request by funeral homes.

Part II:

Stamens may be collected from any species of the lily family and frozen until ready for use.

Part III:

Pistils may be collected from any species of the lily family after summer blooming and preserved for future use by freezing them or placing them in a preservative.

Part IV:

Pollen germination is often dependent on the concentration of the sugar. You may have to vary the concentration of the 10% solution suggested.

Before releasing students to do the hanging-drop preparation, it is best to demonstrate it first.

Lab #9

Be sure the seeds you are using have been packaged for the current growing season. Seeds older than a year may not germinate.

Lab #10

Part I:

For each student, plant 2 bean seeds in an individual container 2 - 3 weeks in advance. Place the containers under a good light source so that the plants grow normally.

Part II:

Demonstrate the marking of the leaves with India ink prior to the students' marking of the leaves.

Review the metric scale of measurements to insure proper measurements by the students.

Lab #11

Mosses and ferns may be collected during the spring and summer and may be kept in terraria, dried and pressed until needed for study.

Refer to unit AG 512-D--Nonvascular and Vascular Plants for information about alternation of generations.

Part II:

You may have the students remove several sporangia and prepare a wet mount. When examined under low power of the microscope, the spores should be visible within the sporangia.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #1--WHAT ARE CELLS?

Name____ Score___________________________

<u>Materials needed</u>

Microscope
Slides
Cover glasses
Forceps
Bottle cork
Razor blade
Onion
Scalpel
Iodine stain

<u>Part I: Observing Cork Cells</u>

More than 300 years have passed since Robert Hooke first described cork cells in his book *Micrographia.* In this investigation, you will repeat Hooke's early experiment with cork cells.

Carefully shave a very thin section from a bottle cork with a razor blade. Prepare a wet mount slide of the cork slide. Examine the specimen under low power, studying it in different positions. In the space provided, draw a sketch of what you observe.

Now examine the specimen under high power. Draw the cells as you see them under high power.

a. How would you describe the units that compose the cork ____________________

____

b. Are these units of similar shape?____________________

c. Are they of similar size? ____________________

d. Are they filled with any material?____________________

e. If so, explain what that content appears to be. ____________________

____

f. Are there spaces between the cells? ____________________

____

g. Do you think that these cells are alive?____________________

Part II: Onion Cells

The epidermis of the onion is ideal for cell study because it is composed of a single layer of cells. As you study these cells, you are looking into functioning units of living material.

Cut an onion lengthwise. Remove a thick scale and peel the delicate, transparent tissue from the inner surface. Cut a square of the tissue and mount it on a slide in a drop of water. (Note: Avoid wrinkling the tissue.) Add a cover glass. Examine the living cells under low power.

a. What is the shape of the cells? ____________________

b. Are they similar in shape?____________________

c. What color is the living cytoplasm? ____________________

Carefully raise one side of the cover glass and add a drop of iodine stain.

d. What effect does iodine have on the cells? ____________________

____

Select one cell that shows the contents clearly. Move it to the center of the microscopic field. Using high power, examine all the parts of the cell.

e. What is the appearance of the cytoplasm? ____________________

f. What is the appearance of the nuclei?____________________

____

g. Are the nuclei always in the same position in the cell? ____________________

____

h. Does the onion epidermal cell have depth? ____________________

i. Explain your answer. ____________________

____

Draw the onion cells under high power.

Part III: Summary

a. What are the units of cork seen under the microscope? ____________________

____

b. How did the cork units differ from those of the onion epidermis? ____________________

____

____

c. Why is an iodine stain used in this investigation? ____________________

____

d. Identify and give the function of the nucleus. ____________________

____

Part IV: Investigations On Your Own

1. Observe many different types of nonliving and living cells. Compare your findings to the cork and onion cells that you observed in this investigation. Draw sketches of the cells and their organelles.

2. It is possible to observe the mitochondria of some cells under the light microscope. Cut a strip of celery stalk containing "strings". Place this strip, with the inner surface up, in a 5% sucrose solution. Cut a thin strip from between the "strings". Observe the mitochondria. If you add a few drops of 0.001% Janus Green B solution, the mitochondria will stain a blue color. However, this color will quickly fade because of enzyme action.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #2--STUDYING CELL PARTS

Name____ Score_____________________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

One way scientists study the insides of cells is by breaking cells apart and spinning them in an *ultracentrifuge*. The ultracentrifuge spins test tubes containing cellular materials at very high speeds. The rapid spinning breaks the cell walls and causes the heaviest cell parts to sink to the bottom of the test tube. Then, these cell parts can be removed for further study. Spinning the remaining material allows additional cell parts to be isolated for study. Though you probably do not have access to an ultracentrifuge, you can isolate and study some cell parts by spinning cellular material in a *centrifuge*. The centrifuge works on the same principle as the ultracentrifuge, but the centrifuge spins at lower speeds. In this laboratory exercise you will use a centrifuge to isolate parts of plant cells.

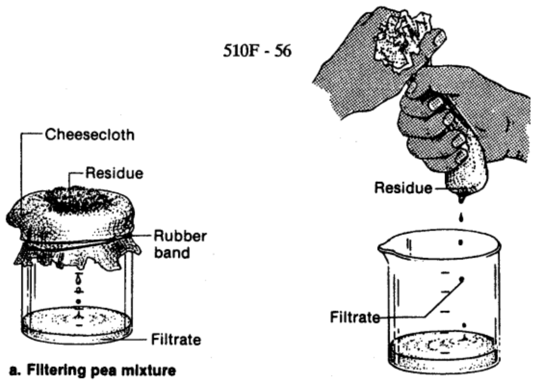
Materials needed

100 ml 0.58 M sucrose solution
50 ml fresh, green peas
Blender
Cheesecloth square, 12 cm x 12 cm
250-ml beaker
Rubber band
Stirring rod
Centrifuge tube
Centrifuge
5 microscope slides
Toothpick
2 ml iodine solution
5 coverslips
Compound microscope
4 disposable Pasteur pipettes
Colored pencils

Part I: Procedure

1. Pour 100 ml of sucrose solution into a blender. Add about 50 ml of peas. Securely cover the blender with its fitted lid. Blend the mixture at highest speed for three minutes. The blending of this mixture will break the cell walls and release cell parts into the sucrose solution.

2. Loosely stretch a piece of cheesecloth over a beaker. Secure the cheesecloth with a rubber band. Pour the blended pea and sucrose mixture through the cheesecloth into the beaker, as shown in a on the following page. The liquid that passes through the cheesecloth is called the *filtrate*. The solid material that collects on top of the cheesecloth is called *residue.* If the cheesecloth becomes clogged and no longer allows liquid to pass through it, remove the rubber band, and fold the corners of the cheesecloth, as shown in **b**. Then, gently squeeze the pea and sucrose mixture so that more filtrate drips into the beaker.



a. Filtering pea mixture

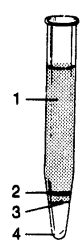
b. Squeezing residue

3. Stir the filtrate with a clean stirring rod. Fill a centrifuge tube three-quarters full of filtrate. Insert your tube and another student's tube, equally full of filtrate, into the holders opposite each other in the centrifuge. This placement balances the centrifuge and allows the centrifuge to spin evenly. Spin the centrifuge at the highest speed possible for ten minutes.

4. While your filtrate is spinning, make a wet mount slide of a small sample of residue, and stain the sample with iodine. *CAUTION: Avoid getting iodine on your hands. Iodine can stain your hands and clothes and is poisonous if ingested.*

5. View the stained residue under a microscope at low and high power. A blue-black color indicates the presence of starch. In the table below record if starch was present in the sediment. Sketch and label cell parts you recognize in the space provided in the Cell Parts Table.

6. After ten minutes, stop the centrifuge, and remove your centrifuge tube. The tube should contain four distinct layers of material. Observe these layers, and use colored pencils to draw them in c, below. Number the layers from top to bottom.



7. Use a pipette to carefully remove several drops of material from the lightest material at the top of the centrifuge tube. Place a drop of this material on a clean microscope slide. Stain this material with iodine, and add a coverslip.

8. Observe the stained material under low and high power. Record the results of the starch test in the table. Sketch what you see in the space in the table.

9. Repeat steps 7 and 8 for the other three layers.

Table. Cell Parts

Layer	Labeled sketch of cell parts observed	Results of starch test	Cell part	Function
Residue			Fibers	
1 (top)			Cell Wall	
2				
3				
4 (bottom)			Leucoplast	

Part II: Analysis

1. Complete the right half of the Cells Parts Table.

2. What does the iodine test indicate about the functions of certain cell parts? ___________________

____

3. Which plant cell parts were not separated using this technique? Give reasons why you might not have been able to see these cell parts.

____

____

____

4. Rank the cell parts you observed in order of density from least dense to most dense. Explain how you knew the relative density of the cell parts.

____

____

____

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #3--ANIMAL AND PLANT CELL DIFFERENCES

Name____ Score______________________________

Materials needed

Elodea leaves (Anacharis)
Microscope
Slides
Cover glasses
Medicine dropper
Colored pencils
Human cheek cells
Toothpick (flat type)
Methylene blue

Part I: Cells of a Leaf

Although most cells of plants and animals are similar in structure, there are a few major differences. In this investigation, you will observe these differences under the microscope.

Prepare a wet mount of an Elodea leaf. The whole leaf should be used. Examine the leaf under the low power of the microscope. Then select a portion of the leaf where the cells are particularly distinct. Center this portion in the microscope field. Bring it into focus under high power. Use the fine adjustment to observe the cells at various depths.

a. In which layer are the widest cells located? ____

____

Observe the small, oval, green bodies that appear in the cells. These are the chloroplasts.

b. Are any of the chloroplasts moving?____

c. If you see movement, are all the chloroplasts moving in the same direction? _________________

d. Are they all moving at the same speed? ____

e. Can you observe any structures for movement? ____

f. Explain how the chloroplasts move. ____

____

Draw some cells of an *Elodea* leaf. Use arrows to indicate the direction of chloroplast movement. Label your drawing, indicating the **cell wall, chloroplasts, cytoplasm** and **nucleus.**

<u>Part II: Human Epithelial Cells</u>

In this part, you will examine the cell structure of human epithelial (cheek) cells, and you will note the absence of the cell wall that was present in the elodea cells.

Gently scrape the inside of your cheek with a clean toothpick. Prepare a wet mount of the material that you have scraped from your cheek. Add a drop of methylene blue and a cover glass. Examine the cells under low power of the microscope. Switch to high power. Carefully look for the outer edge of the cytoplasm.

a. How does it compare with the outer edge of the elodea cells? ______________________________

b. What is this outer edge called? ______________________________

c. Describe the shape of the cheek cells. ______________________________

d. In what ways do the cheek cells differ from the elodea cells? ______________________________

____

____

e. Why did you use methylene blue in this investigation? ______________________________

____

f. Describe the appearance of the cytoplasm. ______________________________

____

In the space provided, draw a single cheek cell (high power) and label the **plasma membrane, cytoplasm,** and **nucleus.**

Part III: Summary

a. In what ways do elodea cells differ from human cheek cells? ____________________

____

b. What is the function of chloroplasts? ____________________

____

c. Why are chloroplasts green in color? ____________________

____

d. What is the outer covering of a cheek cell called? ____________________

e. Do cheek cells contain chloroplasts?____________________

f. Are both plants and animals composed of cells?____________________

Explain your answer based on observations of elodea and cheek cells.

____

____

Part IV: Investigations On Your Own

1. You can investigate many types of plant cells and identify the cell walls as well as the organelles. You may want to include potato cells, tomato pulp cells, and beet cells in your investigation.

2. There are many interesting investigations that one can do with human cells. Some skin taken from under the fingernails can be studied. These cells can be compared with those from the cheek. Identify the structures that you observe.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #4--HOW MONOCOT STEMS DIFFER FROM DICOT STEMS

Name____ Score______________________________

Materials needed

Cross section of a woody dicot stem, 10-15 years old or older
Prepared slide of: herbaceous monocot stem (Zea mays)
Textbook or charts
Microscope

Part I: Microscopic Examination of a Woody Dicot Stem

Dicot stems can be both herbaceous and woody. Herbaceous dicot stems usually live for only a single growing season. When compared to a year old woody stem, close similarities may be observed in the tissues which compose the stem. In this part, you will examine only a woody dicot stem.

Examine the cross section of a woody stem. You commonly hear the terms bark and wood.ÿ

a. Where is the bark located? ____

b. Where is the wood in relation to the bark? ____________________________________

c. What tissue occupies the center of the stem? __________________________________

d. Summarize the tissues that can be observed in a cross section of a woody stem. ____________

____

Bark and wood are both composed of specialized tissues which can only be observed with a microscope. Without the microscope, it can be seen that bark is divided into the outer bark and inner bark. The outer bark is composed of cork tissue.

e. What are some functions of the cork? ______________________________________

f. What tissue composes the inner bark? ______________________________________

g. What is the function of the phloem? _______________________________________

h. Although you are unable to see it, what layer of cells separates the bark from the wood? ________

____

i. What is the function of the vascular cambium? ______________________

____

j. What tissue composes wood? ______________________

k. Estimate the amount of wood in proportion to the amount of bark. ______________________

____

____

l. What evidence is there that the stem has lived for more than a single growing season? __________

____

m. What are these rings commonly called? ______________________

n. Are all of the rings of equal thickness? ______________________

o. Account for your answer. ______________________

____

____

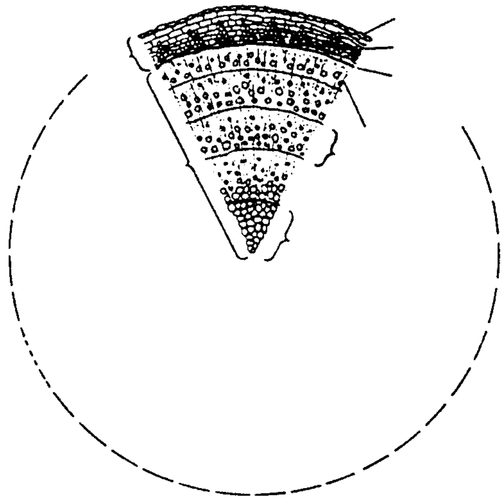
p. What is the function of the xylem? ______________________

____

In the chart below, summarize your observations of the woody dicot stem. Give the function of the tissue where it applies.

	Location	Function
1. Outer covering		
2. Arrangement of vascular tissue		
3. Location of phloem		
4. Location of xylem		
5. Location of vascular cambium		
6. Location of pith		

On the figure of the cross section of a woody stem, label: **cork tissue, phloem, bark, vascular cambium, xylem tissue, wood, pith, annual ring.**



Part II: Examination of a Monocot Stem

Examine the prepared slide of a cross section of the monocot stem with your microscope under low power. The outer layer of cells is the epidermis.

a. Describe the appearance of these cells ____

____

Note that just under the epidermis are additional thick-walled cells. These cells, along with those of the epidermis, compose the rind of the mature stem.

b. What tissue occupies most of the stem? ____

c. Describe the cells which compose this tissue.____

____

Look for the fibrovascular bundles. Count the bundles in an estimated quarter of the stem.

d. How many do you find? ____

e. Where in the stem are they most numerous?____

____

Of what significance is this observation? ____

____

Select a fibrovascular bundle toward the center of the stem. Examine it under **high power**. Note that the bundle has the appearance of a face with distinct facial regions. Large *xylem vessels* are found in the position of the "eyes" and "nose" of the face. The *phloem* occupies the position of the forehead. Locate and distinguish the *sieve tubes* and *companion cells,* which compose the phloem.

g. Is a vascular cambium present?____

h. What effect does its presence or absence have on a monocot stem?_______________

____

____

Locate the thick-walled schlerenchyma fibers surrounding the bundle.

i. What function might they serve?____

The position of the "mouth" is an irregular intercellular space.

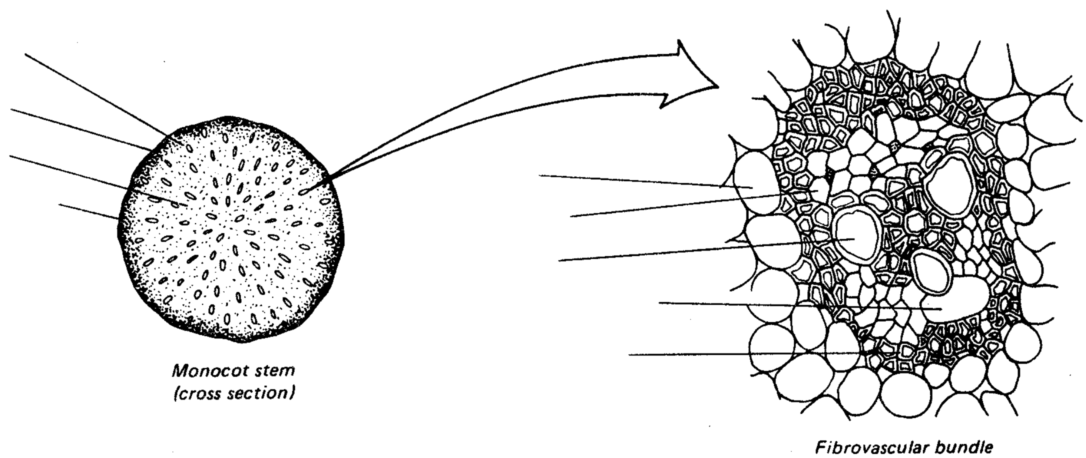
j. What can you observe to confirm that it is a space and not a large cell? _____________

____

k. Suggest how this space might be formed.___________________________________

____

On the general view of the corn stem, label: **epidermis, rind, pith, fibrovascular bundle**. On the figure of the fibrovascular bundle and surrounding tissue, label: **xylem vessels, phloem, intercellular space, pith, schlerenchyma fibers.**



Part III: Summary

In the chart on the following page, summarize the differences and similarities between monocot and dicot stems you have observed and studied.

Characteristic	Dicot	Monocot
1. Herbaceous or woody		
2. Type of vascular tissue present		
3. Arrangement of vascular tissue		
4. Presence of vascular cambium		
5. Location of pith		
6. Means of support		
7. Probable life duration of stem		

Part IV: Investigations On Your Own

1. Obtain a prepared slide of a 3-year dicot stem (Tilia) and examine it under the microscope. You should observe that the tissues in a woody stem are much more complex than what you observe with the naked eye. Consult a biology or botany textbook for descriptions of the cells which compose the outer and inner bark and the xylem. Make a detailed sketch of a pie-shaped section and label the cells and tissues which you observe.

2. Examine a prepared slide of an herbaceous dicot stem (*Helianthus*) and locate the tissues studied in the woody dicot stem. Note the similarities and differences. Make a detailed sketch of a pie-shaped section and label the cells and tissues you observe.

3. Make a collection of cross sections of woody stems 3-4 cm in thickness and 5-8 cm in diameter. Identify each with its scientific and family name. The sanding and sealing of the cross sections will help to preserve them for future use.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

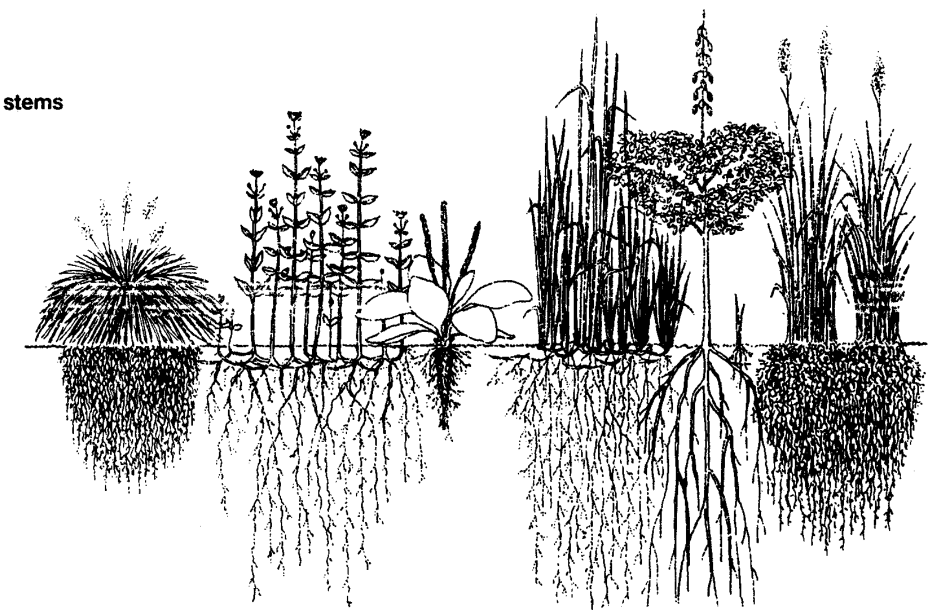
LABORATORY EXERCISE #5--EXAMINING ROOTS AND STEMS

Name____ Score____________________________

Slesnick, Irwin L., Biology Laboratory Manual, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

Plant roots and stems



Look at any plant: a tree growing in a field; grass covering a lawn; a rosebush blooming in a garden. You are really seeing only half of the plant. The roots underground make up the other half of the plant. Roots, such as those in the pictures above, perform several important functions for a plant. They anchor the plant in the soil, absorb water necessary for life and growth, and store food and transport it to the rest of the plant.

Locate the stems in the plant pictures above. Plant stems are often among the most conspicuous parts of a plant. Aside from supporting the plant, the stem also transports substances to and from the leaves, stores food, and in some plants, manufactures food. In this laboratory you will examine the tissues that make up roots and stems. By studying root and stem tissues you will learn how the structures in roots and stems contribute to the healthy functioning of the plant.

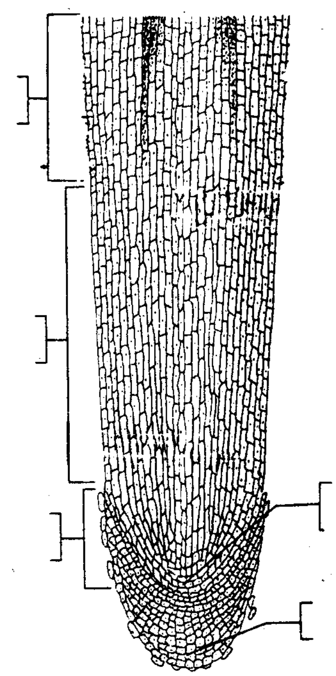
Materials needed:

Sprouted radish seed
Hand lens or stereoscopic microscope
Metric ruler
Compound microscope
Twig
Scalpel
Colored pencils
Prepared slides of longitudinal and transverse cross sections of a root tip, root and herbaceous monocot and dicot stems

Part I: Examining Roots

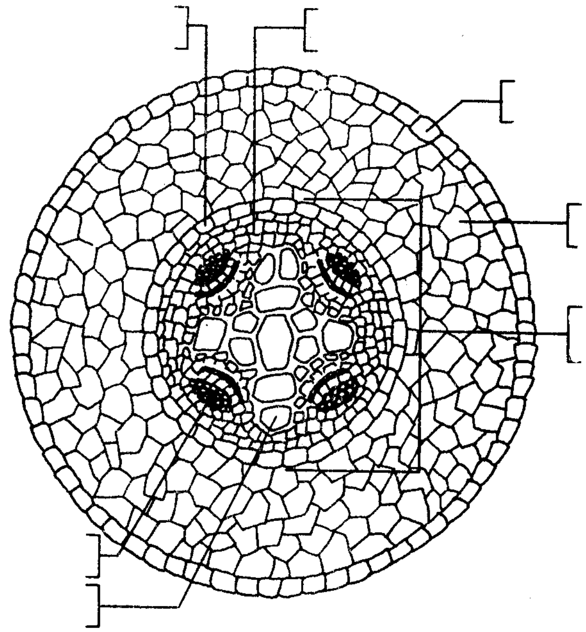
1. Use a hand lens or stereoscopic microscopic to examine the sprout of a radish seed. Notice the region on which root hairs first begin to grow. Locate the longest root hairs. On the cross section in a, draw the *root hairs* showing where they first appear and where the longest root hairs are located. You may wish to add a scale in mm next to your drawing to indicate the length of the region where root hairs appear.

a. Root tip



2. Obtain a prepared slide of a longitudinal cross section of a root tip, and examine it under low and high power. Locate root hairs growing off the side of the root tip. Find the three regions of root growth: the *region of cell division*, the *region of elongation* and the *region of maturation*. The *root cap* is made of larger cells at the very tip of the root. The region of cell division, above the root cap, is made of smaller, dividing cells called the *apical meristem*. Just above the apical meristem, find the lengthening cells that make up the region of elongation. Above this region, in the region of maturation, cells begin to differentiate into specialized tissues. In this region you will begin to notice root hairs. Identify and label the regions in a, above.

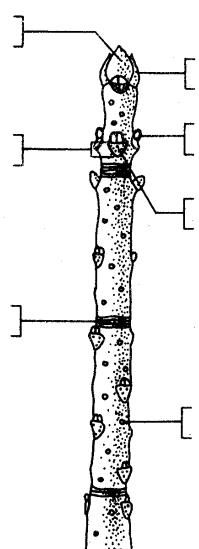
3. Examine a prepared slide of a transverse cross section of the mature region of a root. Find the single layer of *epidermal cells* that protects the root surface. Locate the *parenchyma cells* that make up the *cortex*. These cells may have been stained with iodine, which turns blue in the presence of starch stored in the cortex cells. Notice that cells are very loosely packed to allow water absorbed by root hair to flow to the inner tissues of the roots. The *endodermis*, surrounding the *vascular cylinder*, is the next layer in from the cortex. The thick, waxy cell walls of endodermal cells control the passage of dissolved materials into the vascular tissues. Thus, the endodermis prevents the entrance of harmful substances that might be absorbed by the root hairs and dispersed to the rest of the plant. Find the *vascular tissues* that form a column called the *vascular cylinder* at the center of the root. Locate the *pericycle* layer, just inside the endodermis. Root branches form from pericycle tissue. Inside the pericycle, *xylem* is arranged in the form of a "+." Note the thick walls of the *xylem cells*. The *phloem* cells are in circular patches between the arms of the plus-shaped xylem columns. Compare the thickness of the phloem cell walls to that of the xylem cell walls. Label the structures of the root in b on the following page.



b. Root cross section

Part II: Examining Stems

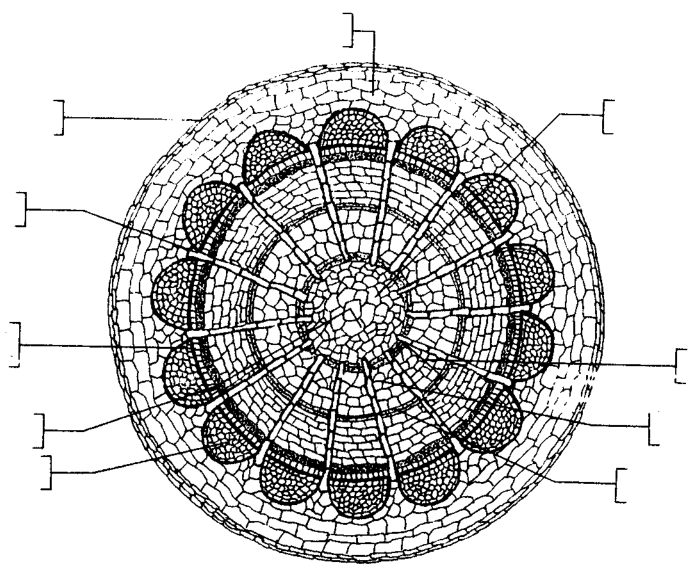
1. Obtain a twig from a woody plant. Note that almost all woody plants are dicots. Observe the places where a leaf was attached to the twig. These marks are called *leaf* scars. Notice the tiny row of dots, arranged in a "v" on the leaf scar. These *bundle scars* indicate where the xylem and phloem entered the leaf stalk. Find the tiny holes in the surface of the bark. These structures--the *lenticels*--allow water vapor and other gases to be exchanged through the stem. Examine the terminal bud, at the end of the twig. The length of a growing twig is determined by how fast the terminal bud grows. Examine the *bud scales* that cover a bud. The scales fall off after they have served their protective function, leaving concentric scars around the twig. Find these *budscale scars* that mark the end of the twig's yearly growing season. Notice the *lateral buds* on the side of the twig. Growth of these buds results in new branches, leaves, and flowers. Label the structures shown on diagram c.



c. Twig

2. Use a scalpel to make a longitudinal cut through the terminal bud. Examine the cut bud with a hand lens. Notice the tiny growing leaves and the green tissue in the lower central portion of the bud. This tissue--the *shoot apex*--is meristem tissue responsible for the growth in height of the stem.

3. Make a transverse cross section of your twig with a scalpel. *CAUTION: Use the sharp blade of your cutting instrument carefully to avoid injury. Always cut away from yourself.* Use a hand lens to locate the large cells of the light-colored pith at the center of the stem. Rings of xylem make up the wood, the bulk of the stem. Xylem cells that make up *spring wood* are large and have thin walls. *Summer wood* is made of smaller, thick-walled xylem cells. The darker-looking summer wood makes a band that contrasts with the lighter spring wood. The contrast in the color of the bands of spring and summer wood can help you determine the age of the twig. Together these bands of different colored xylem cells make up an *annual ring*. Locate the thin layer of vascular cambium surrounding the outermost xylem cells. The inner layers of cambium become new xylem cells and the outer layers become new phloem cells. Tightly packed *phloem cells* are arranged in half-moon shapes outside the vascular cambium. Larger parenchyma cells make up the cortex. These cells store starch for the plant. The outermost layers are made of thick, tough, waterproof cells, called *cork,* that protect the inner tissues. You may notice *vascular rays,* channels that conduct materials between the different tissues. Label the tissues and structures in **d:**



d. Woody stem cross section

4. Nonwoody--or *herbaceous*--stems are present in both monocots and dicots. Obtain prepared slides of transverse cross sections of herbaceous monocot and dicot stems. Examine these slides under low power. Locate the epidermis, the outermost layer of the stem tissue. Draw the epidermis on the stem outlines, e and f, on the following page. Notice the *vascular bundles* contain *phloem cells*, which may be stained green, and xylem cells, which may be stained red. In dicots, a thin layer of *vascular cambium* may be located between the xylem and phloem. Compare the arrangement of vascular bundles in the monocot and dicot stems. Sketch the pattern of vascular bundles in the outlines of the monocot and dicot stem. Observe the large food-storing parenchyma cells around the vascular bundles. In the dicot stem these cells make up the *cortex* to the outside of the vascular bundles; the region of parenchyma cells to the inside of the vascular bundles is called *pith*. In a monocot stem parenchyma cells are referred to as pith in all regions of the stem. Draw the regions of parenchyma cells, and label the regions in both the monocot and dicot stems. Find the green-colored chloroplasts, and sketch these in your stem drawings.

e. Monocot Stem **f. Dicot Stem**

Part III: Analysis

1. Complete the table below by checking those tissues that are present in a root, woody dicot stem, herbaceous monocot stem and herbaceous dicot stem. Also, give the function of each tissue.

Table. Structures of roots and stems

Tissues	Present in:				Function
	Root	Woody dicot stem	Herbaceous monocot stem	Herbaceous dicot stem	
Root cap					
Meristem					
Root hairs					
Epidermal cells					
Cortex					
Endodermis					
Pericycle					
Phloem					
Xylem					
Bud scales					
Lenticels					
Cork					
Vascular rays					
Vascular cambium					
Annual rings					
Chloroplasts					

2. Name four tissues common to both roots and stems. What are the main functions that these tissues serve?

____

____

____

3. Name one tissue unique to roots and one tissue unique to stems.

Roots: ____

Stems: ____

4. Give a reason why root hairs only appear above a certain point on a root. What does the location of root hairs on the root tell you about the way that the root grows?

____

____

5. How does the pattern of growth of woody dicot stems enable you to determine the age of the stem?

____

____

6. Describe the major difference between the structure of monocot and dicot stems. How does this difference affect the growth of the stem?

____

____

7. Imagine you find a scar on the side of a maple tree 2 m above the ground. If the tree grows 4 m in the next 10 years, at what height would you then find the scar? What does this tell you about the way the tree grows?

____

Part IV: Going Further

Make your own transverse and longitudinal cross sections of a root, such as a radish sprout or a carrot. Cut very thin slices of the root so that light will be able to pass through the slices when you look at them under a microscope. Stain the root slices with iodine. *CAUTION: Avoid getting iodine on your hands. It stains and is poisonous if ingested. Cut away from yourself*. Locate the different kinds of cells and tissues that make up the root.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #6--ROOT GROWTH

Name____ Score________________________________

Materials needed:

Radish, bean, pea or corn seeds
Petri dishes
Filter paper
Hand lens
Microscope
Dissecting needles
Dissecting microscope
Prepared slide:
  Longitudinal section of root tip (Allium)
Colored pencils

Part I: Origin of the Root System

A Week in Advance

To study the origin of roots, it is necessary to begin with a germinating seed from which the first root of a plant emerges. To observe the emergence of the primary root, trim a piece of filter paper to fit snugly in the bottom of a Petri dish. Flood the dish with water and drain off the excess. Lay 3 or 4 radish seeds at equal distances from each other on the filter paper and set aside until the roots have developed to a length of at least 2 cm. Repeat the procedure with other available seeds to note any differences in the primary root development.

When the roots have developed, remove the cover from the dish and examine the seedlings with a hand lens. Locate the *primary root*.

a. Describe its structure. ____

____

b. Where are the secondary roots developing? ____

____. The fuzzy outgrowths are root hairs.

c. Locate and describe their growth. ____

____

____

d. What function do root hairs perform? ______________________________

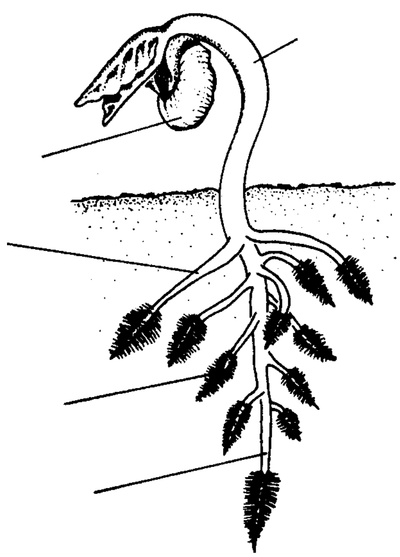
____

____

e. Describe the relationship of the base of the shoot and the base of the root.

____

On the figure, label: primary root, secondary root, root hair, seed coat, shoot.



Bean seedling

Part II: How is Growth Accomplished in Root Tip?

Remove a germinated seed from the Petri dish prepared in Part I. Cut a section of the portion of the root bearing root hairs and place this in a drop of water on a slide. Examine under a dissecting microscope and carefully, with dissecting needles, remove a portion of the tissue bearing the root hairs. In order to see the detail of the cells, add a drop of iodine to the preparation and examine it under low power. Observe the root hairs.

a. Are the root hairs composed of cells? ______________________________

b. Explain your answer. ______________________________

____

c. From what cells do the root hairs project? ______________________________

____

d. Suggest how the root hairs absorb water. ______________________________

____

Examine a prepared slide of a longitudinal section of the young root tip under low power. Use a biology or botany textbook or charts to locate the various regions of the root tip. Move the slide and examine all areas.

e. Are root hairs present? ______________________________

f. If not, explain their absence. ______________________________

____

____

Locate the root cap at the tip.

g. What function does it serve? ______________________________

____

Cells on the surface of the root cap are worn off as it pushes through the soil.

h. Why doesn't the root tip cap disappear entirely in time? ______________________________

____

____

i. Where are the smallest cells of the root tip located? ______________________________

____

Examine these cells closely.

j. What important activity is carried on in this region? ______________________________

____

k. Why is this activity important to the root? ______________________________

____

Move the slide from the tip toward the older regions.

l. What noticeable changes occur in the size of the cells? ______________________________

____

m. What term applies to this region of the root? ______________________________

____

n. Why is the activity of this region important to the root? ______________________________

____

o. Why are the regions of the root not clearly defined?

____

____

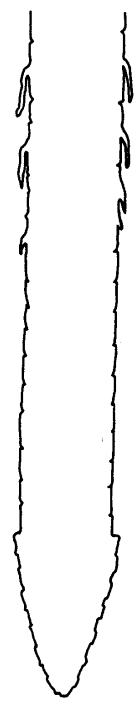
____

From what region do the root hairs originate?____

____

This is the region from which root hairs develop.

In the outline, locate with brackets the **root cap, meristematic region, elongation region, maturation region.** Accurately draw several rows of cells in each region.



Part III: Summary

a. On the basis of your observations of the root tip above, explain how the roots grow longer.

____

____

____

____

Test what you have learned by matching the function of the tissue in the left column with the tissue in the right column. Place the number of the tissue in the space before the function.

_____b.	produces new root cells	1.	maturation region
_____c.	function in the absorption of water	2.	epidermis
_____d.	protects the growing root tip	3.	root hairs
_____e.	activity in this region serves to push a root tip through the soil	4.	elongation region
		5.	root cap
_____f.	region producing root hairs	6.	meristematic region

Part IV: Investigations On Your Own

1. The secondary growth of a root may be studied through the examination of a carrot or similar root. Consult a biology or botany textbook to determine what becomes of the primary tissues as the root increases in diameter. Make drawings of the longitudinal and cross sections and label the tissues you observe.

2. Make a collection of root modifications as they are found on different plants. (for example: adventitious roots of corn, English Ivy, tap roots of Dandelion, and turnip, etc.) Give the name of the plant and tell how the modification serves the plant.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #7--OBSERVING THE STRUCTURE AND FUNCTION OF FLOWERS

Name____ Score_______________________________

Slesnick, Irwin L., Biology Laboratory Manual, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

In all flowering plants--or angiosperms--the flower is a highly refined organ that is specialized for sexual reproduction. The outer structures, the sepals and petals, are actually modified leaves that protect the reproductive structures. Each of the remaining parts plays a specific role in the actual seed formation. In this laboratory you will examine each of the flower structures and see how they are modified for their role in sexual reproduction.

Materials needed

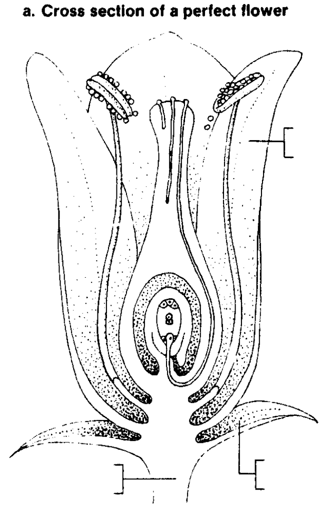
Assorted fresh flowers
Stereoscopic microscope or hand lens
Compound microscope
Coverslips
0.01% Methylene blue solution
Clean sheet of unlined paper
Forceps
Dissecting needle
10% Sucrose solution
Scalpel or single-edged razor blade
Lab or facial tissue
Tape

Part I: Macroscopic Study of the Flower

1. Obtain all the materials listed above and bring them to your work area.

2. Examine the outer structure of your flower. The *sepals*, which are modified leaves, form the outermost circle--*or whorl*. Collectively the sepals form the *calyx*. Find the place where the calyx attaches to the base of the flower. This is the *receptacle*. The petals are found just inside the sepals and the whorl of petals is called the *corolla*. Label the *receptacle, sepal and petal* on a.

a. Cross section of a perfect flower



3 Monocots are flowers whose parts occur in threes or multiples of threes. *Dicots* are flowers whose parts occur in fours or fives or multiples thereof. Is the flower you are observing a monocot or a dicot?

(a) ____

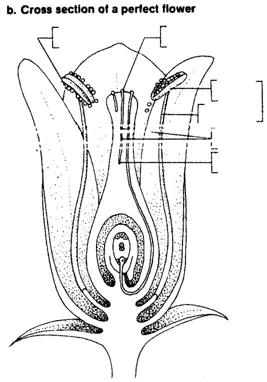
4. Gently remove the sepals and the petals. Tape the sepals along the bottom of a clean sheet of paper. Then tape the petals in a row above the sepals. What do you notice about the number of sepals and petals?

(b) ____

<u>Part II: The Male Reproductive Structures</u>

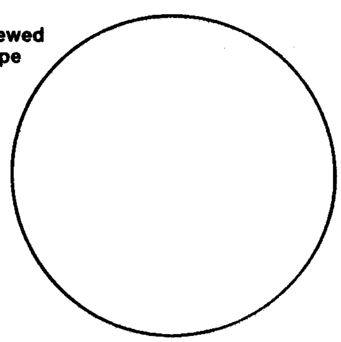
1. Inside the corolla is a circle of *stamens*. These are the male reproductive organs, each consisting of an anther at the tip supported by a tubelike filament. *Pollen grains* found inside the anther are the male gametophytes. Label the *anther, filament and pollen grain* on **b**. Carefully remove the stamens and tape them in a row above the petals.

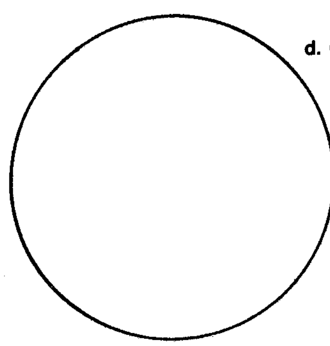
b. Cross section of a perfect flower



2. The anthers contain the *pollen sacs*. The pollen grains are formed from *microspores* in the pollen sacs. To examine the pollen grains more closely, add some pollen grains to a drop of water on a microscope slide. Add a coverslip and examine the pollen grains under high power of your microscope. The small dotlike structures you see are the pollen grains. Make a sketch of a few of the pollen grains in c.

c. Pollen grains viewed under microscope





d. Growth of the pollen tube viewed under the microscope

3. Sprinkle some pollen from your flower onto a drop of sucrose solution on a microscope slide. Add a coverslip and examine at high power at five-minute intervals for 30-60 minutes. The narrow thread-like structures you see growing are the *pollen tubes*. Locate and label the tube nucleus at the tip of the pollen tube in d on the previous page and the two *sperm nuclei* close behind. After 30 minutes make a sketch of the pollen tube growth. Describe the pollen grains and the growth of the pollen tubes.

   (c) ____

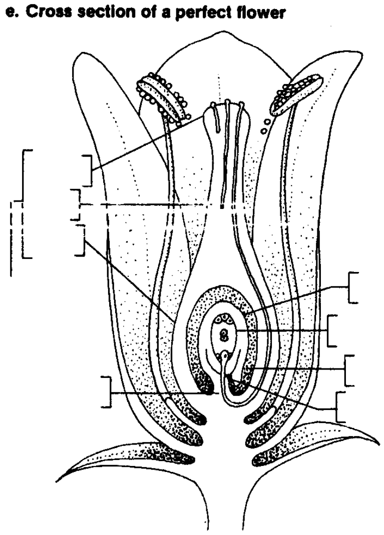
   ____

   ____

Part III: The Female Reproductive Structures

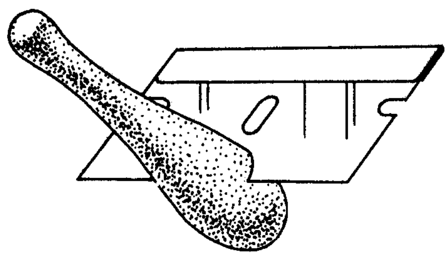
1. The female reproductive organ--or *carpel*--is located in the center of the flower. The top portion of the carpel is the *stigma*. The stigma is usually sticky and is where the pollen grains collect. The *style* is the stalk-like structure that supports the stigma. The enlarged structure at the base of the carpel is the ovary. Ovules within the ovary produce the female gametophytes. Label the *carpel, stigma, style and ovary* on **e.**

e. Cross section of a perfect flower

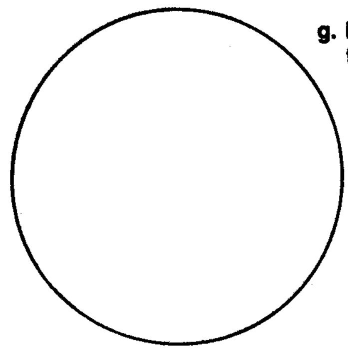


2. With a scalpel or razor blade, carefully remove the carpel by cutting just beneath the ovary. *CAUTION: Use the sharp blade of your cutting instrument carefully to avoid injury. Always cut away from yourself.* Then, make a cross section of the ovary as shown in f on the next page. Tape one half of the cross section on the paper above your drawing of the pollen grains. Secure one half of the cross section with your forceps. Then, using your scalpel, cut a thin slice from the section. Make a wet mount and examine under low power. Find the white spherical *ovules* that are attached to the ovary wall by a tiny stalk, the *funiculus.* The ovules develop into hollow compartments called *locules.* The outer layers of the ovule surround the *embryo sac*. The embryo sac is the female gametophyte and this is where the egg is located. Label the *ovule, funiculus, locule and the embryo sac* on **e.**

3. Using the cross section of the ovary, carefully separate a few ovules. Place the ovules in a drop of water on a clean microscope slide and add one drop of methylene blue stain. Place a coverslip on top. Fold a piece of tissue and place it on top of the coverslip. Gently press down to crush the ovules. Under low power examine the slide and locate the stained nuclei inside the embryo sacs. Make a sketch of the nuclei in g.



f. How to cut a cross section of a carpel



g. Nuclei viewed under the microscope

Part IV: Analysis

1. In what structure are the male gametophytes found?

___

2. In what structure are the female gametophytes found?

___

3. Where is the stigma located on the flower and how does this aid in pollination?

___

___

4. Describe the process of fertilization in angiosperms. Name each of the structures involved.

___

___

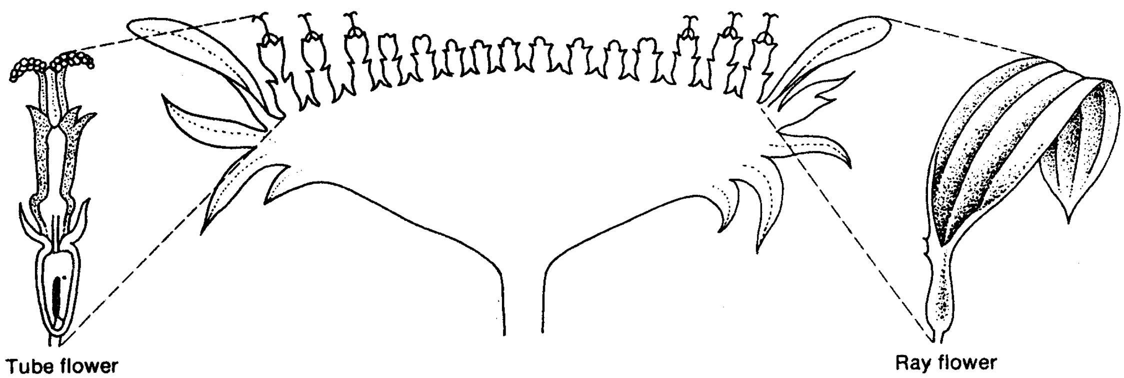
___

___

Part V: Going Further

Obtain a composite flower from your teacher. Notice that there appear to be two kinds of petals. These are actually flowers. The flowers of the outer row--the *ray flowers*--have showy petals. The flowers in the center are called the *tube flowers*. Carefully remove one of the ray flowers at its base. Using your scalpel or razor blade make a longitudinal cut down the center of the flower. Examine one half of the ray flower with your hand lens. List the flower parts present in the ray flower. Carefully remove one of the tube flowers beneath the base. Examine one half of the flower with your hand lens. List the flower parts present in the tube flower. What are the differences between the ray and tube flowers? Sunflowers are an example of a composite flower. The name comes from the arrangement of the flowers. Explain why sunflowers are composite flowers.

A composite flower



PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #8--FLOWER FUNCTIONS IN REPRODUCTION

Name___________________________________ Score___________________________________

Materials needed

Gladiolus flower (tulip, lily or snapdragons will suffice)
Single-edged razor blade
Microscope
Prepared slide of cross section of Lily anther slide
Cover slip
Hand lens or stereoscopic microscope
Dropper
Forceps
Collection of anthers from a variety of flowers
Depression slides
Toothpick
Dissecting needle
Petroleum jelly
10% sucrose solution
Distilled water

Part I: What Are the Parts of a Flower?

Flowers must develop before there can be fruits and seeds. Seeds are contained in the fruits which develop after pollination and fertilization.

As you read this description of a flower, label the parts given in italics on the figure 510F-84. Examine a complete flower and note that it has 4 kinds of floral parts. These parts are arranged in circles or whorls. The parts are supported on a stalk, the *pedicel*. The parts are attached to the swollen tip of the pedicel known as the *receptacle*. The outermost circle of parts is the sepals which may be green. In some species, the sepals appear as petals. Collectively the sepals make up the *calyx* which serves to protect young flower parts in the bud stage.

a. Describe the sepals and their number.____

____

The petals are within the calyx and collectively known as the corolla.

b. Describe the number and appearance of the petals.____

____

____

The male and female organs make up the remaining circles of flower parts.

c. Why are they known as essential parts? ____

____

The male parts are the *stamens.* Each stamen consists of a slender stalk, the *filament* and a knoblike mass, the *anther*.

d. How does the number of stamens compare with the parts already observed?____________________

____

e. What seems to be the number plan of the flower? ____________________________________

____

f. Of what group of flowering plants is this characteristic? ______________________________

____

The female organ, the *pistil*, occupies the center of the flower. Examine it closely and you will see that it is composed of 3 parts. The top portion is the *stigma* on which pollen lands.

g. Why is it necessary that it be sticky? ____

____

The stalk supporting the stigma is the *style.* At the base is a swollen green portion known as the *ovary.*

h. What is produced within the ovary? ____

____

On the figure of the flower, label the parts you have observed.

Part II: The Stamen

Remove a stamen with forceps and examine it under a hand lens.

a. Describe what you observe. ____

____

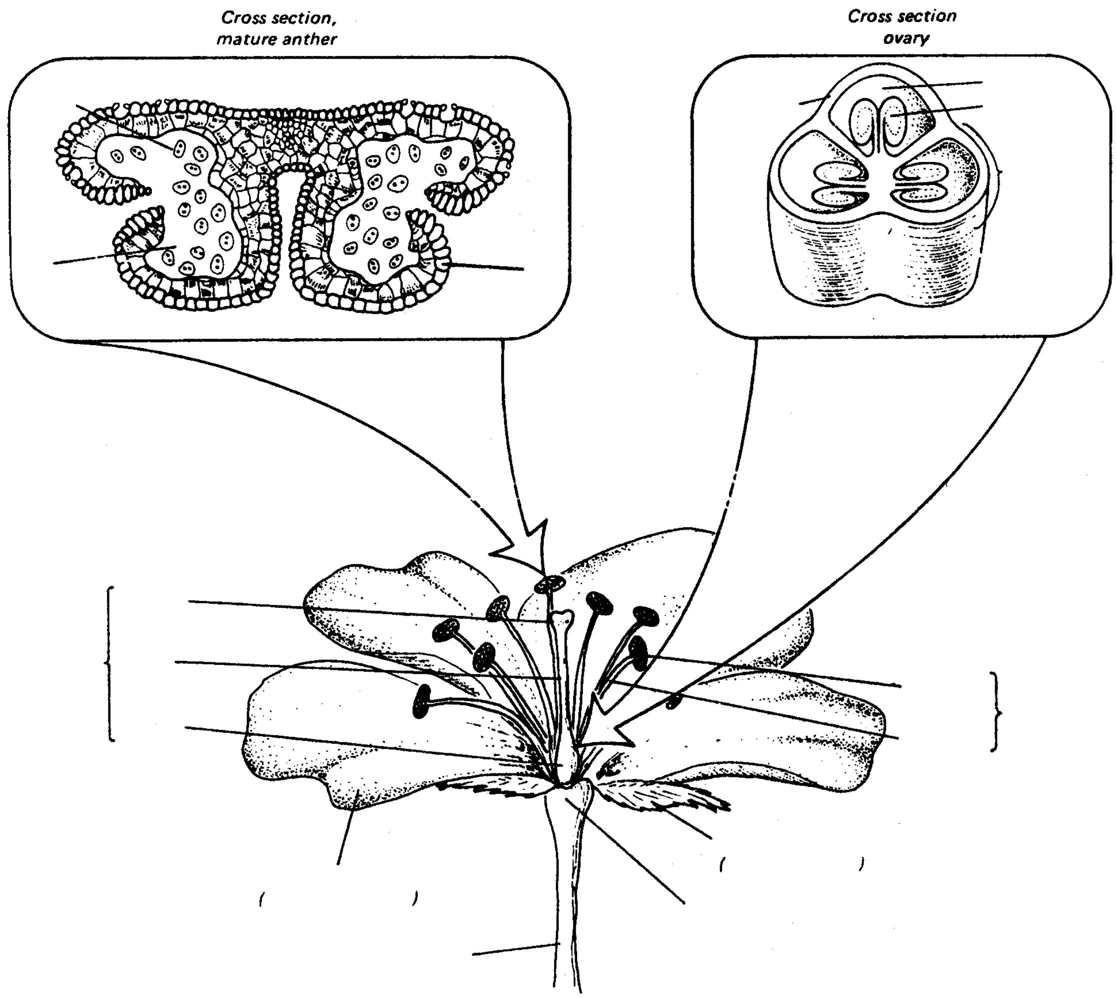
____

Prepare a wet mount of some pollen grains by dusting the anther on a slide. Examine them under low power and high power of the microscope.

b. Describe the surface of the pollen grains. _______________________________________

____

Examine a prepared slide of the cross section of a lily anther under low power.



The parts of a flower

c. How many cavities or pollen sacs are seen? ____________________

d. When the anther matures, how is pollen released? ____________________

____

e. What becomes of pollen as it is released? ____________________

____

____

The pollen grains contain the male sex cells produced as a result of meiosis from special cells within the anther. On the cross section of the anther on the previous page, label: **wall of anther, pollen sac, pollen, grains.**

Part III: Structure and Function of the Pistil

Carefully remove the *pistil* from the flower and examine it closely under a stereoscopic microscope.

a. In relation to pollination, suggest a reason for the stigma being supported as it is by the style.

____

____

Using a sharp, single-edged razor blade, make a wet mount of a cross section of the ovary. Examine it under a stereoscopic microscope. Notice that the ovary is divided into sections known as carpels. Each carpel contains several *ovules.*

b. How do the ovules appear? ____

____

The ovules extend into a cavity known as a *locule.*

c. How many cavities or carpels make up the ovary? _____________________________

____

d. Explain the significance of the number. ____________________________________

____

____

Each ovule contains an egg which is not visible. Observe that an ovule is attached to the ovary wall through a tiny stalk.

e. Why must the ovules be attached as they are? ________________________________

____

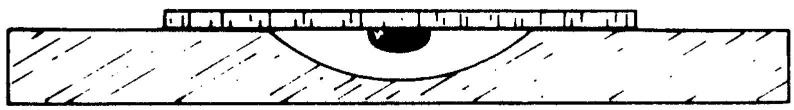
____

On the cross section of the ovary on the previous page, label: **ovary wall, carpel, ovule, locule.**

Part IV: Observing Germinating Pollen Grains

Once pollen of a particular species has landed on the stigma of the same or closely related species, a pollen tube will begin to germinate. This phenomenon can be observed under laboratory conditions.

Obtain a dropper of a 10% sucrose solution from a prepared stock solution. Place a drop of the solution in the center of a cover glass. Transfer some pollen grains to the drop with a dissecting needle or small brush. Use a toothpick to apply a thin ring of petroleum jelly around the depression. The slide should be deep enough to prevent the drop from touching. Turn the slide over and line up the depression with the drop of sucrose solution with the pollen. Gently allow the slide to come in contact with the cover glass. Turn the slide upright and examine under low power of the microscope. Pollen tubes should emerge within 20 minutes. Certain pollen requires one or two days to produce pollen tubes. Periodically check the preparation to determine the extent of germination.



a. What is the function of the pollen tube? ____

____

____

b. Through what structures does it grow? ____

____

c. Toward what structure does it grow? ____

Examine a pollen tube to see if you can find the 2 sperm nuclei.

d. What becomes of these 2 nuclei? ____

____

In the space below, draw the pollen grain at the start of the observation and several stages in the growth of the pollen tube. Label**: pollen tube, sperm nuclei.**

Part V: Summary

In the following chart, briefly relate how each flower part contributes to the function of reproduction.

In the following chart, briefly relate how each flower part contributes to the function of reproduction.

Floral Part	Function
sepal	
petal	
filament	
anther	
stigma	
style	
ovary	

Part VI: Investigations On Your Own

Collect several flowers of varying structure and examine them to determine differences and similarities. Summarize in a chart the number of each of the floral parts and any unusual features that may be observed. Determine whether they are monocots or dicots.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #9--DEVELOPMENT OF SEED PARTS INTO YOUNG PLANTS

Name____ Score ____________________________

Materials needed

Dry and soaked lima beans
Dried ear of corn
Individual grains of corn
Knife or single-edged razor blade
Hand lens
Iodine solution
250-ml beaker
Paper toweling
Blotter or filter paper
Cotton
Colored pencils

Part I: A Dicot Seed--The Bean

The seed is a matured ovule and the final product of angiosperm reproduction. The new plant is provided with stored food and special coverings. Under the proper conditions vegetative growth begins. This is known as seed germination.

Obtain one dry lima bean and one that has been soaked overnight. Examine the dry seed and note its external markings. Locate a scarlike structure, the hilum.

a. What does it represent? ____

____

Locate the micropyle, a tiny opening close to the hilum.

b. What is the significance of the micropyle? ______________________________________

____

c. Would you expect all seeds to have a hilum and a micropyle? _____________________

Explain your answer.____

____

____

Examine a dry seed which has been soaked overnight. Compare this seed to a dry seed.

d. What changes have occurred? ____

____

Offer an explanation for what you observe.____

____

Remove the thin outer seed coat, the testa.

f. Describe the cotyledons which are now visible. ____

____

g. What is their function? ____

Separate the cotyledons allowing the embryo plant to remain attached to one of them. The epicotyl, often called the plumule, consists of two, tiny leaves which enclose the terminal bud of the future plant. Below the epicotyl is the hypocotyl, the embryonic stem. Locate the radicle at the base of the hypocotyl. The radicle is the embryonic root. Add a drop of iodine to the testa, cotyledon, epicotyl and hypocotyl. Remember that starch turns purple or blue-black in the presence of iodine.

h. Which contains the greatest amount of starch? ____

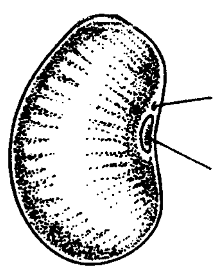
____

i. Suggest an explanation for what you have observed. ____________________________________

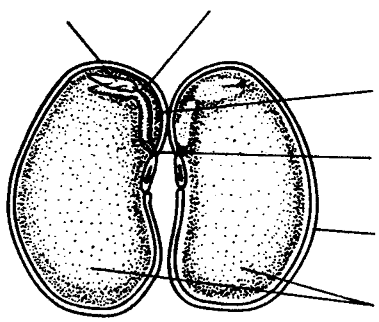
____

____

On the figure of the external view of the bean, label**: hilum, micropyle**. On the figure of the internal view, label: **cotyledons, epicotyl, hypocotyl, radicle**.



External



Internal

<u>Part II: A Monocot Seed--Corn Grain</u>

Examine an ear of corn.

a. Is this the product of a single flower or a group of flowers?________________________________

Explain your answer.____

____

Remove a single grain. Locate the silk scar as a projection near the top of the grain.

b. Account for the location of the silk scar.____

____

A corn silk represents a greatly elongated style ending in the stigma. It is attached to an individual ovary.

c. If an ear of corn had 250 grains, how many corn silks would there have been?_______________

Explain your answer.____

____

d. Would you expect of find a hilum and micropyle in the corn grain? _______________________

Explain what you are able to locate. ____

____

____

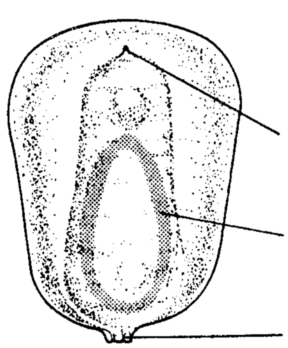
Locate the prominent dent on one side of the grain marking the location of the cotyledon and the embryo plant. In corn, the *point of attachment* corresponds to the stalk of the bean's flower. It is the pathway through which the grain receives nourishment. On the figure of the external view, label**: point of attachment, silk scar.**

Position a soaked kernel "dent" side up. Using a sharp razor blade, cut lengthwise at right angles to the broadside of the grain. Observe the embryo and its parts in longitudinal view. The outer covering is the *ovary wall*. The lower portion contains the embryo and *cotyledon*. The upper part of the embryo is the *epicotyl sheath*, directly below is the *hypocotyl*. The cotyledon is attached to the epicotyl and hypocotyl. The bulk of the grain is *endosperm* tissue which supplies food to the embryo plant. Add a drop of iodine to the endosperm.

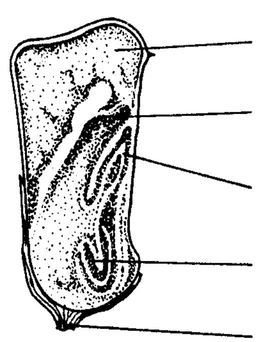
e. What color appears? ____

f. In what form is food stored in the corn grain? ____

On the figure of the internal view, label: **embryo, cotyledon, epicotyl sheath, hypocotyl, endosperm.**



External



Cross section

Part III: From Seed to Seedling

Prepare a germination jar by cutting a piece of blotter paper to line a 250-ml beaker. Tightly pack cotton on the inside to give support to the blotter. Place several bean seeds and corn grains in a row between the blotter and the glass about one half the distance from the top of the beaker. Moisten the cotton so that it is damp and avoid excess water. Put the beaker in a warm location. Allow the seeds to germinate until the young seedling plants are well formed. Observe the plants daily and make the following observations.

Bean Seeds: a. What embryonic structure emerges from the seed coat? ______________________________

Why is this important to the seedling? ____

____

Observe the growth of the hypocotyl.

c. How does it appear? ____

d. Of what advantage could this be to a seedling growing in the soil? __________________________

____

____

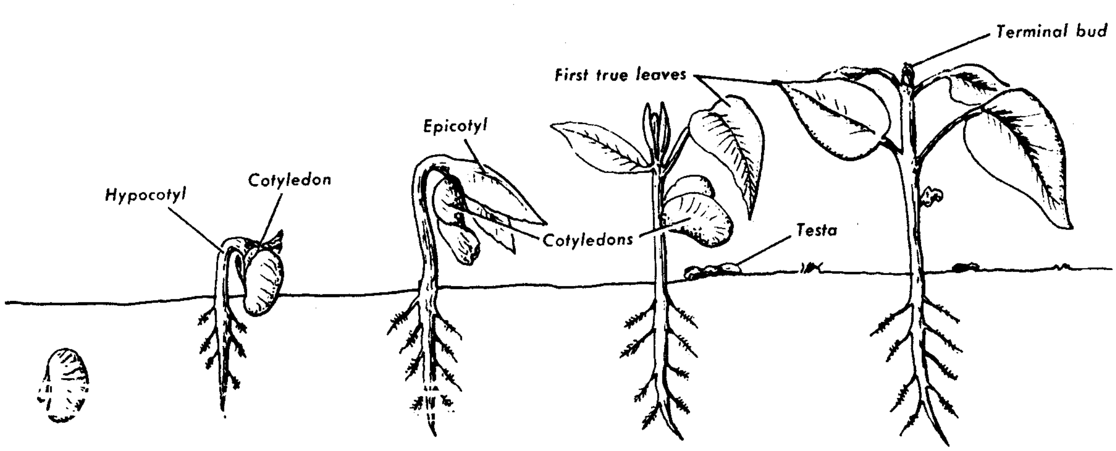
e. Describe the position of the cotyledons. ____

____

f. As germination progresses, what becomes of the cotyledons? ______________________________

____

Study the drawings representing stages in the germination of a bean seed. Use colored pencils to indicate each part of the embryo in the earliest stage. With the same color, shade in those structures in later stages.



Steps in the germination of a bean seed

Corn Grain: Observe a germinated corn grain. Note the direction of development of the emerging root and shoot.

a. How are you able to distinguish each? ____

____

b. What type of tropism does each exhibit? ____

____

Examine a seedling that has "emerged" above ground level. Look for a colorless structure known as the epicotyl sheath, which surrounds and encloses the developing shoot. A similar structure is at the root tip.

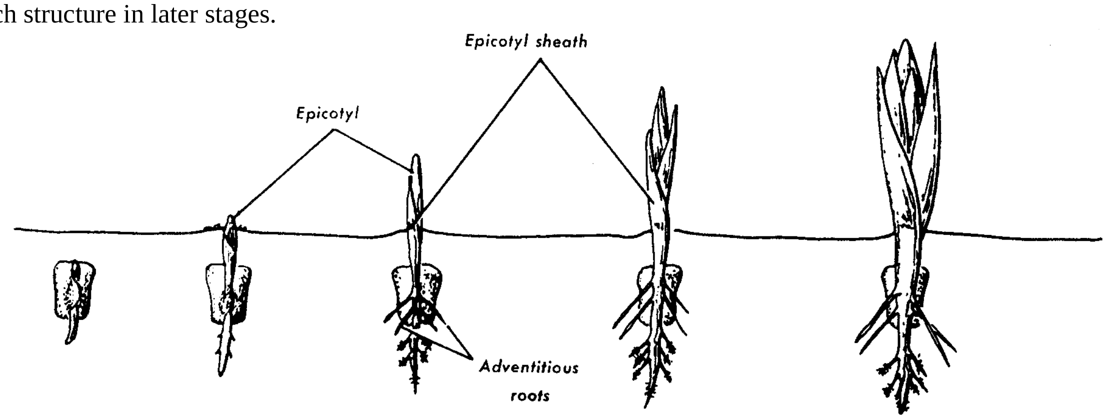
c. What function would these structures have for the developing seedling?______________________

____

d. What becomes of the epicotyl sheath as the foliage develops?_____________________________

____

Below, use colored pencils to indicate each part of the embryo in the earliest stage. Use the same color for each structure in later stages.



Steps in the germination of a corn seed

Part IV: Summary

Review what you have learned about seed structure and germination by filling in the blanks in the following statements. The answers are given at the right.

a. The ____________________of the seed becomes the first true leaves of the newly emerged dicot plant.

b. The radicle of the seed becomes the ________________________ of the new seedling.

c. The _______________________of a dicot seed supply food to the developing embryo.

cotyledons

epicotyl sheath

epicotyl

radicle

hypocotyl

d.	The _______________________in the bean marks the point at which the ovule was attached to the fruit.	silk scar
e.	The _______________________of the corn grain contains starch.	hilum
f.	The point at which the pollen tube entered the embryo sac is marked by the ___________________________.	point of attachment
		micropyle
g.	The arching over of an emerging bean plant serves for protection of delicate tissues. In a corn seedling this function is served by the _________________________.	primary root
		endosperm
h.	The _____________________________of a corn grain is likened to the pedicel on the ovary of a bean plant.	

Part V: Investigations On Your Own

Seed viability is the capability of seeds to germinate. Select 100 seeds of several species to test for their viability. Wet a piece of muslin or burlap and lay it out. Place 100 seeds of the same species in well spaced rows on the wet cloth. Wet another piece of cloth and lay it over the seeds carefully. Roll the two pieces together, loosely. This device in known as a "rag-doll tester." Prepare such a device for each species of seed. Keep the seeds moist for several days to a week. Check regularly to see if the seeds have germinated.

When germination has occurred, unroll the cloths and count the number of germinated seeds. Summarize your results in a bar graph indicating percent of seeds germinated for each species. Discuss why some seeds were unable to germinate and differences you observed when compared to the predicted viability of the seeds.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #10--PLANT GROWTH

Name____ Score_______________________________

Selection from *Modern Biology*, Biology Investigations, Teacher's Edition, by James H. Otto, Albert Towle, W. David Otto, and Myra E. Madnick.

Materials needed

1 vigorously growing bean plant in an individual container
2 bean seeds
1 flower pot (7 to 10 cm) or suitable container
Mixture of sand and loam (1:1)
Metric ruler (divided into millimeters)
Thread
India ink

Part I: Observing Vegetative Organs

Obtain a bean plant growing in an individual container. The plant should be about 15-18 cm tall. Turn over the container to empty the entire mass of soil and roots. Wash the soil from the roots to expose the root system. You are now able to observe all of the vegetative organs of a seed plant.

a. What parts of the plant can you observe? ____

____

b. What does it mean for an organ to be vegetative?____

____

c. Examine the root system closely, and describe what you see.________________________________

____

d. What characteristic may be observed which indicates the anchoring function of the roots in the soil?____

____

e. What are some other functions of roots?____

____

Examine the stem.

f. What obvious plant organ is attached to the stem? ____

____

g. On the basis of your answer to (f), what is one of the functions of the stem?___________________

____

h. What color is the stem?____

i. What pigment is present? ____

j. Name another function that may be carried out in the stem.________________________________

____

k. How do water and minerals get to the leaves from the roots?________________________________

____

l. How do materials move from the leaves to the roots? _____________________________________

____

m. On the basis of your answers in (k) and (l), what function is being performed?_________________

_____________________________________ Like the root, the stem often functions in the storage of food. Examine the leaves.

n. What color are they? ____

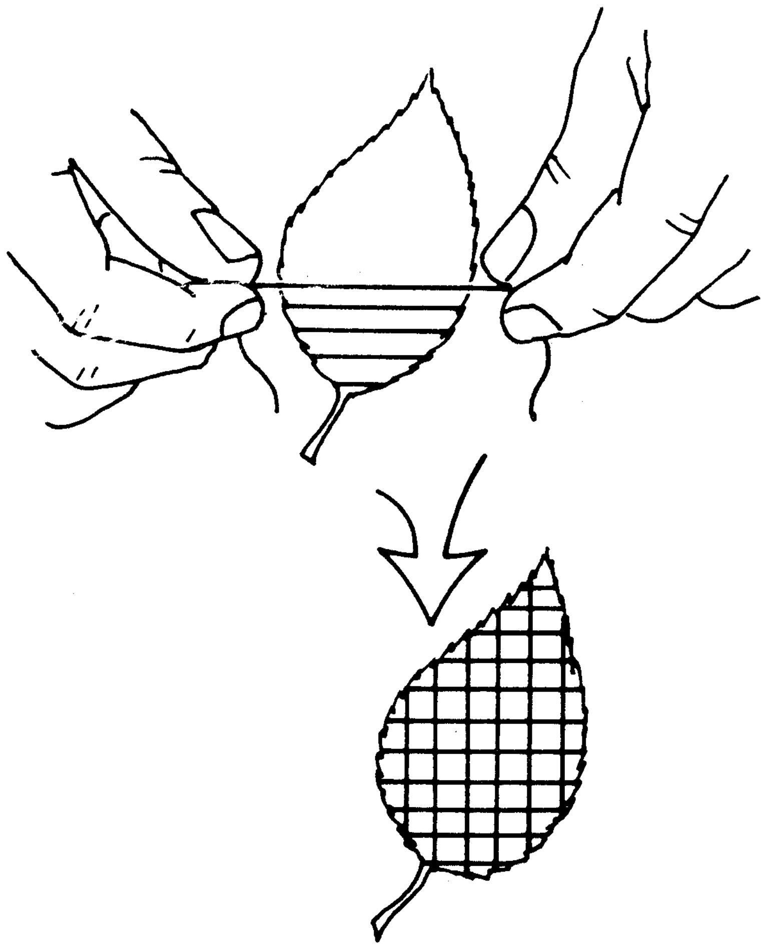
o. What is the principal function of the leaves? ____

In the space provided, sketch the entire plant. Include the details of the branching pattern of the roots, and the shape and venation of the leaves. Label: **roots, stem** and **leaf.** Summarize the functions of each vegetative organ.

Part II: How Fast Do Plant Parts Grow?

Plant a bean seed in a pot containing equal parts of sand and loam. Plant it just below the soil surface. Water the soil well and pour off the excess. Place the pot in a light source and keep the soil moist. Once the true leaves of the plant are formed, your observations and determination of the rate of growth may begin.

To observe where the leaf expands in its growth, mark a small leaf in the following manner: Draw a piece of thread (15-20 cm) tightly between the forefinger and thumb of each hand. Have your partner moisten the thread with the applicator from an India ink bottle. Carefully place the moistened thread on the leaf to make a straight line across the leaf. Repeat the procedure and make the next line approximately 3 mm from the first. Continue until the leaf is marked as shown in the figure below. In the same manner, mark the stem from the soil surface to the tip of the stem.



a. What will the markings help you to observe? ____

____

As the leaf expands, record your observations in a series of drawings by accurately representing the regions of expansion.

b. How will you be able to determine where the leaf and stem grew? ____________________________

____

____

Use a metric ruler to obtain actual growth measurements. Measure in millimeters the length of the stem from the soil level to the growing tip. Record the measurement in the table below.

Count and record the number of leaves. Determine the surface area of each leaf by multiplying the length of the leaf (base to tip) by the average width (measure in three places) of the blade. Record the total surface area of all leaves. Repeat the measurement at 2-3 day intervals for a period of two weeks. Record all data in the table.

After the last measurements are recorded, carefully remove the plant from the soil. Wash the soil from the roots. Measure each root and record the total length of the root system.

Base your answers on the markings and the measurements taken.

c. Was the rate of growth uniform in the stems and leaves during the growth period?

____

Date of Measurement	Interval Between Measurements	Length of Stem	Number of Leaves	Total Leaf Area	Total Length of Roots (Last Measurements)

d. If not, when is the rate of growth most rapid?____

____

____

e. Compare the total length of the stem with that of the root.______________________________

____

f. Did the leaf blades continue growth at a uniform rate?_________________________________

g. If not, what variation occurred? ____

h. Where were new leaves produced? ______________________________

i. How does the area of the plant above and below the ground compare? ______________________________

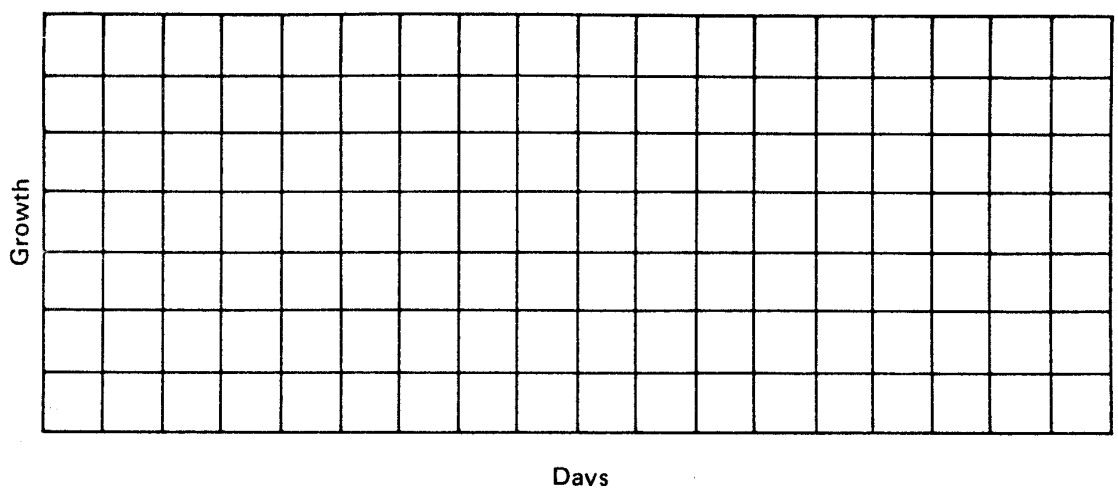
____

Part III: Summary

a. Using a suitable scale of numerical value, prepare a graph with separate lines for length of stem, number of leaves and total leaf area. Explain any observable relationship.

____

____



In the space provided, indicate which vegetative organ(s) of the plant perform the function indicated.

b. ______________________________ conduct water and minerals to upper plant parts.

c. ______________________________ are the principal organs of photosynthesis.

d. ______________________________ serve to anchor the plant.

e. ______________________________ produce leaves.

f. ______________________________ store food substances.

g. ______________________________ exchange gases between the plant and the atmosphere.

h. ______________________________ absorb water and minerals.

i. ____ have a secondary function of photosynthesis.

j. ____ conduct water and minerals up and down the plant.

k. ____ display leaves to light.

l. ____ function in the process of transpiration.

Part IV: Investigations On Your Own

Select various growth media such as sand, vermiculite, heavy clay soil, etc. Observe how the type of soil influences seedling growth. The procedure as presented in Part 2 should be followed. To observe the effects of soil nutrients, you may wish to use laboratory prepared nutrient solutions or those prepared commercially in addition to selected soil types.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #11--PLANT REPRODUCTION WITHOUT SEEDS

Name____ Score________________________________

Materials needed

Moss plants with female sex organs
Moss plants with male sex organs
Fresh clump of living moss plants
Dissecting microscope
Textbook or charts
Microscope
Slide, cover glass
Dissecting needle
Fresh fern frond bearing sori
Hand lens

Part I: How Do Moss Plants Reproduce?

Moss plants may be found growing in dense clumps on the forest floor or compact mats on a fallen log. A clump of moss plants is composed of many gametophyte plants growing close to each other for support. At certain times of the year, the sporophytes may be seen growing from certain plants.

Examine a small portion of a clump of moss, using a hand lens. Remove a single gametophyte and examine it closely under a dissecting microscope. The rootlike structures at the base of the leafy stem are rhizoids which function to absorb water and minerals. Examine a *leafy shoot*.

a. Of what adaptive value is the arrangement of the leaves on the stem axis? ____________________

____

Gamete-producing structures, archegonia and antheridia, are located at the tips of the leafy stems in a cluster of leaves.

b. What gamete is produced by the archegonia? ____

c. by the antheridia? ____

These gamete-producing structures may be observed by squeezing them from the tip of the stem. Roll the tip of the stem between the thumb and the forefinger as you bring the tip in contact with a large drop of water on a slide. Use a dissecting needle to remove the fragments of the tip. Some of these pieces will be either antheridia or archegonia depending on the sex of the plants used. Use pictures in a biology or botany textbook or charts as reference. Repeat the procedure for a plant of the opposite sex. Observe the slide under the low power of the microscope.

d. Describe the structure of an antheridium. ____

____

e. Describe the structure of an archegonium. ____________________

____

____

f. How does a sperm reach an egg for fertilization? ____________________

____

g. Explain why mosses are not found growing in locations having little or no moisture.

____

h. What cell is produced when the sperm fertilizes the egg? ____________________

i. Where is the zygote formed? ____________________

Examine a gametophyte bearing a stalk and capsule.

j. Why is it known as the sporophyte generation? ____________________

____

k. From what cell did the sporophyte develop? ____________________

l. Explain why the sporophyte is present only on certain gametophyte plants. ____________________

____

Locate the capsule at the tip of the seta. Examine the capsule using a hand lens. Determine if a tiny lid, the operculum, is present. As spores mature within the capsule, the operculum will fall away. Under favorable conditions a spore germinates into a threadlike structure, the protonema. The protonema eventually develops into a mature gametophyte.

m. What have you observed about the sporophyte that indicates it is nutritionally dependent on the gametophyte? ____________________

____

____

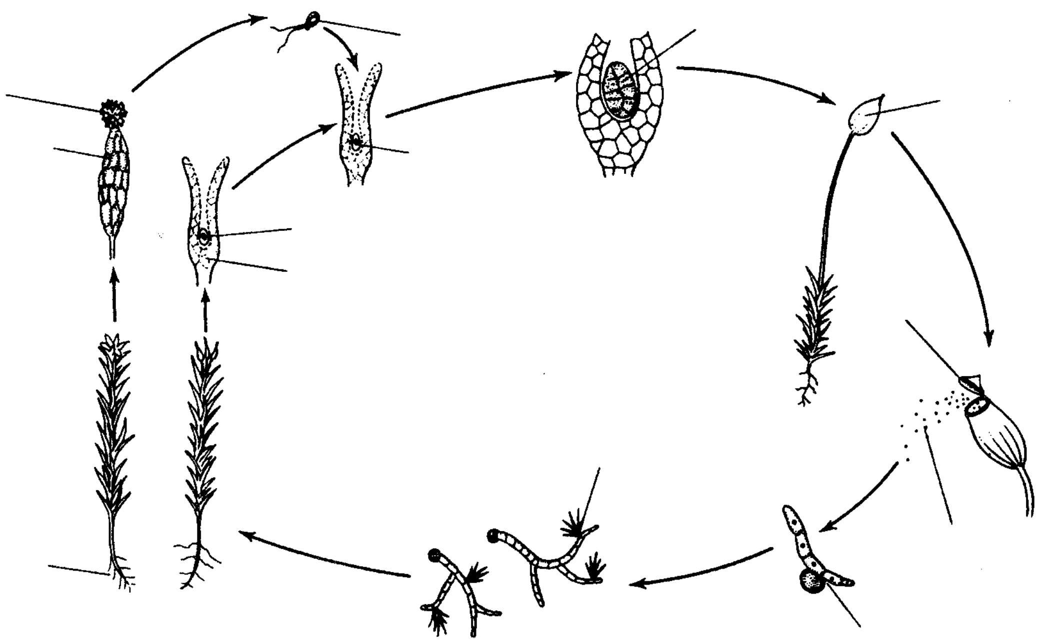
n. Explain how moss plants exhibit alternation of generations.

____

____

____

Examine the stages in the life cycle of the moss plant. Label the following structures**: rhizoids, archegonia, antheridia, egg, sperm, capsule, operculum, spores, protonema, young gametophyte**. Also indicate the **gametophyte generation** and the **sporophyte generation.**



Life cycle of a moss plant

<u>Part II: Alternation of Generations in Ferns</u>

Examine the living fern frond or study the figure in the life cycle. The familiar fern plant is the sporophyte generation. Unlike the mosses, it is free living and independent. The fronds (leaves) of the fern grow from a horizontal, underground stem, the *rhizome*. The fronds first emerge from the ground as *fiddleheads*. Each consists of a stalk and a blade divided into leaflets or *pinnae*. When certain of the fronds mature, small dots known as sori (singular--sorus) are produced on the lower surface. A sorus contains a cluster of spore producing structures called *sporangia.*

a. Compare the sporophytes of the moss and fern. ____

____

____

b. With what structure of a moss does a fern sorus compare?_______________________________

____

Examine a single pinna with sori under a dissecting microscope.

c. Describe the number and position of the sori.____

____

When the spores are released and land in a favorable location, they germinate and develop into gametophytes. The gametophyte is called a *prothallus.* The prothallus measures about 1 cm in diameter. The prothallus produces antheridia and archegonia which produce sperms and eggs.

d. How is fertilization accomplished in ferns? ____

____

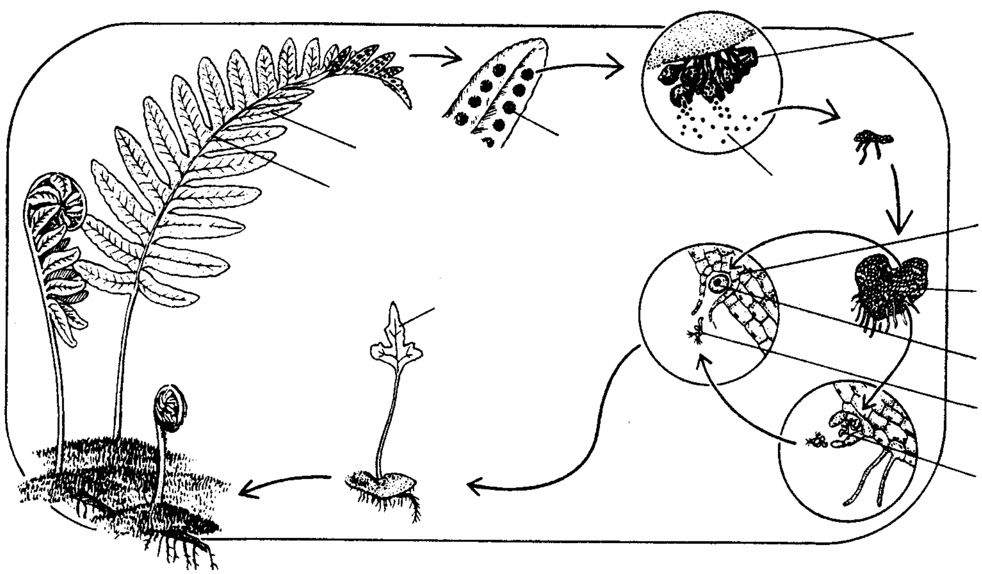
e. How does the size and structure of the prothallus make this possible?________________________

____

The cell formed upon fertilization is the zygote.

f. What generation does the zygote develop into? ____

On the diagram of the fern life cycle, label**: frond, pinna, egg, spores, sporangium, sperm, prothallus, young sporophyte, antheridium, archegonium, sorus.** Also indicate the **sporophyte generation and the gametophyte generation.**



<u>Part III: Summary</u>

a. From what you have observed and studied, relate how mosses and ferns reproduce without

seeds. ____

____

____

____

b. Summarize your observations of mosses and ferns by filling in the blanks of the following chart.

	Mosses	Ferns
1. Produces eggs		
2. Produces sperm		
3. Sporophyte independent (Yes/No)		
4. Structure producing spores		
5. Spores germinate into:		
6. Inconspicuous generation		
7. Conspicuous generation		
8. Medium for fertilization		
9. Agent for spore dispersal		
10. First cell of sporophyte		
11. First cell of gametophyte		
12. General habitat		

Part IV: Investigations On Your Own

1. To become acquainted with the mosses in your region and to determine their various habitats, make a collection of mosses. Look in any environment where there is moisture and reduced light. Collect shoots bearing stalks and capsules. Place the specimens in different envelopes and record the location, date and habitat in your notebook. Use identification keys to trace your specimens to their particular genus. Leaf and capsule structure are used for identification purposes. The characteristic size and shape of spores are often used for identification.

2. Make a collection of fern fronds. Before beginning your collection, you should become familiar with the characteristics used in their identification. These include: general form and structure; distribution of the sori, the sporangia and the indusia; and the form of the frond. Collect a portion of a frond and put it in a book or magazine. Assign a collection number to the specimen and record this number in your field notebook along with other data such as the location, date and habitat. When you return to the laboratory, identify your specimens. The fronds can be pressed and saved for later study by drying them between several layers of newspaper.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #12--GROWING A BEAN PLANT

Name________________________________ Score____________________________________

Introduction

Beans for cross-pollination are raised inside greenhouses to avoid unfavorable environmental conditions and accidental cross-pollination. Remember the flowers need to be protected in order to accomplish cross-pollination. So a growth chamber, greenhouse or a shelter must be constructed first.

Part I: Planting the Bean Seeds

1. The beans may first be treated with a suitable fungicide before being planted.

2. Well-drained and fertile soil, such as a mixture of loam, peat and sand in a 7,3,2 soil mixture with a pH of 6 to 6.5, is needed. You can mix this soil yourself and autoclave it to rid it of pathogens or you can buy it in bulk from your local nursery.

3. Seeds can be planted directly into (15-20 cm) clay or plastic pots. Or they can be germinated in a planting medium such as Perlite and then transplanted into the pots that contain the 7,3,2 soil mixture.

Part II: Preparing the Pots and Planting

1. Fill the pots to an inch below the rim with 7,3,2 soil mixture and wet it down thoroughly. Peat is very hard to get moist if it is dry and moist soil is needed for the seeds to germinate.

2. Plant one to two plants into the pots. Use your first and middle fingers to poke out the holes in the middle of the pot. Seeds should be planted at a half an inch deep.

3. After planting the seeds, go back and water the pot thoroughly. Beans are very sensitive to water logged soil so this will be the only watering for the next three days.

Part III: Care of the New Plant

1. Two to three applications of a complete nutrient solution (N, P, K, and Ca, Zn, Bo, Mg, and Mo) is needed throughout the growing season.

2. Bean plants do not react well to the water-logged soil or insufficient water. So a regular watering program must be developed to suit the needs of your particular growth chamber.

3. Splashing the leaves of the bean plants must be avoided when watering the plants because this helps to spread pathogens.

Part IV: Temperature Considerations

1. The optimum daytime temperatures should be between 20-25^{o}C ideally and the night temperatures should be around 5^{o}C cooler than that.

   a. Temperatures below 15^{o}C cause the plant to fail to grow and to flower abnormally. The results are poor and small flowers for cross-pollination.

   b. Temperatures above 30^{o}C can result in poor growth and reproduction. The high temperatures and photoperiod can react together and produce very spindly plants. If this is mixed with moisture stress the plants can lose their flowers and pods are aborted.

Part V: Disease and Pests

1. It is extremely important that the bean plants are both disease and pest free.

   a. Different chemicals should be used periodically to prevent resistance to a chemical. Because the leaves are very sensitive, high concentrations of pesticides should not be used.

   b. Pests that may be troublesome are the following: White fly, Spider mites, Aphids and Leaf miner.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #13--PLANT PROPAGATION FROM SEED

Name___________________________________ Score ___________________________________

Materials needed

Flat
Soil mix: peat moss, sand, soil
Newspaper
Row marker
Variety of seed
Thermostatic heating pad (optional)
"Six-pack" containers

Introduction

Many plants can be propagated dependably by vegetative means such as cuttings or tissue culture, and the results can be satisfactory. So why do we use seed so often to plant our crops and gardens? Properly managed, the results we get from planting seed can be extremely reliable, resulting in very uniform crops. However, the most important reasons we depend so much on seed is convenience and low cost.

Convenience in planting, transportation and storage

Whether planting in small or large quantities, seed is very easy to handle and manage because of its small size and uniformity of shape. This is particularly important in large field plantings, where seeds are planted mechanically. Not only is the seed Nature's device for reproduction of plants, but it is a natural "package" for the transportation and storage of living plant material. Imagine the difficulties which would occur if a seed company had to ship living plants instead of seed for large scale food production! Over-wintering, storage and transportation of seed is extremely convenient compared to the alternatives. Seed should always be stored at cool temperatures (the refrigerator is fine) and at low humidity (make it a frost free refrigerator).

Largely because of the factors described above and the low amount of labor required to handle it, seed is a relatively low-cost method of propagating plants.

Part I: Properly Prepare and Seed a Flat

1. Place a single sheet of newspaper in the bottom of the flat.

2. Fill the flat with soil mix. The soil mix should be sterilized (steamed or fumigated) The mix should contain 1/3 peat moss, 1/3 number 2 sharp sand, and 1/3 soil (fine sandy loam). Soil should have a low to medium pH, suitable for seeds (usually the peat moss provides a slightly acid pH in which most seeds germinate well). Soil should have a uniform texture, free of clods. Soil must drain well, but hold sufficient moisture for germination. Fungicide coated seeds will resist damping-off disease.

   Germinating seedlings are very susceptible to attack by fungus (damping-off disease), and may require protection by the use of fungicide. The best strategy to avoid damping-off is to work only with clean tools and equipment, sterile growing medium, sterile container and clean seed.

3. Level the flat leaving about a half inch space between the soil and the top of the flat. Tamp the flat lightly.

4. Seed can be broadcasted evenly over the flat or planted in rows. Seed planted too densely will result in spindly seedlings. Most seed should be covered with a thin layer of growing medium, vermiculite or a sheet of newspaper. This will help retain moisture around the seeds and allow watering without dislodging the seed. Certain types of seed will not germinate well without light, and should not be covered. If planting in rows, mark out the rows using a row marker. Plant the seeds in rows and cover with vermiculite or soil not more than two times the size of the seed.

5. Water gently. After watering initially, the flat will probably need only occasional watering until germination. Should the medium covering the seeds dry out, water lightly until the flat drains.

6. As a general rule, seed germinates best at temperatures between 70o and 80oF. This temperature can be maintained by the use of a thermostatic heating pad.

7. Prepare the label and place it in the flat. It is important to label properly because it is difficult to identify plants in the seedling stage. Most people want to know the flower color of the plants they are buying. Without proper labeling, you won't know until it blooms.

   Information for side 1 of the label: Date planted, plant name and variety.
   Information for side 2 of the label (optional): Dates of fertilization, pesticide application, etc.

Part II: Factors Causing Poor Seed Germination

1. Old seed: Seed should be fresh and should have been stored under cool, dry conditions. Seed loses viability as it gets older.

2. Uneven moisture: Seed must have a constant supply of moisture as it swells and germinates. Germinating seedlings are very susceptible to drying out as they have no root system to supply moisture.

3. Temperatures are too low or too high: Temperature requirements vary by species, but 70-80^{o}F is generally a good range for germinating seed. In the field, seed will not germinate if planted too early in the season when night temperatures are too low.

4. Fungus: Damping-off organisms such as Rhizoctonia directly attack germinating seedlings. Plants are at the most susceptible stage of their life cycle when germinating, and must be provided a clean environment or protected from such attack during this period.

5. Improper planting depth: Seed planted too deep will not have enough stored energy to emerge. Seed planted too shallow will dry out. These are concerns mainly when germinating seed in the field.

Part III: Seedling Care

After germination, seedlings require careful care, as they are very tender and susceptible to damage, drying and disease.

1. Watering: Seedlings must have a constant supply of moisture until roots have a chance to develop.

2. Fertility: Fertilization should be at low levels until plants are well established.

3. Light: Bright light will keep seedlings from becoming spindly.

4. Temperature: In the greenhouse, seedlings should be grown at temperatures 5^{o} to $10^{o}F$ lower than germination. This will prevent too-tall, spindly growth.

Part IV: Transplanting

1. Maturity: Seedlings can generally be transplanted after their first true leaves develop fully. Seedlings to be planted directly in the field should be considerably more mature.

2. Hardening off: Seedlings require a "hardening" process before transplanting. This involves gradually reducing day and night-time growing temperatures, and reducing the frequency of watering.

3. Handling: When transplanting, handle seedlings only by their leaves, preferably the seed leaves. Do not hold seedlings by the stem, which is susceptible to damage, particularly in small or tender seedlings.

4. Most seedlings can be planted deep. Tall or spindly seedlings, especially, should be planted deeply so they can stand upright.

5. Throw away seedlings which are damaged or exhibit poor root development.

6. Group larger, more vigorous seedlings together in the same flat.

7. Watering transplants: This is the most critical point in the transplanting process. Plants should be double watered after transplanting to insure solid contact of the roots with moist growing media. Watering should be done immediately after transplanting.

8. Soil fertility: Withhold high levels of fertilizer from transplants until they are solidly re-established.

Transplant seedlings into "six-pack" containers for later transfer to the field or larger containers.

Part V: Care of Young Plants

1. Light: Young plants must be protected from light intensities high enough to cause sunburn.

2. Water: Adequate moisture should be provided without over-watering. Over-watering and waterlogging are common causes of root rot and slow growth in young stock.

3. Soil fertility: Fertilizer levels can be increased as plants grow, moving from higher levels of phosphorus and potassium to a higher nitrogen level as transplants become established.

4. Temperature: Young transplants are generally tender, and require protection against extreme temperatures, especially cold.

5. Protection: Young transplants usually need a protective environment in which to become established. A shade structure of some kind will provide protection against drying winds, excessive sun and cold temperatures.

6. Pests and diseases: Young plants are quite susceptible to pest and disease problems. While pesticides can be used to combat such problems, it is a better strategy to prevent pest and disease problems to begin with by careful cultural practices. If a disease does take hold, it is often better

to cull the diseased material and cut losses at an early stage, rather than devoting excessive resources (time, money, etc.) to fighting an "uphill battle".

Care for the transplanted seedlings until maturity. Transplant them into larger containers as necessary, market them or have students take them home.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

LABORATORY EXERCISE #14--PRODUCE ROOTED CUTTINGS

Name____ Score_________________________________

Introduction

Since herbaceous plants are easily propagated, you can use coleus, Impatiens or Creeping Charlies to produce rooted cuttings in less than one week.

Materials needed

3 inch coleus cuttings (or other herbaceous plants)
Soil mix: peat, perlite, sand
One gallon can
Plastic bag

Part I: Procedure

1. Take ten 3 inch coleus cuttings (remove lower 1/2 to 1/3 of leaves).

2. Put soil mix of 1/3 peat, 1/3 perlite and 1/3 sand in a one gallon can.

3. Using a dibble, or your finger, make a hole and insert the cutting; press soil back around cutting so it does not dry out. Do not bury the leaves.

4. Water the cuttings with about one pint of water.

5. Cover with plastic bag and place the can where it receives a great deal of indirect light.

6. The coleus or herbaceous cuttings should root in about 3-10 days.

7. If you use soft wood cuttings, it is recommended that you use a rooting compound (for example: Hormodin). They will take 2 weeks to a month usually to root.

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

ANSWERS TO LABORATORY EXERCISES

Lab #1

Part I:

Diagram: Power 100X; 430-450X

a. Appear like stacked boxes.
b. No
c. Yes
d. No
e. They may be filled with water.
f. No, they are closely joined.
g. No

Part II:

a. Rectangular
b. Yes
c. Grey
d. The individual structures become more distinct
e. Yellow in color
f. Yellow to brown
g. No
h. Yes
i. Different parts of the cell are in focus as the body tube is raised and lowered.

Diagram: Power 430X

Part III:

a. Empty cell walls
b. The cork units were not alive - no cytoplasm.
c. To help in the examination of cell structures.
d. Nucleus contains the chromosomes (will not be evident).

Lab #2

Part II:

Layer	Labeled sketch of cell parts observed	Results of starch test	Cell part	Function
Residue	Students may sketch large pieces of cell walls and fibers	Negative	Fibers	Strengthen the cell walls
1 (top)	Students may sketch cell wall fragments and mitochondria	Negative	Cell wall	Protects the cell
2	Students should sketch chloroplasts	Negative	Chloroplast	Manufactures food for the plant
3	Students should sketch nuclei	Negative	Nucleus	Directs the cells' activities
4 (bottom)	Students should sketch leucoplasts	Positive	Leucoplast	Stores starch

2. The presence of starch indicates that the cell part functions to store food.

3. Cell membranes, endoplasmic reticulum, Golgi apparatus, mitochondria, microtubules, microfilaments, ribosomes and nucleoli remained unobservable. They were broken apart or are too small to see with compound microscope.

4. Cell wall fragments; chloroplasts; nuclei; leucoplasts. The cell parts settle according to their density after being centrifuged. Least dense materials are at the top.

Lab #3

Part I:

a. The inner layers
b. Most likely
c. Yes
d. No
e. No
f. They are carried along in the circulating cytoplasm.

Part II:

a. It appears to be thinner and less rigid.
b. Plasma membrane
c. Broad and flat
d. Cheek cells tend to be less uniform in shape because of the plasma membrane, rather than the rigid surface of the cell wall.
e. It makes cell structures more distinct.
f. Grainy and dotted

Part III:

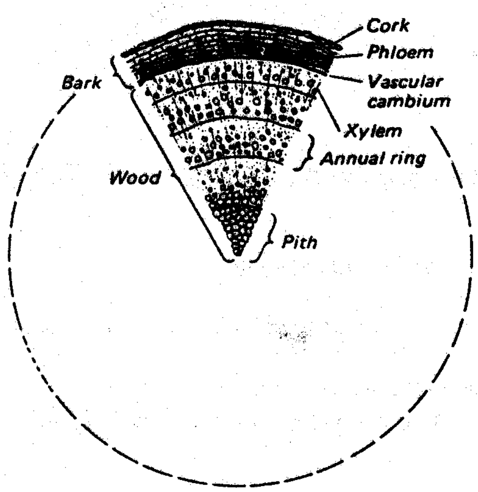
a. Elodea cells have rigid cell walls and chloroplasts. Cheek cells have thin cell membranes.
b. Production of food
c. They contain the pigment chlorophyll.
d. Cell membrane
e. No, they are animal cells.
f. Yes. They are both made up of structural units called cells.

Lab #4:

Part I:

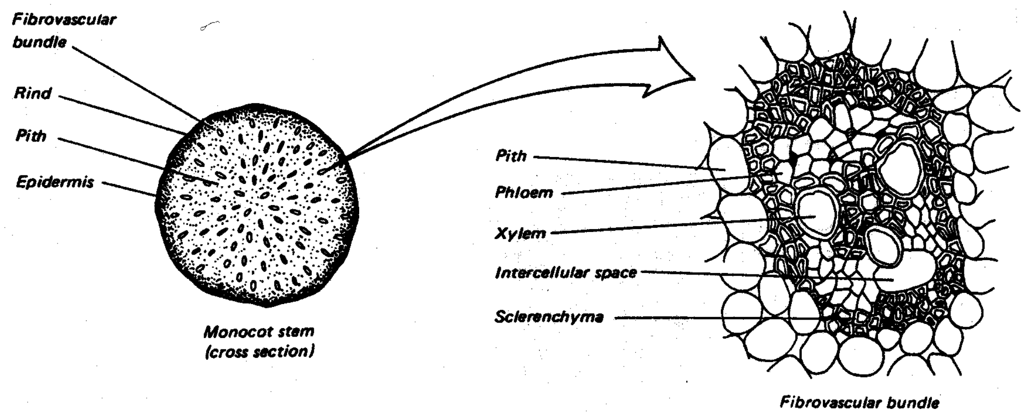
a. On the outside of the stem.
b. To the inside of the bark.
c. Pith
d. Bark, wood and pith.
e. Cork resists the passage of water and gases from stem tissues, offers protection against disease and provides insulation.
f. Phloem
g. To conduct food materials up and down the stem.
h. The vascular cambium.
i. The cells of the cambium divide to produce phloem cells and xylem cells.
j. Xylem
k. Answer will vary depending on the age of the stem.
l. The wood is produced in rings. Each ring represents a year's growth.
m. Annual rings.
n. No
o. Environmental factors affect the amount of wood produced each season by the cambium.
p. Conduction and support.

	Location	Function
1. Outer covering	bark	prevents gas and water loss, protection
2. Arrangement of vascular tissue	concentric rings	- - - - - - - - - - -
3. Location of phloem	inner bark	conduction of food materials up and down stem, some support
4. Location of xylem	interior, woody portion of stem	conduction of water and minerals, support
5. Location of vascular cambium	between xylem and phloem	divides to form new phloem and xylem cells
6. Location of pith	center of stem	storage



Part II:

a. The cells are thick walled.
b. Pith
c. Thin-walled, large cells.
d. Answers will vary.
e. Toward the outside of the stem.
f. The bundles toward the outside give strength to the stem.
g. No
h. Monocots can grow in diameter only until their cells have reached a maximum size.
i. Support
j. The cells surrounding the space have their own cell walls.
k. As the bundle matures, the cells that were once in contact are pulled apart from each other.



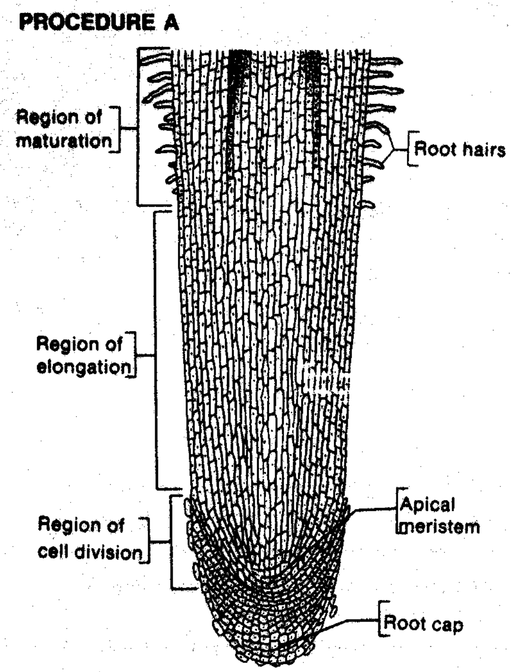
Summary:

Characteristic	Dicot	Monocot
1. Herbaceous or woody	herbaceous and woody	herbaceous
2. Type of vascular tissue present	xylem and phloem	xylem and phloem
3. Arrangement of vascular tissue	concentric rings	scattered bundles
4. Presence of vascular cambium	present	not present
5. Location of pith	center of stem	most areas of stem
6. Means of support	primarily woody tissue	rind, and distribution of vascular bundles
7. Probable life duration of stem	herbaceous-a single growing season; woody-many years	with exceptions, only one growing season

Lab #5

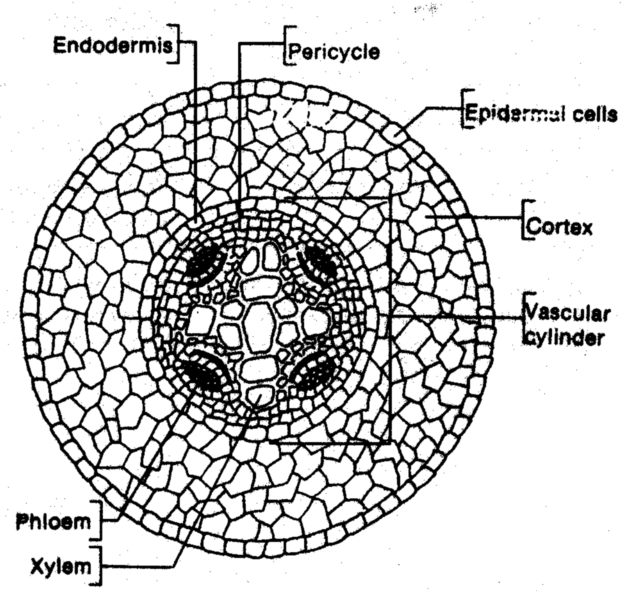
Part I:

Step 2:



a. Root tip

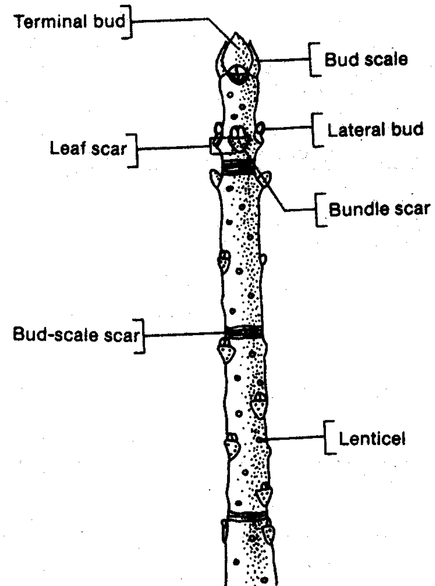
Step 3:



b. Root cross section

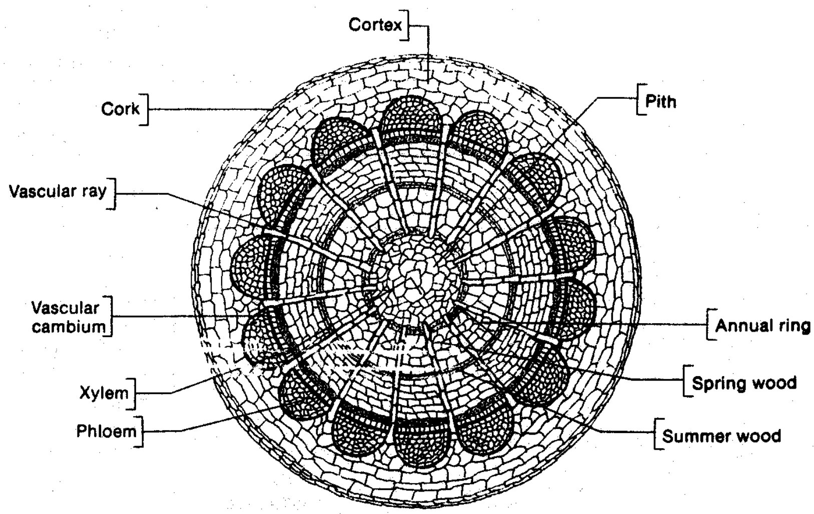
Part II:

Step 1:



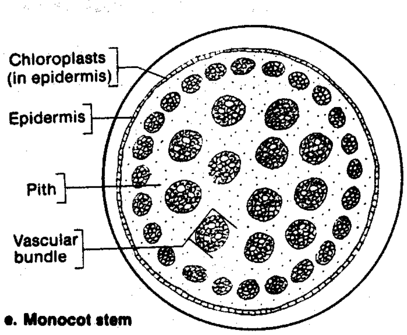
c. Twig

Step 3:

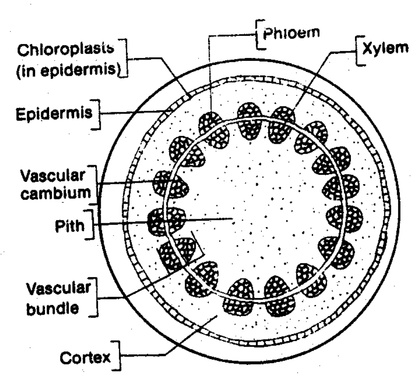


d. Woody stem cross section

Step 4:



e. Monocot stem



f. Dicot stem

Part III:

Table: Structures of roots and stems

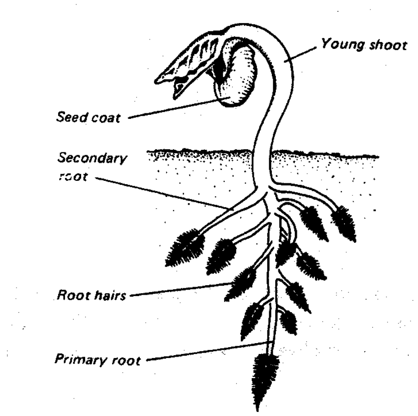
Tissues	Present in:				Function
	Root	Woody dicot stem	Herbaceous monocot stem	Herbaceous dicot stem	
Root cap	✓				Protects growing root tip.
Meristem	✓	✓	✓	✓	Dividing cells for growth.
Root hairs	✓				Increase surface area; aid absorption.
Epidermal cells	✓		✓	✓	Protect inner tissues.
Cortex	✓	✓	✓	✓	Stores food (starch); provides support.
Endodermis	✓				Controls entrance of substances into vascular tissues.
Pericycle	✓				Gives rise to root branches.
Phloem	✓	✓	✓	✓	Transports materials between leaves and roots; provides support.
Xylem	✓	✓	✓	✓	Transports water from roots to leaves; provides support.
Bud scales		✓			Protect growing shoot.
Lenticels		✓			Allows for exchange of gases for woody stem.
Cork		✓			Protects inner tissues.
Vascular rays		✓			Transport substances laterally in woody stem.
Vascular cambium	May not be notice-able	✓		May not be noticeable	Allows for growth in girth.
Annual rings		✓			[redacted]
Chloroplasts			✓	✓	Make food for plant.

2. Meristem contributes to growth; cortex stores food and provides support; phloem transports materials between leaves and roots and provides support; xylem transports water from roots to leaves and provides support.
3. Students may mention the root cap, endodermis or pericycle as unique root structures. Unique stem structures include bud scales, lenticels, cork or vascular cambium of woody stems or the chloroplasts of herbaceous stems.
4. Root hairs are cells that have differentiated; thus, they only appear in the region of maturation. Their location indicates that growth occurs in the tip.
5. Wood formed in the spring is lighter in color than wood formed in the summer. The bands of different colored wood form a ring each year.
6. Monocot has scattered vascular bundles; dicot has bundles in a ring. Structure and arrangement of bundles in dicots allows more than one season of growth.
7. The scar would remain at 2 m because growth in the stem occurs at the tip.

Lab #6

Part I:

a. It appears white and is long and tapering. Delicate strands project from the upper portion.
b. From the upper regions of the root
c. The root hairs are located a short distance from the tip of the root and appear as many numerous hairs.
d. They absorb water and increase the absorptive surface of the root.
e. The developing root supplies the developing shoot with necessary water and minerals.

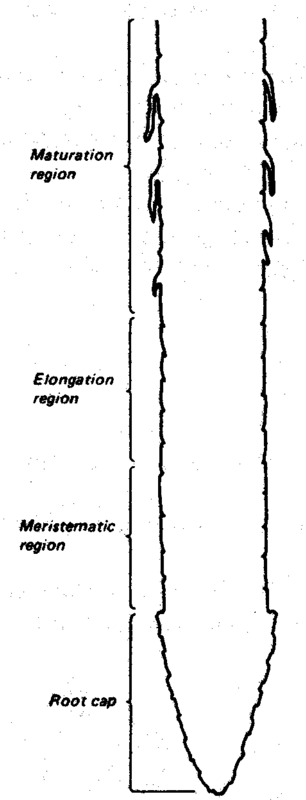


Bean seedling

Part II:

a. No
b. They appear cellular, but are actually long projections from a single epidermal cell.
c. Epidermal cells
d. Water is absorbed by osmosis.
e. Probably not
f. Being delicate structures, they were probably lost in the process of making the slide preparation.
g. It protects the meristematic region where new root cells are being produced.
h. New cells are formed from the meristematic region to replace the cells that are worn off.
i. Meristematic region
j. Production of new root cells by mitosis.
k. Without new cells, the root could not grow.
l. They lengthen.
m. Elongation region

n. As the cells elongate, the root grows and is pushed through the soil.
o. Cells are produced at different rates by the meristematic region and, therefore, elongate and mature at different rates.
p. Maturation region



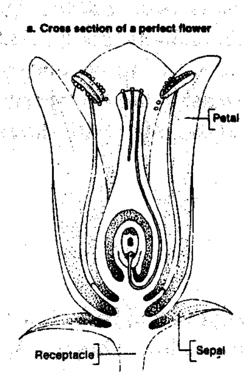
Part III:

a. New cells produced by the meristematic region become pushed back to where they elongate. The process of elongation serves to push the root tip through the soil whereupon growth in length is achieved. Following elongation, the cells mature into tissues dependent on their location in the root tip.
b. 1
c. 3
d. 5
e. 4
f. 2

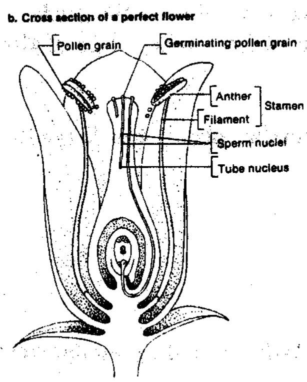
Lab #7

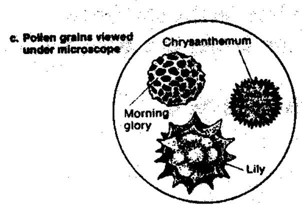
Part I:

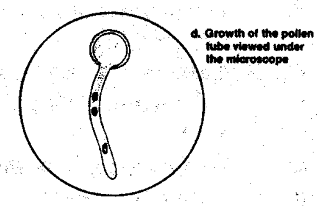
(a) **Answers will vary with sample.**
(b) **They are the same.**



Part II:

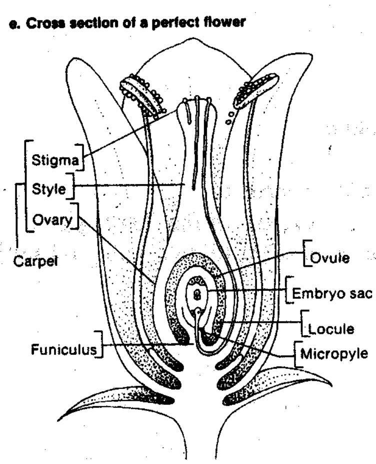


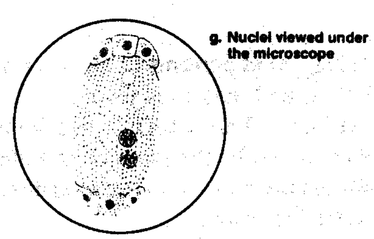




(c) **The pollen tube begins to grow and at the tip is the tube nucleus. Behind the tube nucleus are the two sperm cells moving down the tube.**

Part III:





Part IV:

1. The pollen grains.
2. The embryo sac.
3. The sticky surface of the stigma is located at the tip of the carpel to collect pollen.
4. Pollen grains, released from the anthers, are carried to the stigma. A germinating pollen grain sends a pollen tube through the carpel to the embryo sac. When the tube nucleus reaches the embryo sac, the tube opens releasing the two sperm nuclei into the embryo sac. One sperm nucleus unites with the egg and the other with the two polar nuclei.

<u>Lab #8</u>

Part I:

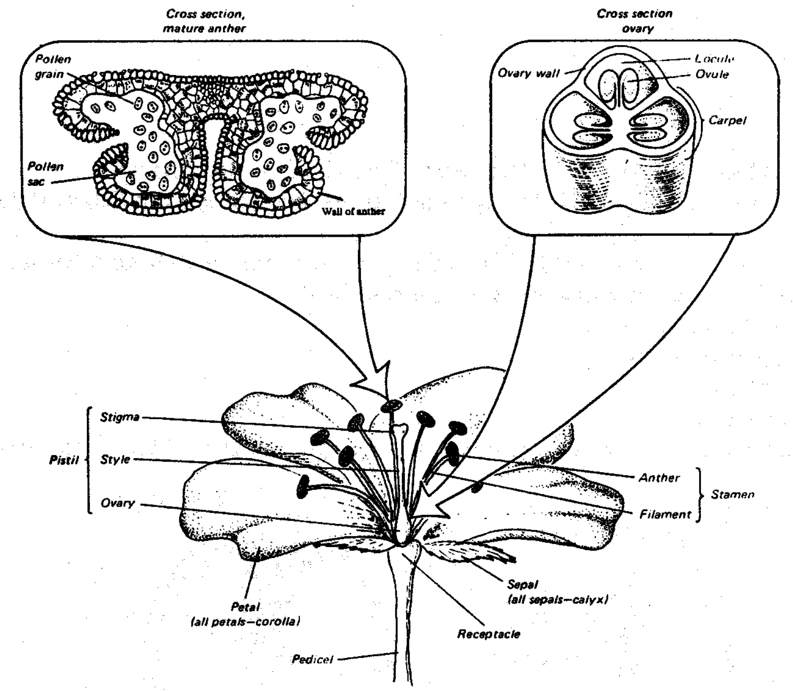
a. The sepals may be green or colored and be 3, 4 or 5 in number.
b. The petals may be white or have color. They are 3, 4 or 5 multiples thereof depending on the specimen used.
c. These parts are necessary to carry out reproductive processes and form the seeds.
d. The number of stamens should be equal to or a multiple of the number of parts already observed.
e. Answers will vary depending on the specimen.
f. If the number plan is 3, the flower is a monocot; if the number plan is 4 or 5, the flower is a dicot.
g. To hold the pollen which lands on it
h. The future seeds

Part II:

a. The stamen consists of several long, saclike structures which may have granular structures or pollen grains adhering to them.
b. They may have a smooth surface or have a textured surface.
c. Usually four
d. The pollen sacs rupture, releasing the mature pollen grains.
e. Some will land on the stigma of the female organ, most will be wasted as it is carried away by wind currents, etc.

Part III:

a. To elevate it to wind currents or insects carrying pollen
b. Small, white, round masses of tissue.
c. Answers will vary: Three, four or five depending on the specimen.
d. The number should be the same as or a multiple of the number of the flower parts.
e. This allows the pollen tube to grow through the tissues of the pistil to accomplish fertilization of the egg within the ovule.



The parts of a flower

Part IV:

a. To deliver a sperm cell nucleus to the egg contained within the ovule so that fertilization may take place.
b. Stigma, style and ovary wall.
c. The ovule
d. One fertilizes the egg, the other fertilizes the polar nuclei.

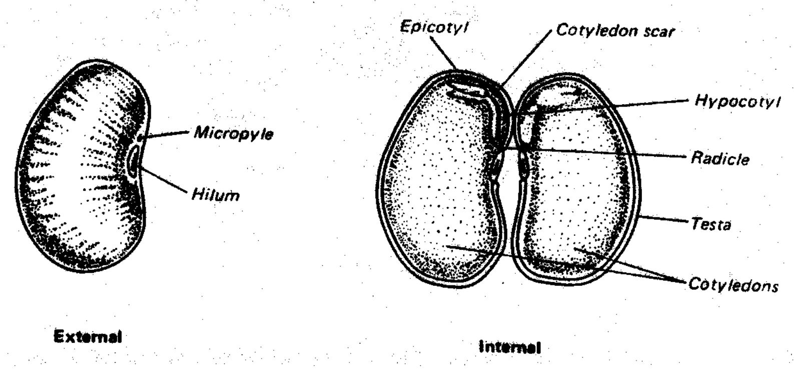
Part V:

Floral Part	Function
sepal	protects the young and delicate flower parts in bud stage; supports other flower parts
petal	attracts insects for pollination; protects inner flower parts
filament	supports and elevates the anther to wind currents; supplies nutrients to anther
anther	produces pollen grains which contain the male gametes
stigma	the uppermost part of the pistil provides a sticky surface on which pollen lands and adheres
style	supports and elevates the stigma to wind carrying pollen or to receive pollen from the anther
ovary	contains the egg-producing ovule which, when fertilized, becomes the embryonic plant; develops into the fruit

Lab #9

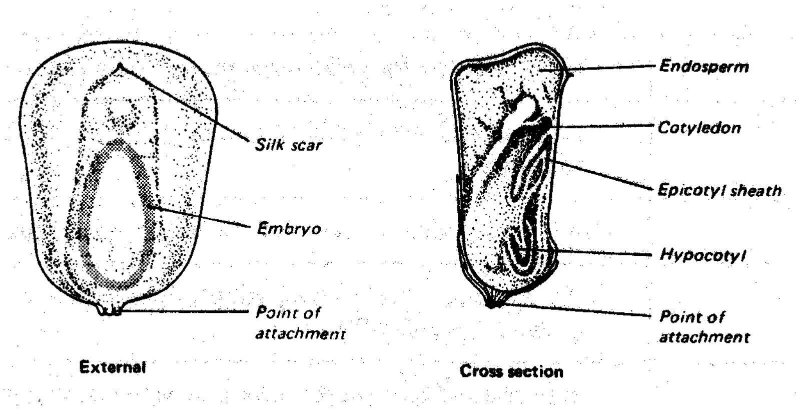
Part I:

a. The point where the seed was attached to the wall of the pod (ovary).
b. It is the opening in the ovule through which the pollen tube grew to deliver the sperm cell to the egg.
c. Yes. They must first be fertilized and then receive nourishment from the parent plant.
d. The seed has expanded and the seed coat is wrinkled.
e. Water has been absorbed.
f. The cotyledons are fleshy.
g. Food storage.
h. The cotyledons.
i. The starch will be digested by enzymes to supply glucose as food for the growing plant.



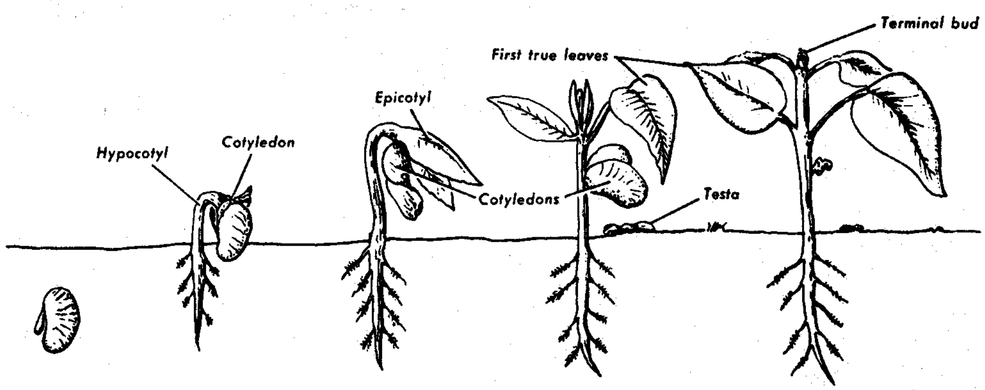
Part II:

a. A group of flowers. Each grain of corn contains a seed which is surrounded by a seed coat, the ovary wall of an individual flower.
b. It marks the point where the silk was attached to the ovule.
c. 250. For each corn grain to have matured, there must have been a silk through which the tube cell grew to accomplish fertilization.
d. Yes. They are present but not plainly visible since they are covered by a three-layered fruit coat. They are located within the point of attachment
e. Purple or blue-black.
f. Starch.



Part III:

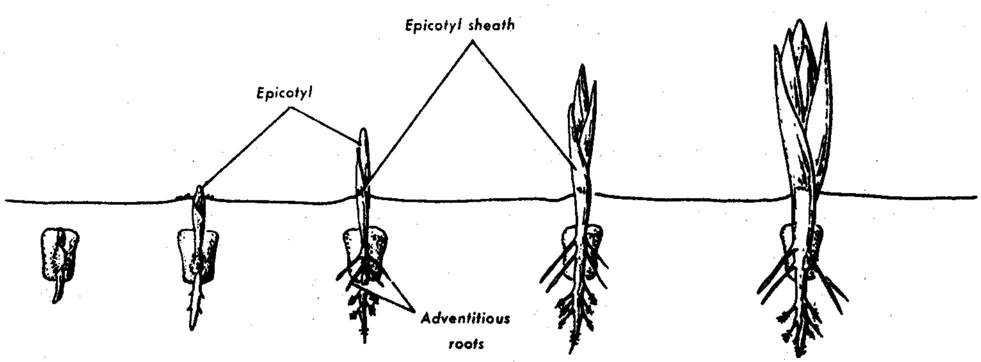
a. The radicle (root).
b. Further development of the radicle into the primary root serves to establish a means of absorbing water.
c. It is arched or bent over.
d. It would serve to break the soil and prevent damage to the delicate leaves of the epicotyl.
e. They are attached to the hypocotyl.
f. As the plant becomes photosynthetically independent, they wither and fall off.



Steps in the germination of a bean seed

Corn Grain:

a. The shoot is growing upward and the somewhat longer root is growing downward.
b. The shoot exhibits negative geotropism and the root positive geotropism.
c. They protect the meristematic regions as growth occurs.
d. It disintegrates.



Steps in the germination of a corn seed

Part IV:

a. epicotyl
b. primary root
c. cotyledons

d. hilum
e. endosperm
f. micropyle
g. epicotyl sheath
h. point of attachment

Lab #10

Part I:

a. Roots, stems and leaves
b. A vegetative organ performs all the processes necessary for life except the formation of seeds.
c. The root system is highly branched and is lacking any color.
d. The root system is highly branched and spreading.
e. Absorption of water and minerals, conduction of water and minerals to other plant parts, food storage
f. Leaves
g. Produce and display leaves to light
h. Green
i. Chlorophyll
j. Photosynthesis
k. They are carried in the stem.
l. They are carried in the stem.
m. Conduction
n. Green
o. Photosynthesis

Part II:

a. Where growth occurs in the leaves and stem

b. The squares on the leaf will change shape indicating that growth has occurred. The markings on the stem will become further apart indicating growth has taken place in that region of the stem.

c. No

Answers will vary on the chart

d. Growth should proceed more rapidly during the first half of the growth period and then slow down.

e. Answers will vary

f. No

g. The squares formed by the lines on the leaf have changed shape. This indicates that the leaf grew more from the center regions of the leaf.

h. At the sides of the shoot apex

i. The area is approximately the same.

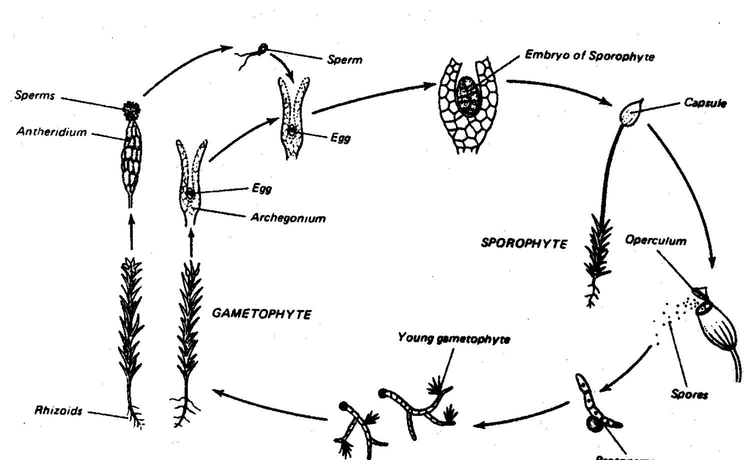
Part III:

a. Generally, the three curves will follow the same pattern. As the stem length increases, more leaves are produced and the total surface area of the leaves will also increase.
b. Roots
c. Leaves
d. Roots
e. Stems
f. Roots and stems
g. Leaves
h. Roots
i. Stems
j. Stems
k. Stems
l. Leaves

<u>Lab #11</u>

Part I:

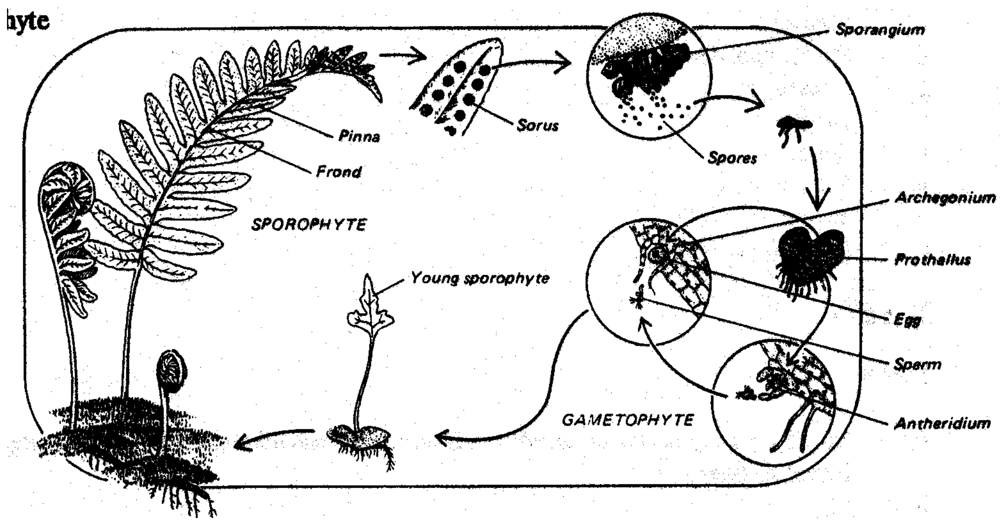
a. The leaves are arranged in whorls around the axis allowing the greatest possible exposure of leaves to light.
b. egg
c. sperm
d. It is a saclike structure supported on a short stalk.
e. It is bottle-shaped and consists of a slender neck and a swollen base.
f. It swims to the egg.
g. An abundant supply of moisture is necessary for the sperm to swim to the egg.
h. zygote
i. within the archegonium
j. In this generation, a moss plant produces spores.
k. zygote
l. Fertilization may not have been accomplished in all gametophytes containing an archegonium.
m. When mature, it lacks chlorophyll and it is structurally attached to the gametophyte.
n. The union of an egg and sperm produced by gametophyte plants gives rise to a zygote which develops into a spore-producing plant. Spores produced by the sporophyte germinate and grow into a new gametophyte and the cycle is repeated.



Life cycle of a moss plant

Part II:

a. The fern sporophyte is much larger and grows independently of the gametophyte.
b. the capsule of the moss sporophyte
c. Answers will vary depending on the species of fern being used.
d. The sperms swim to the egg in a film of water.
e. It is flat and grows close to the soil, and its size requires that only small amounts of moisture be present for fertilization.
f. the sporophyte



Part III:

a. Reproduction is dependent on the production of egg and sperm in the gametophyte plant. These form the zygote upon fertilization. The zygote develops into the sporophyte. The spores produced by both plants germinate and develop into gametophytes. There is no seed production.

b.

	Mosses	Ferns
1. Produces eggs	archegonium	archegonium
2. Produces sperm	antheridium	antheridium
3. Sporophyte independent (Yes/No)	No	Yes
4. Structure producing spores	capsule	sporangium
5. Spores germinate into:	protonema	prothallus
6. Inconspicuous generation	sporophyte	gametophyte
7. Conspicuous generation	gametophyte	sporophyte
8. Medium for fertilization	water	water
9. Agent for spore dispersal	wind	wind
10. First cell of sporophyte	zygote	zygote
11. First cell of gametophyte	spore	spore
12. General habitat	damp, shaded environments	damp, shaded environments

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

UNIT TEST

Name___________________________________ Score___________________________________

1. Match terms associated with plant growth and development to the correct definitions. Write the correct numbers in the blanks.

_____a.	Union of the male (pollen) nucleus with the female (egg) cell	1.	Node
		2.	Internode
_____b.	Plant having two seed leaves	3.	Bud
_____c.	The part of a stem between two nodes	4.	Leaf scar
_____d.	Vascular tissue that transports water and minerals from the root system to the leaves	5.	Vascular bundle scar
_____e.	The embryonic root	6.	Monocot
_____f.	Seed bearing organ of a flower; composed of ovary, style and stigma	7.	Dicot
_____g.	Plant having one seed leaf	8.	Vascular bundle
_____h.	The part of a stem where a leaf is attached	9.	Xylem
_____i.	An embryonic shoot of a plant	10.	Phloem
_____j.	The part of the embryo above the cotyledons and below the next leaves	11.	Pistil
		12.	Stamen
_____k.	A scar left on the stem when a leaf falls	13.	Fertilization
_____l.	Transfer of pollen from the anther to the stigma	14.	Pollination
_____m.	The young plantlet within the seed	15.	Embryo
_____n.	The part of an embryo between the cotyledons and the radicle	16.	Radicle
_____o.	Part of the flower which produces the pollen; composed of the filament and anther	17.	Hypocotyl
		18.	Epicotyl
_____p.	A strand of tissue containing xylem and phloem enclosed by a sheath of cells		
_____q.	A spot within a leaf scar left by the vascular bundles when a leaf falls		

_____r. Vascular tissue that conducts food from the leaves to regions of growth or storage

2. Name the three stages of plant growth and development.

   a. ____________________

   b. ____________________

   c. ____________________

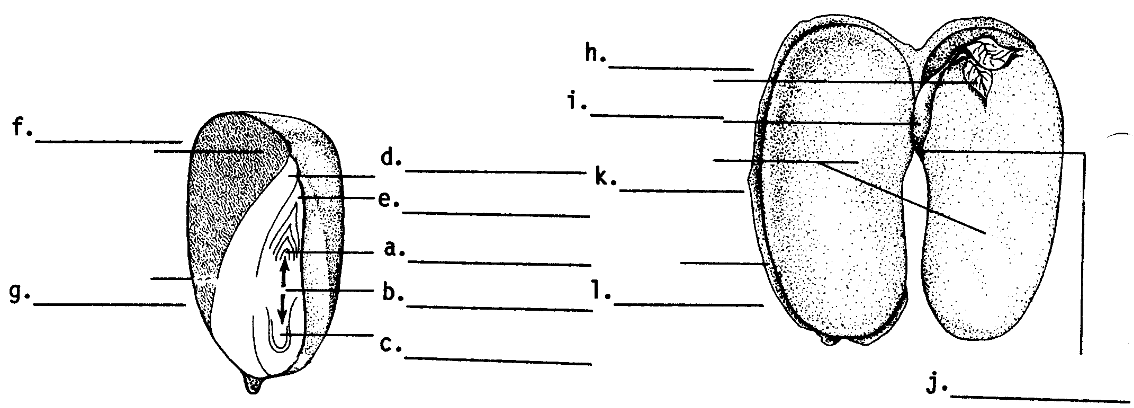
3. Name three requirements for good seed germination.

   a. ____________________

   b. ____________________

   c. ____________________

4. Label the parts of a monocot and a dicot seed. Write the correct names in the blanks.



5. Arrange in order the stages of germination. Write a "1" before the first step, a "2" before the second step, and so on.

Monocot

_____a. The coleoptile emerges

_____b. The epicotyl elongates, the coleoptile piercing the soil as it grows upward

_____c. Absorption of water and oxygen into seed

_____d. The coleoptile unfolds

_____e. The seed coat ruptures and the radicle begins to grow downward

Dicot

_____a. The seed coat ruptures and the radicle begins to grow downward

_____b. Emergence of seedling

_____c. The hypocotyl pulls the cotyledons toward the soil surface

_____d. The cotyledons spread apart and the stem tip is exposed to air and sunlight

_____e. Absorption of water and oxygen into seed

6. Select from the following list factors that cause poor seed germination. Write an "X" in the blank before each correct answer.

_____a. Number of seeds per pound

_____b. Seeds planted too deeply in soil

_____c. Presence of hardpan in root zone

_____d. Fungal disease

_____e. Low soil temperature

_____f. Low soil moisture

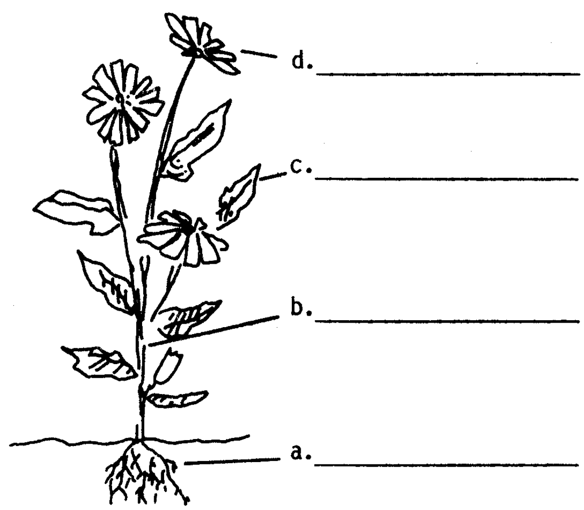
_____g. Damaged seed

_____h. Deficiency of nutrients in soil

_____i. Period of time between harvesting and planting of seed

_____j. Conditions under which seed is stored

7. Label the primary parts of a plant. Write the correct names in the blanks.



8. Match the primary plant part to its correct function. Write the correct numbers in the blanks.

_____a. Absorb water and nutrients; anchor and support the plant; site of food storage in carrots

_____b. Site of photosynthesis; necessary for transpiration; site of food storage in lettuce

_____c. Support leaves and flowers; conduct water, nutrients and food; site of food storage in potatoes

_____d. Site of reproduction; site of food storage in apples

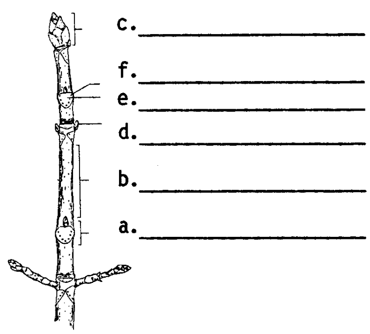
1. Roots
2. Stems
3. Leaves
4. Flowers

9. Name two types of root systems.

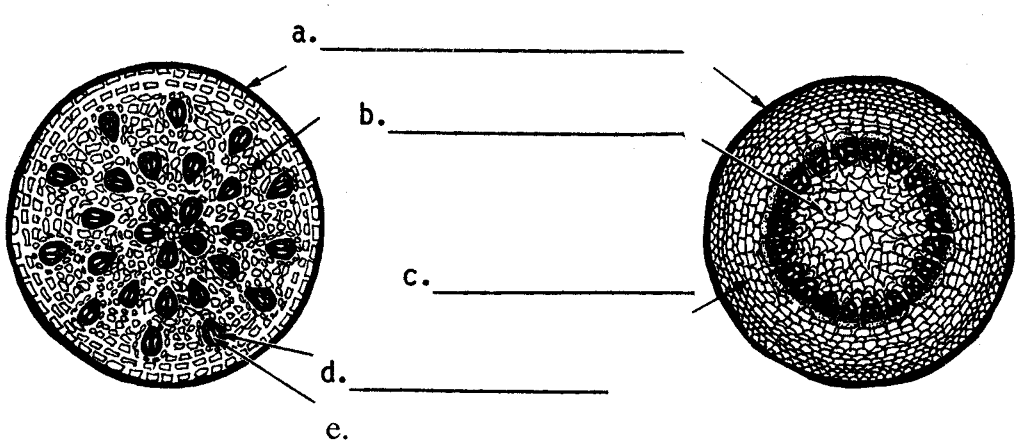
a. ____________________

b. ____________________

10. Label the parts of a stem. Write the correct names in the blanks.



11. Label the tissues in a monocot and dicot stem. Write the correct names in the blanks.



12. Match the stem modification with the correct description. Write the correct numbers in the blanks.

_____a.	Enlarged fleshy part found at the tip of a rhizome; potato	1.	Crown
		2.	Stolon
_____b.	Appears laterally on branches of fruit trees and bears fruit; apple	3.	Spur
_____c.	Short disc-shaped stem surrounded by leaf-like scales; onion	4.	Rhizome
		5.	Tuber
_____d.	Fleshy, short underground stem with very few buds; gladiolus	6.	Corm
_____e.	Runners that grow along top of soil surface; strawberry	7.	Bulb
_____f.	Underground stems that grow horizontally below soil surface; quackgrass		
_____g.	Appears just above or just below ground level from which modified stems grow; wheat		

13. Select from the following list conditions affecting the vegetative growth of crop plants. Write an "X" in the blank before each correct answer.

_____a. Soil fertility

_____b. Amount of erosion

_____c. Depth seed is planted

_____d. Amount of rainfall

_____e. Presence of weeds

_____f. Soil moisture

_____g. Crop being produced

_____h. Presence of insects

_____i. Soil compaction

_____j. Presence of disease

14. Name the three vegetative growth stages of small grains.

a. ____

b. ____

c. ____

15. Name the four vegetative growth stages of corn.

a. ____

b. ____

c. ____

d. ____

16. Describe sexual reproduction in plants.

____

____

____

____

17. Describe asexual reproduction in plants.

____

____

____

____

18. Arrange in order the life cycle of a flowering plant. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Pollination

_____b. Flower formation

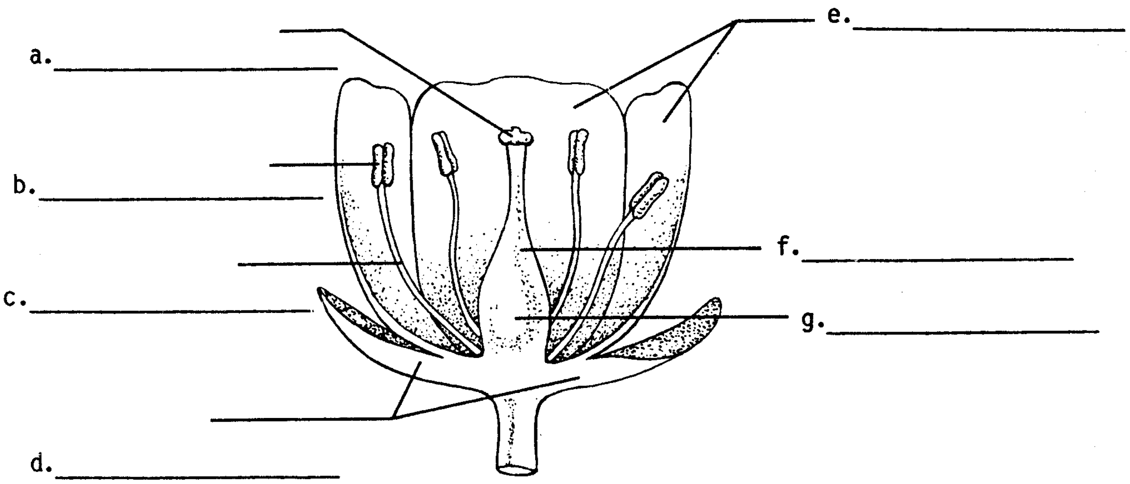
_____c. Seed germination and seedling growth

_____d. Fertilization

_____e. Seed development

_____f. Vegetative growth

19. Label the parts of a complete flower. Write the correct names in the blanks.



20. Match the type of flower to the correct description. Write the correct numbers in the blanks.

_____a. Has only male flower parts

_____b. Has stamens and pistils, but no petals or sepals; common to monocots

_____c. Staminate and pistillate flowers found on the same plant; corn

_____d. Has both stamens and pistils on the same flower

_____e. Has only female flower parts

_____f. Staminate and pistillate flowers found on separate plants; spinach

_____g. Has stamens, pistils, petals and sepals on the same flower; common to dicots

_____h. Has either stamens or pistils, but not both on the same flower

1. Complete
2. Incomplete
3. Perfect
4. Imperfect
5. Staminate
6. Pistillate
7. Monoecious
8. Dioecious

21. Match the types of pollination to the correct description. Write the correct numbers in the blanks.

_____a. Transfer of pollen from the anthers to the stigma of the same flower on the same plant

_____b. Transfer of pollen from the anthers of one plant to the stigmas of another plant

1. Self-pollination
2. Cross-pollination

22. Name three ways pollen is moved.

a. ______________________________

b. ______________________________

c. ______________________________

23. Explain the process of fertilization in plants.

____

____

____

____

____

____

____

____

____

24. Define the two basic types of plant tissue.

a. Meristem ______________________________

____

____

____

b. Permanent ______________________________

____

____

____

25. Identify the types of meristematic and permanent tissues. Write the correct name of the tissue in the blank.

______________________ a. Constitutes the majority of wood; principal conductor of water and dissolved minerals

______________________ b. Account for girth and growth of woody stems; composed of cellulose and pectin; provide mechanical support for plant

______________________ c. Found in the tops of the shoots; responsible for producing new buds and leaves in a uniform pattern at the end of the stem and laterally along stems

______________________ d. Elongated cells with unevenly thickened primary walls; gives support to young stems, petioles and leaf veins

______________________ e. Bark of maturing stems, tree trunks and potato skins; cell walls are waterproofed with suberin (waxy material); die soon, but retain shape

______________________ f. Active tissues that have been separated from the shoot terminal meristem by regions of more mature or developed tissue; found near the nodes of grasses; reason for continuous growth after mowing grasses

______________________ g. Thick-walled cells; common in stems and bark; found as stone cells in pear fruits and walnut shells; nonliving when mature

______________________ h. Single, exterior layer of cells that protects stems, leaves, flowers and roots; outside surface of epidermal cells usually covered with cutin

______________________ i. Main conducting tissue for dissolved food material; basically composed of cells called sieve elements arranged into sieve tubes

______________________ j. Growing points for the root system; found at the various ends of the roots

______________________ k. Living, thin-walled cells with large vacuoles and many flattened sides; most common and abundant plant tissue making up the fleshy part of the organism and functioning in food and water

PLANT ANATOMY, GROWTH AND DEVELOPMENT

AG 510 - F

ANSWERS TO TEST

1.

a.	13	f.	11	k.	4	p.	8		
b.	7	g.	6	l.	14	q.	5		
c.	2	h.	1	m.	15	r.	10		
d.	9	i.	3	n.	17				
e.	16	j.	18	o.	12				

2. Seed germination and seedling growth; Vegetative; Reproduction

3. Proper temperature; Sufficient moisture; Ample supply of oxygen

4.

a.	Epicotyl	g.	Seed coat
b.	Hypocotyl	h.	Epicotyl
c.	Radicle	i.	Hypocotyl
d.	Cotyledon	j.	Radicle
e.	Coleoptile	k.	Cotyledons
f.	Endosperm	l.	Seed coat

5. (in order) Monocot: 4, 3, 1, 5, 2

   (in order) Dicot: 2, 4, 3, 5, 1

6. b, d, e, f, g, i, j

7.

a.	Roots	c.	Leaves
b.	Stem	d.	Flowers

8. a. 1 b. 3 c. 2 d. 4

9. Tap root system; Fibrous root system

10.

a.	Node	d.	Lateral bud
b.	Internode	e.	Leaf scar
c.	Terminal bud	f.	Vascular bundle scar

11.

a.	Epidermis	c.	Cortex
b.	Pith	d.	Phloem
		e.	Xylem

12.

a.	5	d.	6	g.	1
b.	3	e.	2		
c.	7	f.	4		

13. a, b, d, e, f, g, h, i, j

14. Tillering; Jointing; Boot

15. Two-leaf stage; Six-leaf stage; Ten-leaf stage; Fourteen-leaf stage

16. Sexual: Reproduction by seed: Involves the combination of two different sets of genes to create offspring with a new genetic makeup; Often the most efficient and economical method for reproducing annual bedding plants and some biennials and perennials; The function of the seed is to produce a new plant; A seed is produced by the combination of nuclear material in the process of fertilization; Results in zygote formation

17. Asexual: Reproduction by vegetative propagation; Uses plant parts such as leaves, roots and stems to start new plants; No new genetic material introduced--the offspring will be identical to parents; Methods include cuttings, layering, separation, division, grafting

18. a . 4 b. 3 c. 1 d. 5 e. 6 f. 2

19.

a.	Stigma	e.	Petal
b.	Anther	f.	Style
c.	Filament	g.	Ovary
d.	Sepal		

20.

a.	5	e.	6
b.	2	f.	8
c.	7	g.	1
d.	3	h.	4

21. a. 1 b. 2

22. Answer should contain three of the following:

Gravity; Wind; Insects; Birds; Man

23. After a pollen grain alights on the surface of the stigma, it forms a pollen tube. The pollen tube grows down the style to the ovary. It penetrates the ovary and the male cell unites with the ovule. This is called fertilization, the union of the male and female cells. The result is a zygote. Cell division takes place and the zygote becomes the embryo of the seed

24. Meristem (meristematic tissue): Comprised of actively dividing cells that develop and differentiate into other tissues and organs; Cells have thin walls and dense protoplast
Permanent: Develops from the meristems; Non-dividing differentiated cells

25.

a.	Xylem	g.	Schlerenchyma tissue
b.	Lateral meristems	h.	Epidermis tissue
c.	Shoot meristems	i.	Phloem
d.	Collenchyma tissue	j.	Root meristems
e.	Cork tissue	k.	Parenchyma tissue
f.	Intercalary meristems		

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

UNIT OBJECTIVE

After completion of this unit, students should be able to match terms and definitions and identify the parts of a leaf, flower and stem. Students should also be able to classify plants and identify common crop and weed plants. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with the identification of plants and weed pests to the correct definitions.
2. Discuss the importance of plant identification.
3. Select reasons plant identification cannot be made easily.
4. Arrange in order the binomial system of plant classification.
5. Name three classifications of plants by life cycle.
6. Name three classifications of plants by difficulty of control.
7. Label a drawing showing the parts of a simple leaf.
8. Label a drawing showing the parts of a compound leaf.
9. Identify two types of compound leaves.
10. Identify three types of leaf arrangements.
11. Identify the four types of leaf veination.
12. Identify three types of leaf margins.
13. Identify four types of leaf attachment to the stem.
14. Label a drawing showing the parts of a stem.
15. Label a drawing showing the parts of a complete flower.
16. Identify four types of inflorescence.
17. Select the correct plant family when given the common name of a plant.
18. Name three natural resources crops and weeds are in competition for.
19. Name three losses caused by weeds.

20. Select ways that weeds spread.

21. Match the general categories of weed control to the correct description.

22. Select methods of cultural weed control.

23. Select methods of mechanical weed control.

24. Match the classifications of herbicides to the correct description.

25. Discuss biological weed control.

26. Describe the conditions necessary to obtain effective biological control.

27. Discuss the advantages of biological control.

28. Discuss four limitations of biological control.

29. Identify weed seeds as either prohibitive noxious or restricted noxious.

30. Examine the structure of leaves.

31. Study the relationship of leaf structure to function.

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Crop Plants*, 80-page manual, color photos and descriptions; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801; approximate cost $12.00.

b. *Weed Plants*, 80-page manual, color photos and descriptions; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801; approximate cost $12.00.

c. *Weeds,* instructional unit; available from Agri-Farm Publications, Inc., 1019 Market Street, Gowrie, Iowa 50543; approximate cost $17.50; order no. 209.

2. Filmstrips, slideshows, etc.

a. *Agricultural Weed Identification*, 40 slides; available from VEP, Cal Poly State University, San Luis Obispo, California 93407; approximate cost $25.25.

b. *An Aid to Identifying 70 Crop and Weed Plants*, slides, script and manual; available from Ohio Agricultural Education Curriculum Materials Center, Ohio State University, Columbus, Ohio 43210; approximate cost $23.00; order no. 1005M, 1006S.

c. *Crop Seed Identification*, 105 slides and cassette, 28 minutes; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $41.60; order no. D1.

d. *Fundamentals of Plant Identification*, slides and manual; available from Ohio Agricultural Education Curriculum Materials Center, Ohio State University, Columbus, Ohio 43210; approximate cost $8.50; order no. 1008M, 1009S.

e. *Identification of Weed Seedling - Broadleaf*, filmstrip or slide set; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801; 2 parts.

f. *Identification of Weed Seedling - Grasses*, filmstrip or slide set; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801.

g. *Plant and Seed Identification*, slide set or video; available from Department of Agricultural Education, University of Idaho, Moscow, Idaho 83843, (208-885-6358).

h. *Seedling Identification of Legume Plants,* 24 slides and cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $31.20; order no. D6.

i. *Weed Identification*, filmstrip or slide set; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland Dr., Urbana, Illinois 61801.

j. *Weeds and Weed Seed Identification*, 29 slides and cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $120.64; order no. D2.

k. *Weed Seed Identification* Kit, 30 weed seeds in plastic holders on 3" x 5" cards; available from IAVIM, 208 Davidson Hall, Iowa State University, Ames, Iowa 50011; approximate cost $12.50; order no. 450.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information sheet and laboratory exercises.

E. Discuss information sheet and laboratory exercises.

F. Demonstrate procedures outlined in laboratory exercises.

G. Invite county weed supervisor to speak on noxious weed laws, identification and control.

H. Tour county with students, parents, etc. to determine the status of noxious and common weeds in your locality.

I. Have a weed collection and identification contest. Have students collect pressed samples of weeds, identify them and submit to the instructor. The student with the largest number of different weed/crop specimens wins. Save the collected samples for future classroom use.

J. Invite a county agent, seed specialist or other qualified person to speak to class on economics of weeds and weed control.

K. Assign students or let them select an agronomic crop, identify problem weeds for that crop, and develop a weed control plan to use.

L. Review and give test.

M. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Binomial System of Plant Classification
2. TM 2--Winter Annuals
3. TM 3--Summer Annuals
4. TM 4--Biennials
5. TM 5--Perennials
6. TM 6--Parts of a Simple Leaf
7. TM 7--Parts of a Compound Leaf
8. TM 8--Types of Compound Leaves
9. TM 9--Types of Leaf Arrangement
10. TM 10--Types of Leaf Veination
11. TM 11--Types of Leaf Margins
12. TM 12--Types of Leaf Attachment
13. TM 13--Parts of the Stem
14. TM 14--Parts of a Complete Flower
15. TM 15--Types of Inflorescence
16. TM 16--Types of Inflorescence (continued)

E. Instructor notes for laboratory exercises

F. Laboratory exercises

1. LE 1--Examining the Structure of Leaves
2. LE 2--Relationship of Leaf Structure to Function

G. Answers to laboratory exercises

H. Test

I. Answers to test

III. Unit references

A. Anderson, W.P., *Weed Science: Principles*, 2nd edition, West Publishing Co., St. Paul, Minnesota, 1983.

B. Baysinger, O.K. and Lee, G.A., *1979 Survey of Exotic Noxious Weeds in Idaho*, University of Idaho, Agricultural Experiment Station, Moscow, Idaho.

C. Callihan, R., *"Plant Science 338: Weed Control*", Class notes, Fall 1984, University of Idaho, Moscow, Idaho.

D. *Chemical Weed Control*, Ag II: Unit VI, Oklahoma State Board for Vocational Technical Education, Stillwater, Oklahoma.

E. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

F. Courson, R.L., *Controlling Weeds*, University of Illinois at Urbana, Vocational Agriculture Service, Champaign, Illinois.

G. Delorit, R.J., et al., *Crop Production*, 4th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

H. Erickson, L.C., *How to Know the Weeds of Idaho*, University of Idaho, Moscow, Idaho.

I. Gaines, X.M. and Swan, D.B., *Weeds of Eastern Washington and Adjacent Areas*, C.W. Hill Printers, Camp-Na-Bor-Lee Association, Inc., Spokane, Washington, 1972.

J. Harrington, H.D. and Durrell, L.W., *How to Identify Plants*, Swallow Press Books and Ohio State University, Athens, Ohio, 1981.

K. Hartmann, Hudson T., et al., Plant Science - *Growth, Development, and Utilization of Cultivated Plants*, 5th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

L. Hughes, H.A., *Crop Chemicals*, 2nd edition, John Deere Technical Services, Moline, Illinois, 1982.

M. *Idaho FFA Association State Contest Rules and Regulations*, University of Idaho, Moscow, Idaho 83843, 1989.

N. Naskali, R., "Biology 203: *General Botany*", Class notes, Fall 1983, University of Idaho, Moscow, Idaho.

O. *Weed Control*, Vo-Ag II, Unit IV-E, Teaching Materials Center, Agriculture Education Department, Texas A & M University, College Station, Texas.

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

INFORMATION SHEET

I. Terms and definitions

A. Weed--Any plant that interferes with human affairs

B. Noxious weed--Any plant which is determined by a state agency to be injurious to public health, crops, livestock, land or other property

C. Shrub--A woody perennial plant smaller than a tree and usually with several basal stems

D. Herb--A plant with no persistent woody stem above ground

E. Vine--A plant that climbs on some support, the stem cannot stand upright by itself

F. Tree--A perennial woody plant of considerable stature at maturity with a main trunk

G. Rosette--A dense, basal cluster of leaves arranged in a circular fashion like the leaves of the common dandelion

H. Prostrate--Lying flat on the ground

I. Evergreen--Bearing green leaves throughout the year

J. Deciduous--Plants that shed their leaves annually

K. Alternate--Not opposite, one leaf at a node

L. Opposite--Leaves two at a node and situated across the stem from each other

M. Simple leaf--Of only one part; leaf not completely divided into separate segments

N. Compound leaf--A leaf completely separated into two or more leaflets

O. Midrib--The main or central rib of a leaf

P. Vein--Threads of vascular tissue in a leaf

Q. Blade--The expanded, usually flat portion of a leaf or petal

R. Petiole--The stalk of a leaf blade or compound leaf

S. Pinnate--Compound leaf with the leaflets on opposite sides

T. Internode--The part of a stem between two nodes

U. Node--The place on a stem where one or more leaves are attached

II. Importance of plant identification

A. To recognize a problem, to seek a solution, to diagnose a condition

B. To be able to talk or write about the plant

(Note: When an object must be designated again and again, then some sort of name becomes a real need.)

C. To be able to look up information about the plant

(Note: Questions may arise like the following: Is the plant palatable to animals? Is it a weed and if so, can it be controlled? Is it poisonous to man? These questions and many others may be answered very completely in various publications. However, all this information is ordinarily unavailable if the name of the plant is unknown.)

III. Plant identification cannot be made easily

A. There is a special procedure involved

B. Technical descriptive terms must be mastered

C. Constant practice is necessary

D. Microscopic detail is often necessary

IV. The binomial system of plant classification (Transparency 1)

(Note: Several hundred thousand species of plants exist in the world. Botanists have chosen to organize, classify and group plants according to what they think has been their evolutionary development, with related plants near and unrelated plants far apart.)

A. Division--A group of related classes

B. Class--A group of related orders

C. Order--A group of related families

D. Family--A group of related genera

E. Genus--A group of related species

F. Species--The plants of one kind

Example:

CORN

Category	Name	Description
Division	Anthophyta	Vascular plants with seeds and flowers; ovules enclosed in an ovary; pollination indirect; the angiosperms
Class	Monocotyledonae	Embryo with one cotyledon; flower parts usually in threes; many scattered vascular bundles in stem
Order	Commelinales	Monocots with fibrous leaves; reduction and fusion in flower parts
Family	Poaceae	Hollow stemmed monocots with reduced greenish flowers; fruit a specialized achene; the grasses
Genus	Zea	Robust grasses with separate staminate and pistillate flower clusters
Species	Zea Mays	Corn

V. Classification of plants by life cycle (Transparencies 2, 3, 4, 5)

A. Annual--Completes life cycle within the period of one year

B. Biennial--Forms rosette in the first year and in the second year flowers, produces seed and dies

C. Perennial--Lives for three years or more and can reproduce sexually and asexually by means of rhizomes and stolons

VI. Classification of weeds by difficulty of control

A. Common weeds--More abundant and most easily controlled

B. Secondary noxious weeds--Intermediate to others

C. Primary noxious weeds--Very persistent and difficult to control; mostly perennials

VII. Parts of a simple leaf (Transparency 6)

A. Blade

B. Veins

C. Petiole

D. Stipules

VIII. Parts of a compound leaf (Transparency 7)

A. Leaflet

B. Veins

C. Petiolule

D. Rachis

E. Petiole

F. Stipules

IX. Types of compound leaves (Transparency 8)

A. Pinnate

B. Bipinnate

C. Palmate

D. Trifoliate

X. Types of leaf arrangement (Transparency 9)

A. Alternate

B. Opposite

C. Whorled

XI. Types of leaf veination (Transparency 10)

A. Parallel

B. Pinnate

C. Palmate

D. Netted

XII. Types of leaf margins (Transparency 11)

A. Entire--No teeth or lobes on margin

B. Serrate--Toothed with teeth directed forward

C. Incised--Toothed with sinuses deeper than teeth

D. Lobed--Margin cut in about one-half way to midrib; sinuses and tips of segments rounded

XIII. Types of leaf attachment to the stem (Transparency 12)

A. Petiolate--Leaf attached by a petiole

B. Sessile--Leaf without a petiole; blade attached to stem

C. Clasping--Sessile leaf with the lower edges of the blade partly surrounding the stem

D. Decurrent--Point of attachment extends downward on the stem

XIV. Parts of a stem (Transparency 13)

A. Node

B. Internode

C. Terminal bud

D. Lateral bud

E. Leaf scar

F. Vascular bundle scar

XV. Parts of a complete flower (Transparency 14)

A. Stamen--Male part of the flower producing the pollen

1. Anther--Bears the pollen

2. Filament--Supports the anther

B. Pistil--Female part of the flower producing the egg

1. Stigma--Upper part of pistil that catches pollen

2. Style--Supports stigma

3. Ovary--Produces ovules which develop into seeds

C. Accessory parts

1. Corolla--Petals of the flower

2. Calyx--Sepals of the flower

3. Pedicel--Stalk of an individual flower

XVI. Types of inflorescence (Transparencies 15, 16)

A. Spike--Flowers sessile along the main axis

B. Raceme--Flowers single on pedicels along the rachis

C. Panicle--Two or more flowers on each pedicel, arranged along rachis

D. Corymb--A raceme with lower pedicels elongated and rachis shortened

E. Umbel--Pedicel of each flower attaches to a common point

F. Compound umbel

G. Head--Dense cluster of flowers

H. Solitary--Flowers borne singly, not in clusters

XVII. Major plant families

A. Gramineae (grass family)

1. Wild oats
2. Annual bluegrass
3. Barnyard grass
4. Green foxtail
5. Foxtail barley
6. Quackgrass
7. Wheat
8. Corn
9. Barley
10. Oats

B. Compositae (sunflower family)

1. Bull thistle
2. Meadow salsify
3. Common yarrow
4. Common groundsel
5. Dandelion

6. Chicory
7. Canada thistle
8. Prickly lettuce
9. Annual sowthistle
10. Mayweed
11. Spotted knapweed

C. Chenopodiaceae (lambsquarter family)

1. Russian thistle
2. Kochia
3. Lambsquarter

D. Solanaceae (potato family)

1. Longleaf groundcherry
2. Hairy nightshade
3. Cutleaf nightshade
4. Potato
5. Tomato

E. Polygonaceae (buckwheat family)

1. Curly dock
2. Prostrate knotweed
3. Wild buckwheat
4. Rhubarb

F. Plantaginaceae (plantain family)

1. Buckhorn plantain
2. Broadleaf plantain

XVIII. Weed competition with crops

A. Competition for water

B. Competition for nutrients

C. Competition for light

(Note: Crops and weeds have the same basic requirements for normal growth and development. In a mixed community of crops and weeds, the more aggressive species will dominate.)

XIX. Losses caused by weeds

(Note: Losses from weeds exceed losses by any other agricultural pest. One estimate put the total loss from weeds in the U.S. at $15 billion per year, or $6000 per year per farm.)

A. Decreased crop yields

B. Decreased crop quality

C. Cost of control activities

XX. How weeds spread

A. Wind

B. Flowing water

C. Animals and manure

D. Impure seed

E. Farm machinery, cars, pickups and trucks

F. Earth moving equipment

G. Wild flower pickers

XXI. General categories of weed control

A. Prevention--Practices to prevent the establishment of specific weed species in areas not currently infested

(Note: An ounce of prevention is worth a pound of cure.)

B. Eradication--Complete elimination of a given weed species so that it will not reappear in a given area

C. Control--Practices where weed populations are kept at a level that does not seriously interfere with crop production or yield

XXII. Methods of cultural control

A. Weed-free crop seed--Planting only crop seeds that have been cleaned to remove weed seeds

B. Smother crops--Crops that are highly competitive with weed species for light, nutrients and water

(Note: Examples are small grains, grasses and alfalfa.)

C. Crop rotation--Prevent or reduce the build up of certain weeds common to a particular crop

XXIII. Methods of mechanical control

A. Hand pulling--Best adapted to small areas for control of annual and biennial weeds

B. Hoeing--Best adapted for small areas for control of annual, biennial and perennial weed seedlings

C. Mowing--Prevent seed production and restrict rank weed growth

D. Cultivation--Kill weeds by cutting off tops, burying or removing from soil

E. Mulching--Smother plants to cut off sunlight

F. Burning

XXIV. Classification of herbicides

A. Herbicide selectivity

1. Selective--Used to kill weeds without significant damage to crop

2. Non-selective--Kill all plants present if applied at an adequate rate

B. Mode of herbicide action

1. Contact--Kills only part of plant to which it is applied; not translocated

2. Systemic--Absorbed by roots or foliage and translocated throughout plant

C. Time of application

1. Preplant--Applied to soil before crop is planted

2. Preemergence--Applied prior to emergence but after crop planting

3. Postemergence--Applied after emergence of the crops or weeds

XXV. Biological weed control--Involves the introduction of a natural enemy to weaken or destroy a particular weed species; insects have achieved the most success, but microorganisms, parasitic plants, animals, birds and fish are also used. The goal is not eradication, but reduction of the weed population to an acceptable level

Example: Leafcutting beetles to control St. Johnswort

XXVI. Conditions necessary to obtain effective biological weed control

A. Insect or biotic agent must be specific to the weed that is to be controlled (or it may attack the crop species)

B. The weed must be abundant enough to provide sufficient food to maintain the insect or biotic agent

C. The insect or biotic agent must be free of natural enemies

XXVII. Advantages of biological weed control

A. Economical

B. Well adapted for use on low-value uncultivated land (pastures, woodland and rangeland) where mechanical control is uneconomical or impossible

C. Eliminates residue problems

D. More permanent than other methods

E. Does not require fossil fuel energy

XXVIII. Limitations of biological weed control

A. Not well suited to croplands because it can't respond quickly enough to check seasonal weed control before yield reduction occurs

B. Doesn't reduce the weed population to an acceptable level for the production of some crops

C. Not effective on a stand of mixed weed species

D. Not adapted for use on weeds that are closely related to crop plants

E. A plant considered to be a weed to some may be regarded as a valuable plant by others

Example: Downey brome is a problem in wheat, but provides spring grazing on ranches

XXIX. Plants of economic impact to Idaho

A. Crops

Alfalfa	Red Clover
Alsike Clover	Rye
Beans	Six Row Barley
Birdsfoot Trefoil	Smooth Brome Grass
Club Wheat	Strawberry Clover

Common Wheat
Crested Wheat Grass
Kentucky Bluegrass
Lentils
Oats
Orchard Grass
Peas
Potatoes
Sugarbeet
Sweet Clover
Tall Fescue
Tall Oatgrass
Timothy
Two Row Barley
White Clover

B. Weeds

Barnyard Grass
Black Medic (Yellow Trefoil)
Black Mustard
Broadleaf Plantain
Buckhorn Plantain
Bull Thistle
Burdock
Canada Thistle
Chicory
Cocklebur
Common Groundsel
Crab Grass
Curled Dock
Cutleaf Night Shade
Dalmation Toadflax
Death Camas
Diffuse Knapweed
Dodder
Mallow
Mayweed (Dog Fennel)
Meadow Salsify (Yellow Goatsbeard)
Medusahead
Musk Thistle
Nut Sedge (Yellow Nut Sedge)
Perennial Pepperweed
Poison Hemlock
Poverty Weed
Prickly Lettuce
Prostrate Knotweed
Puncture Vine
Purslane
Quackgrass
Red Root (erect) (Rough Pigweed)
Rush Skeletonweed

Downey Brome Grass

Dyers Woad

Field Bindweed
(Morning Glory)

Field Pennycress
(Fan Weed)

Foxtail Barley

Green Foxtail

Hairy Night Shade

Halogeton

Hoary Cress
(White Top)

Hounds Tongue

Kochia

Lambsquarter

Larkspur

Leafy Spurge

Longleaf Groundcherry

Russian Knapweed

Russian Thistle

St. Johnswort
(Goat Weed)

Scotch Thistle

Shepards Purse

Showy Milkweed

Silvery Lupine
(Lupine)

Sow Thistle

Spotted Knapweed

Teasel

Water Hemlock

Wild Buckwheat

Wild Oat

Yarrow

Yellow Starthistle

XXX. Prohibited noxious weed seeds

Syrian Beancaper

Field Bindweed

Buffalobur

Skeleton Leaf Bursage

Camelthorn

Wild Carrot

Hoary Cress

Common Crupina

Austrian Fieldcress

Goatgrass

Perennial Pepperweed

Poison-Hemlock

Puncturevine

Quackgrass

Tansy Ragwort

Rush Skeletonweed

Perennial Sowthistle

Leafy Spurge

Common St. Johnswort

Yellow Starthistle

Smooth Groundcherry	Swainsonpea
Black Henbane	Canada Thistle
Johnsongrass	Musk Thistle
Diffuse Knapweed	Scotch Thistle
Russian Knapweed	Dalmation Toadflax
Spotted Knapweed	Yellow Toadflax
Purple Lythrum	Dyers Woad
Silverleaf Nightshade	

XXXI. Restricted noxious weed seeds

A. Dodder

B. Halogeton

C. Blue Lettuce

D. Wild Oats

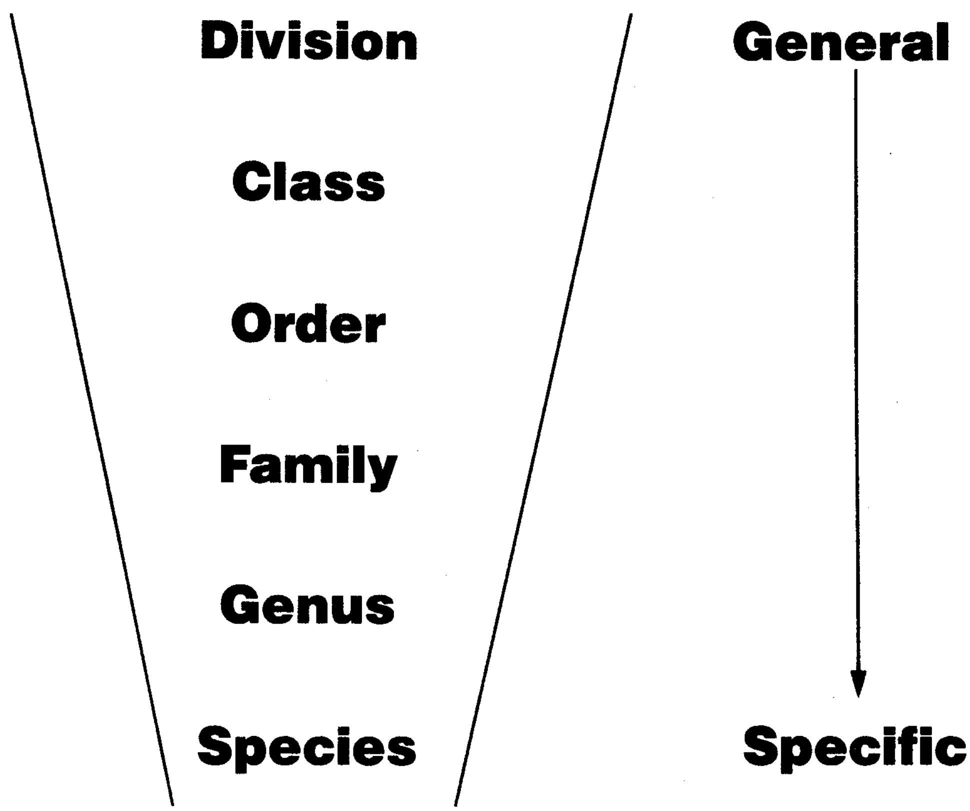
E. Buckhorn Plantain

F. Western and Perennial Ragweed

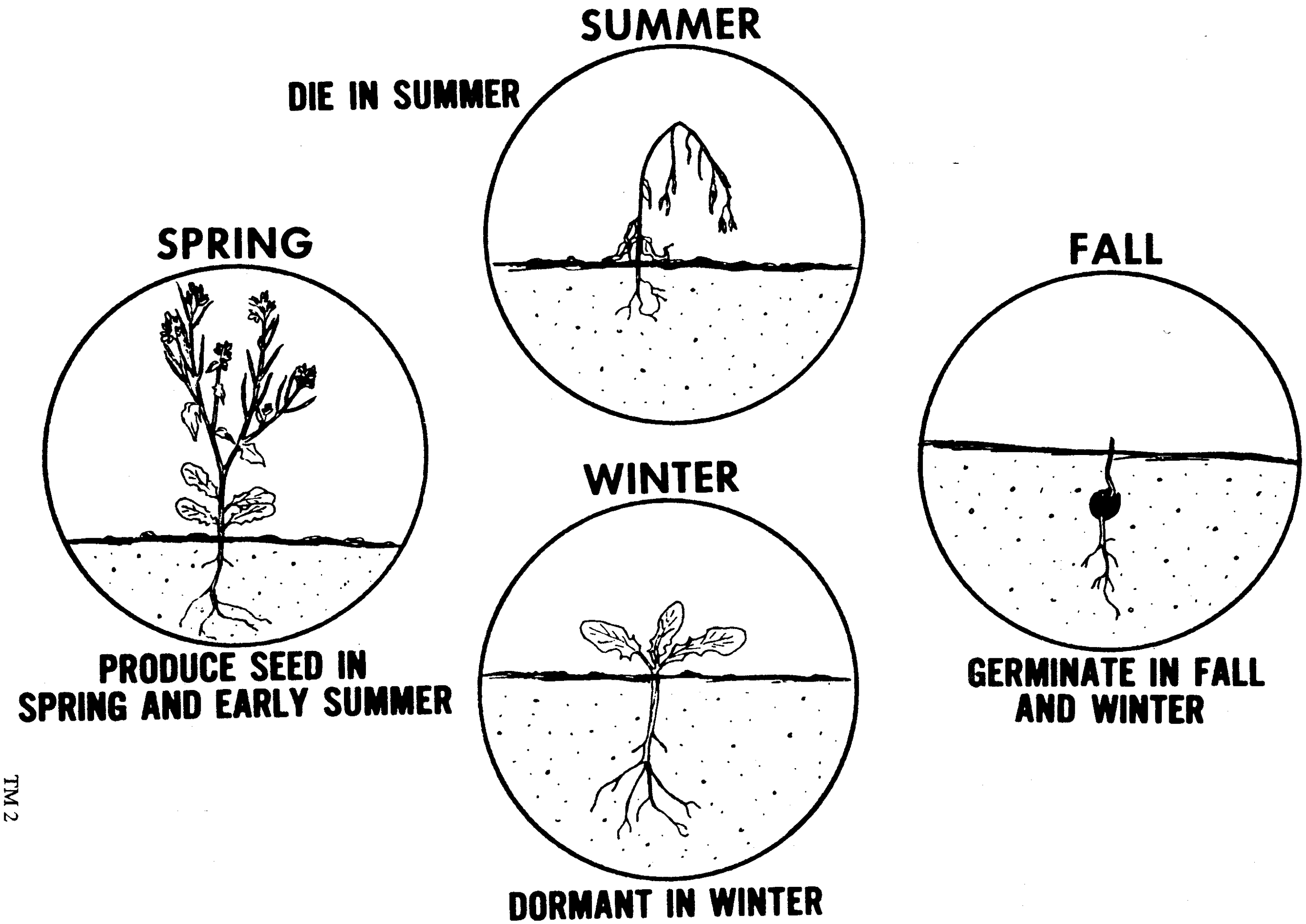
G. Medusahead Rye

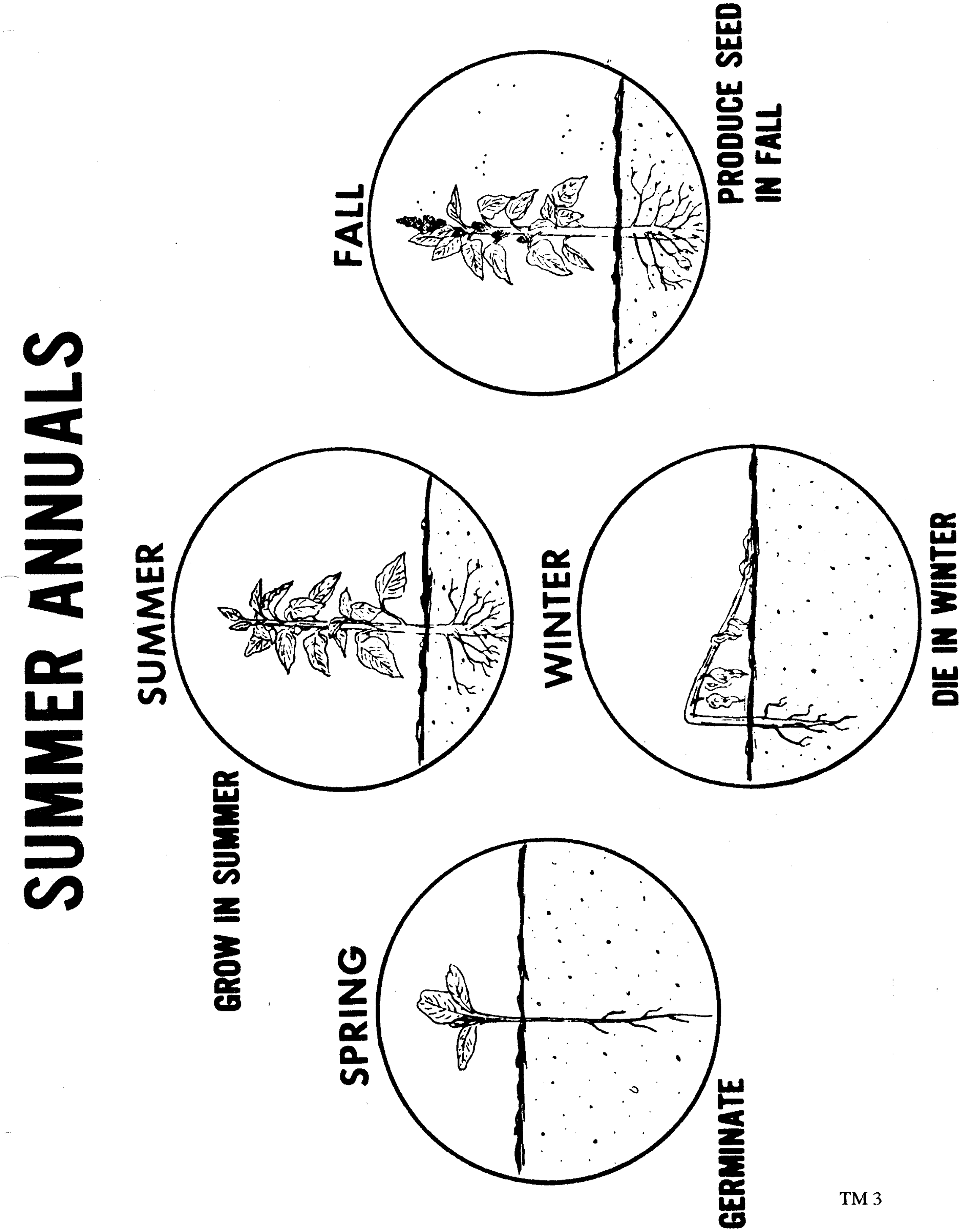
H. Poverty Sumpweed

Binomial System of Plant Classification

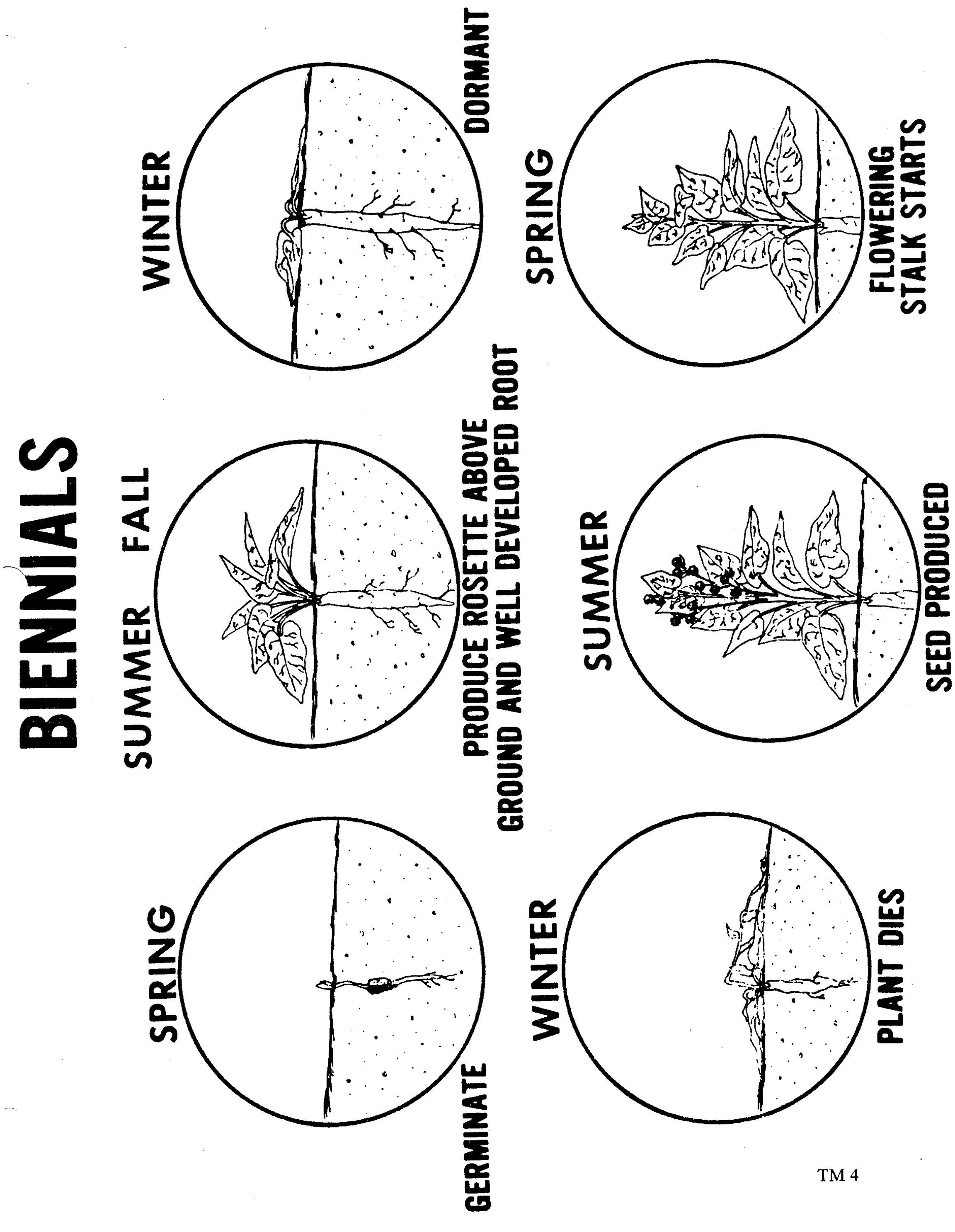


WINTER ANNUALS

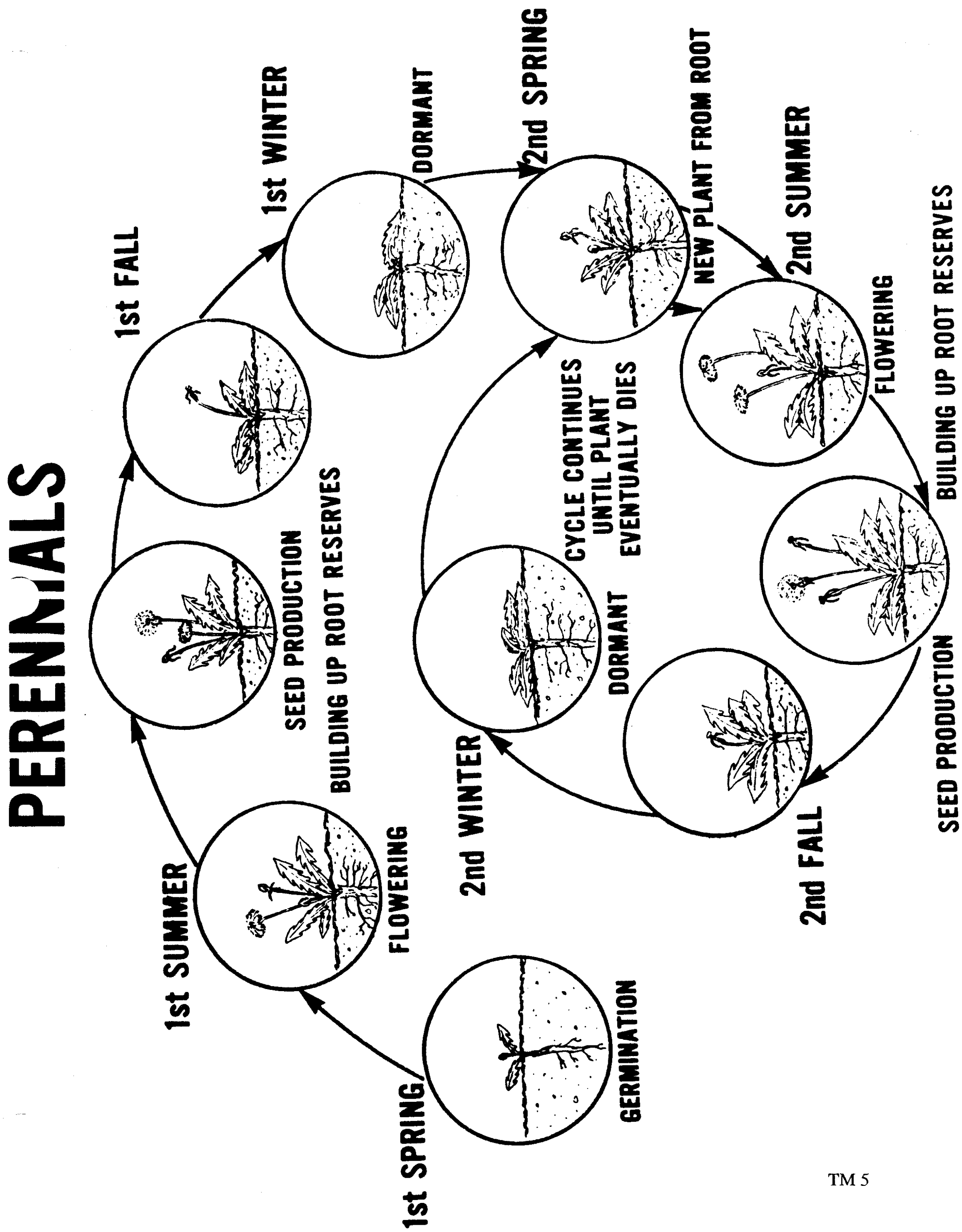



SUMMER ANNUALS
SPRING
GERMINATE
SUMMER
GROW IN SUMMER
FALL
PRODUCE SEED
IN FALL
WINTER
DIE IN WINTER

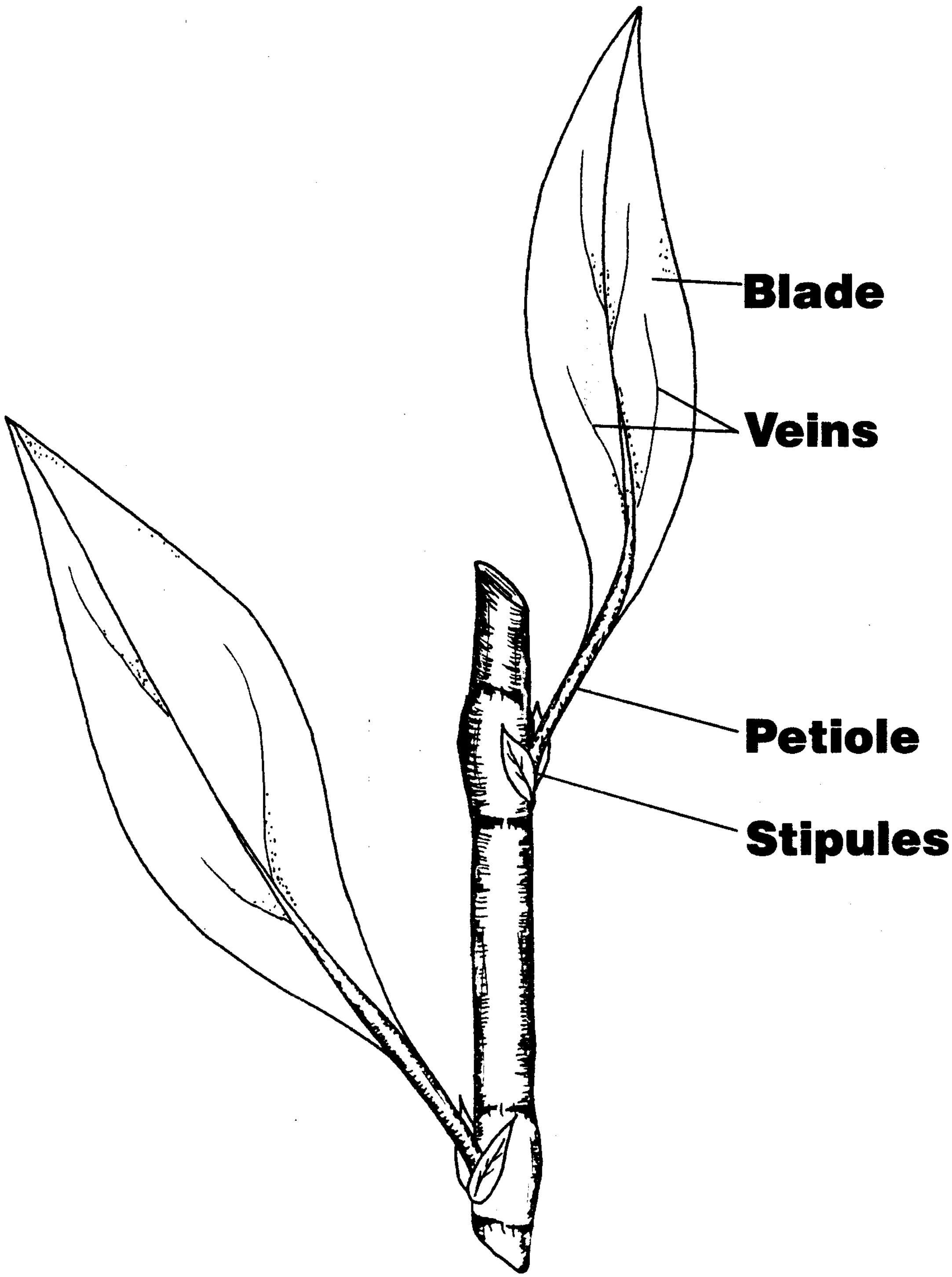
TM 3


BIENNIALS
SPRING
GERMINATE
SUMMER FALL
PRODUCE ROSETTE ABOVE
GROUND AND WELL DEVELOPED ROOT
WINTER
DORMANT
WINTER
PLANT DIES
SUMMER
SEED PRODUCED
SPRING
FLOWERING
STALK STARTS

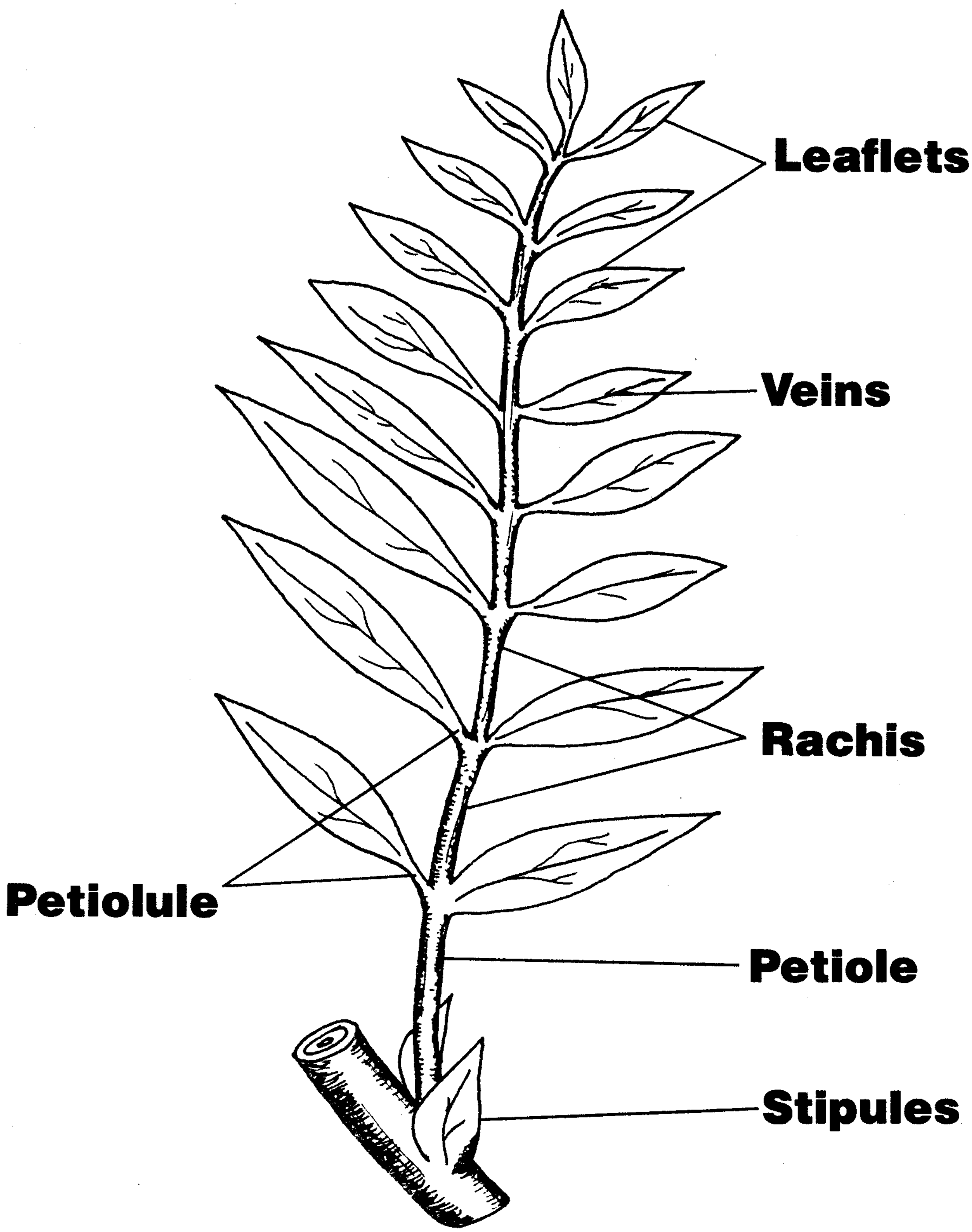
TM 4


PERENNIALS
1st SPRING
GERMINATION
1st SUMMER
FLOWERING
SEED PRODUCTION
BUILDING UP ROOT RESERVES
1st FALL
1st WINTER
DORMANT
2nd SPRING
NEW PLANT FROM ROOT
2nd SUMMER
FLOWERING
BUILDING UP ROOT RESERVES
SEED PRODUCTION
2nd FALL
2nd WINTER
DORMANT
CYCLE CONTINUES
UNTIL PLANT
EVENTUALLY DIES

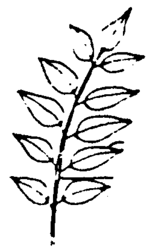
Parts of a Simple Leaf



Parts of a Compound Leaf

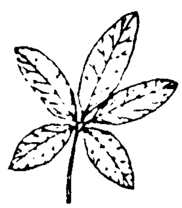


Types of Compound Leaves

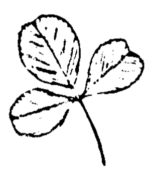


Pinnate

Bipinnate

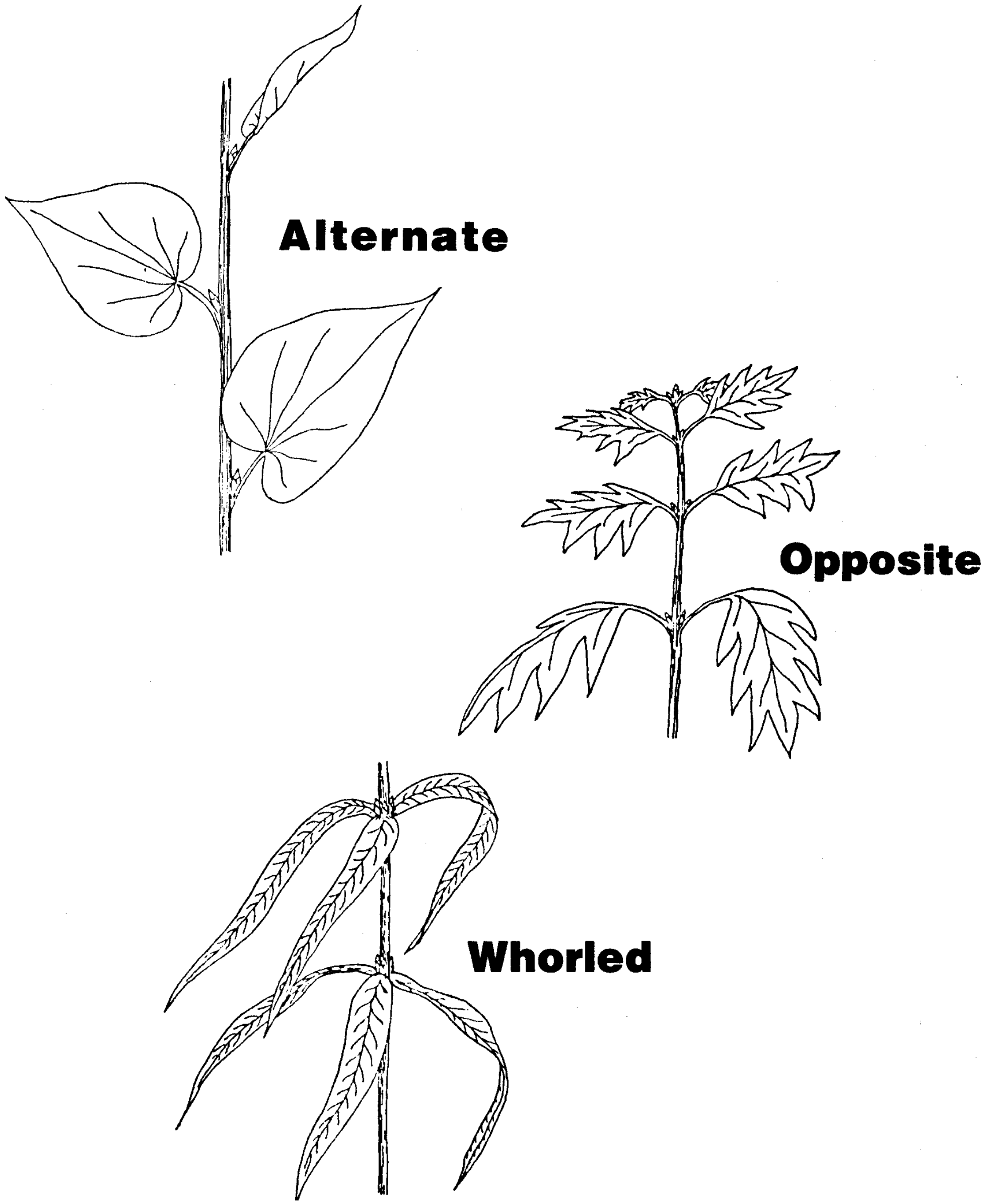


Palmate

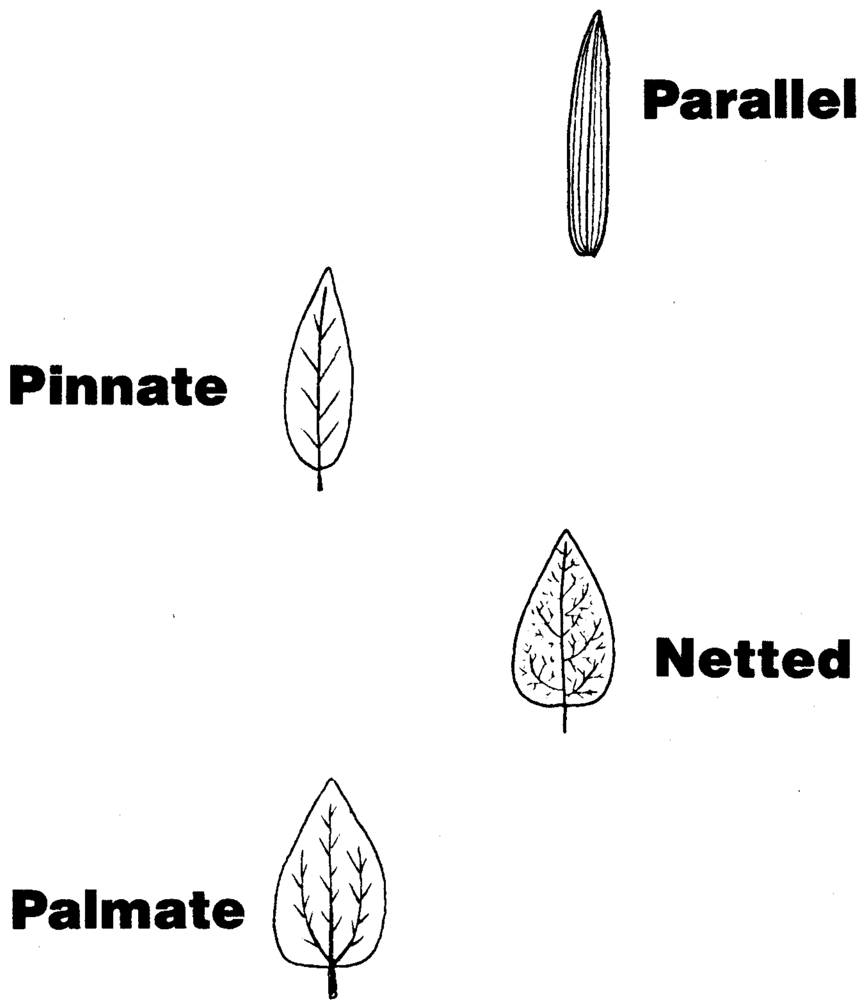


Trifoliate

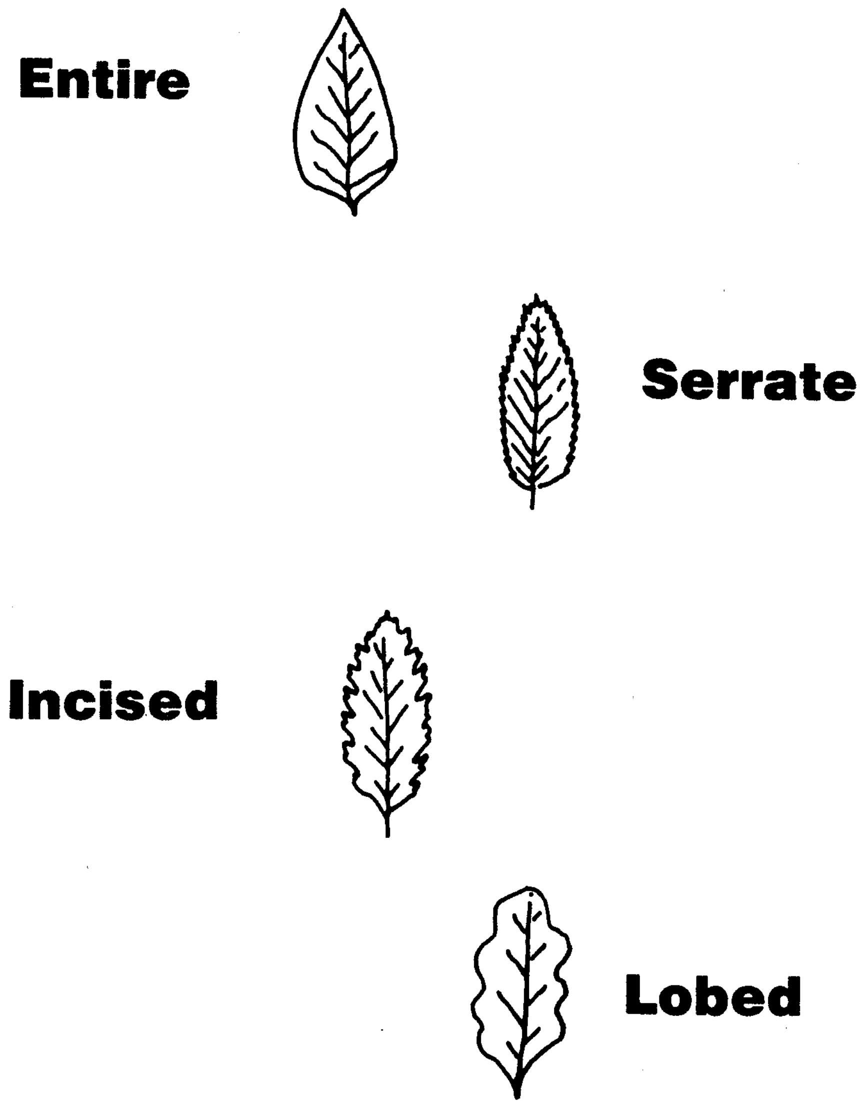
Types of Leaf Arrangement



Types of Leaf Veination



Types of Leaf Margins

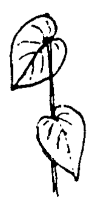


Types of Leaf Attachment

Petiolate

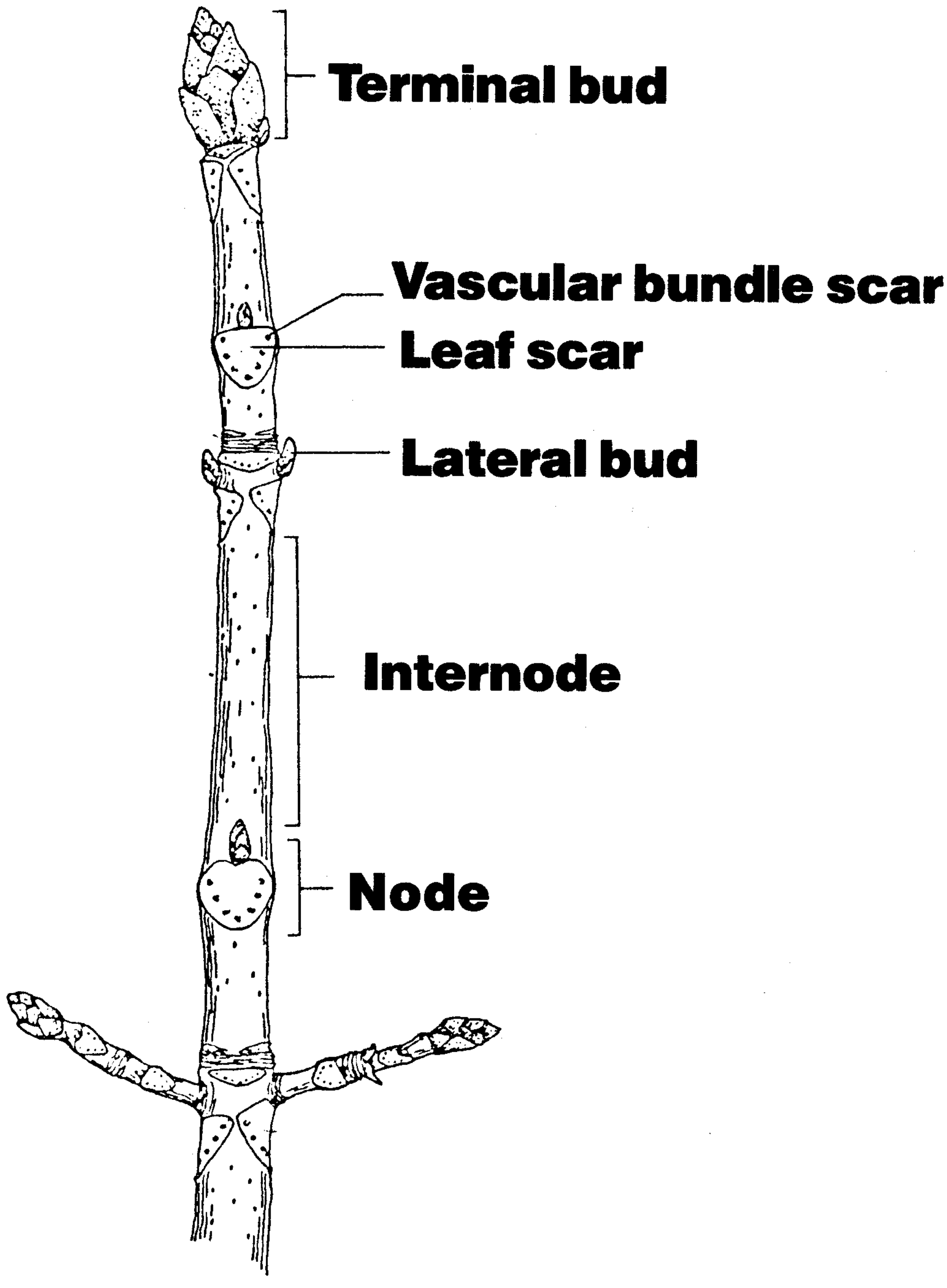
Sessile

Clasping

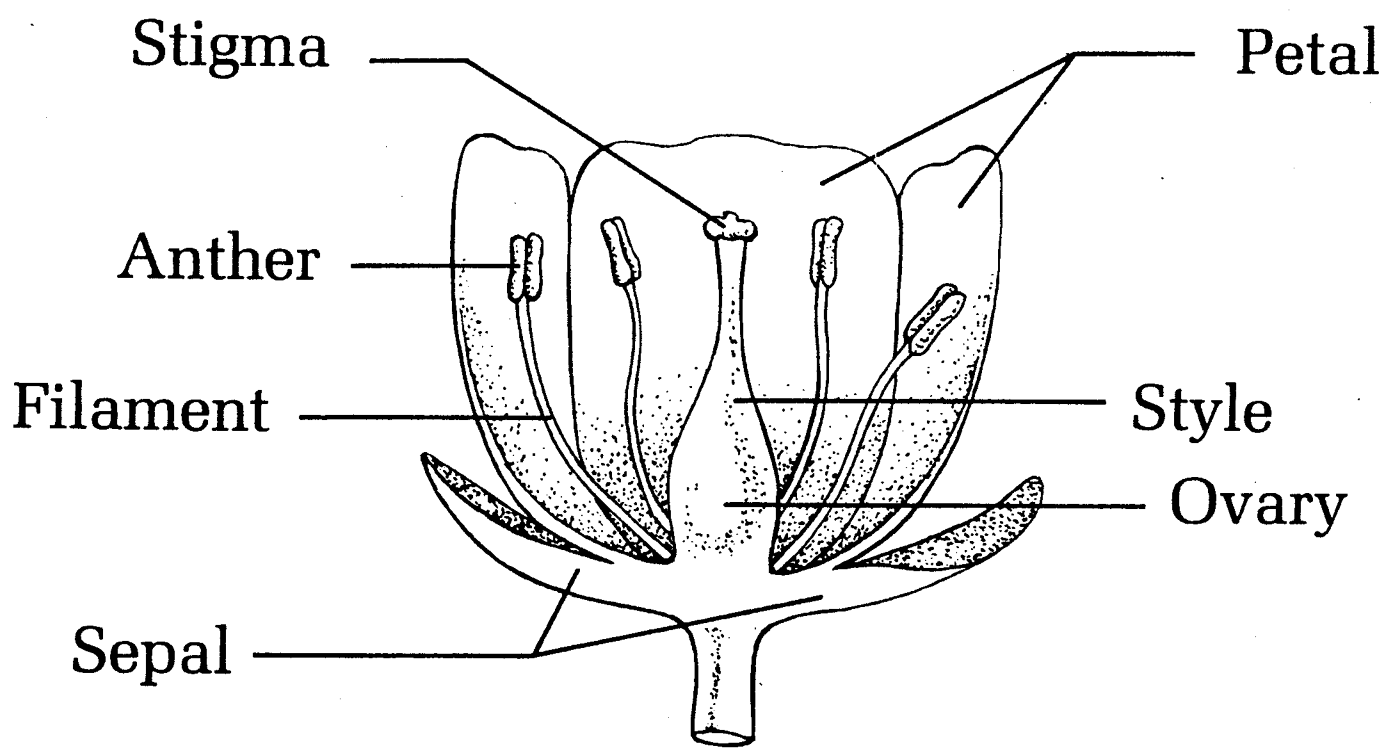


Decurrent

Parts of the Stem

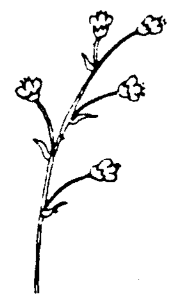


Parts of a Complete Flower

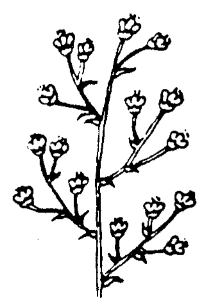


Types of Inflorescence

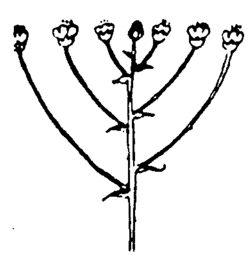
Spike



Raceme



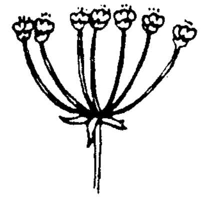
Panicle

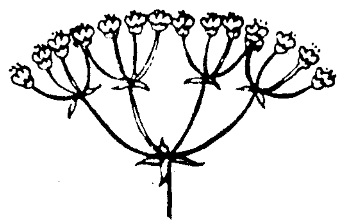


Corymb

Types of Inflorescence (Continued)

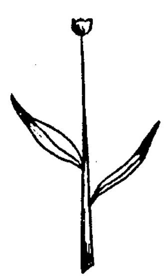
Umbel





Compound Umbel

Head



Solitary

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

INSTRUCTOR NOTES FOR LABORATORY EXERCISES

Lab #1

Monocot leaves include corn, scallions, leeks, orchids and lilies.

Dicot leaves include elm, maple, oak, spinach, *Geranium* and other houseplants.

Modified leaves include Jade plant leaf, cactus spine and pitcher plant.

Scalelike leaves include juniper, arborvitae and cypress.

Needlelike leaves include pine, fir and spruce.

Prepared slides of leaves include privet (*Ligustrum*) leaf or lilac (dicots) or lily leaf, milo leaf, bluegrass leaf or beach grass leaf (monocots).

Part I:

Step 1: Many monocots have no petiole; some common monocots, such as lilies, have a petiole

Step 3: Give each leaf an identification number. Ask the students to copy the number of each leaf they choose in the space next to step 1. In this way, you can check the students' answers to the questions in the laboratory text

Part II:

Step 1: Remind students to focus carefully to avoid damage to prepared slide or microscope

Table II: Color and recognizability of chloroplasts depend on how the leaf tissues have been stained Guide students to notice that the stromata are more numerous in the lower epidermis. Tell students if they orient their slides so that the upper epidermis is at the top of their microscope fields, they can see the leaf layers in the order they are listed in Table II

Diagram c: Students can switch to high power to examine the cuticle and epidermis more closely

Allow students to examine prepared slides of other types of leaves. On a separate piece of paper suggest that the students make a labeled drawing of each type of leaf they observe. Note the tissues and structures that all leaves have in common. Identify the tissues and structures that help adapt a plant to its particular environment. Slides might include some of those listed in the materials section or a variety of slides listed in biological supply catalogs.

Part III:

Collect leaves of trees and plants native to your area. Then, give students "mystery" leaves. Tell students to examine each leaf, using Table I to identify whether it is a monocot, dicot or conifer. Then, use a field guide to identify the species of plant the leaf came from.

Extension:

Encourage students to make their own cross sections of different kinds of leaves. To make a leaf more rigid for easier cutting, students can place the leaf between two halves of a carrot and tie the carrot halves together with a string. Soak the carrot in water for 20 minutes. Warn the students to use caution when cutting their leaf cross sections. Cut very thin sections of each soaked leaf, and place the leaf sections in water to prevent them from curling. Use forceps to select the thinnest leaf sections. Make wet mount slides of these sections, and examine them under low power. Ask students to sketch each and label each cross section.

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

LABORATORY EXERCISE #1--EXAMINING THE STRUCTURE OF LEAVES

Name____ Score_____________________________

Slesnick, Irwin L., *Biology Laboratory Manual*, Scott, Foresman and Company, 1985. Reprinted by permission of Scott, Foresman and Company.

Introduction

Leaves vary in size and shape from long, narrow blades of grass, to wide, lobed sugar maple leaves, to pine leaves, which are long and thin like needles. Although leaves come in a variety of sizes and shapes, they share one common trait: they are the main organs of photosynthesis for a plant. In this laboratory you will examine the external and internal structure of different kinds of leaves. You will find out how leaves are adapted to carry out photosynthesis and how a leaf's structure can help make a plant adapted to its environment.

<u>Materials needed</u>

Monocot leaves
Dicot leaves
Modified leaves
Scalelike leaves
Needlelike leaves
Prepared slide of angiosperm leaf cross section
Compound microscope
Green colored pencil
Prepared slide of conifer leaf cross section

Part I: Comparing the Structure of Monocot and Dicot Leaves

1. Obtain one monocot and one dicot leaf. Notice that the dicot leaf is made of two parts: the stalk-like petiole and the green, flattened blade. Find the blade of the monocot leaf. Does the monocot leaf have a petiole?

   a. ____

   ____

2. The ribs, or major veins, of a leaf contain xylem and phloem tubes, which transport materials and provide support. Find the veins in your dicot leaf. Does your dicot leaf have a midrib continuous with the petiole or does it have several major veins that branch off the petiole?

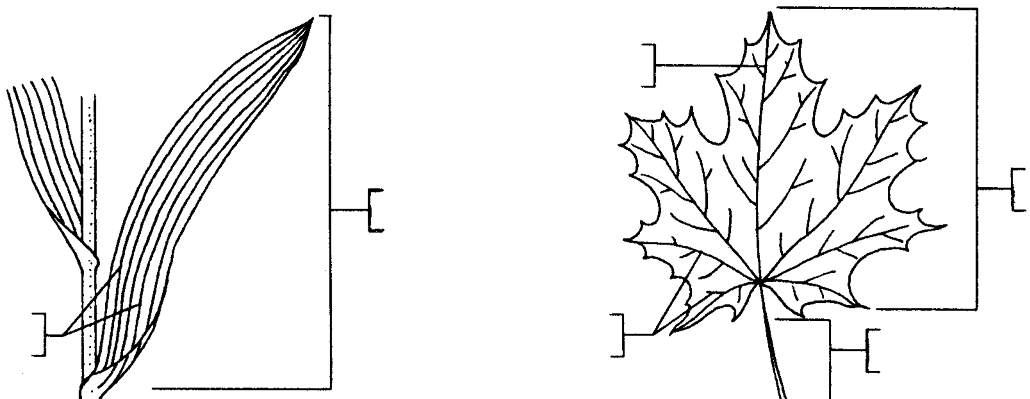
   b. ____

   ____

   How does the vein pattern in the monocot leaf compare to the vein pattern of your dicot leaf?

   c. ____

3. To review the structures that make up monocot and dicot leaves, label the structures in a and b below.

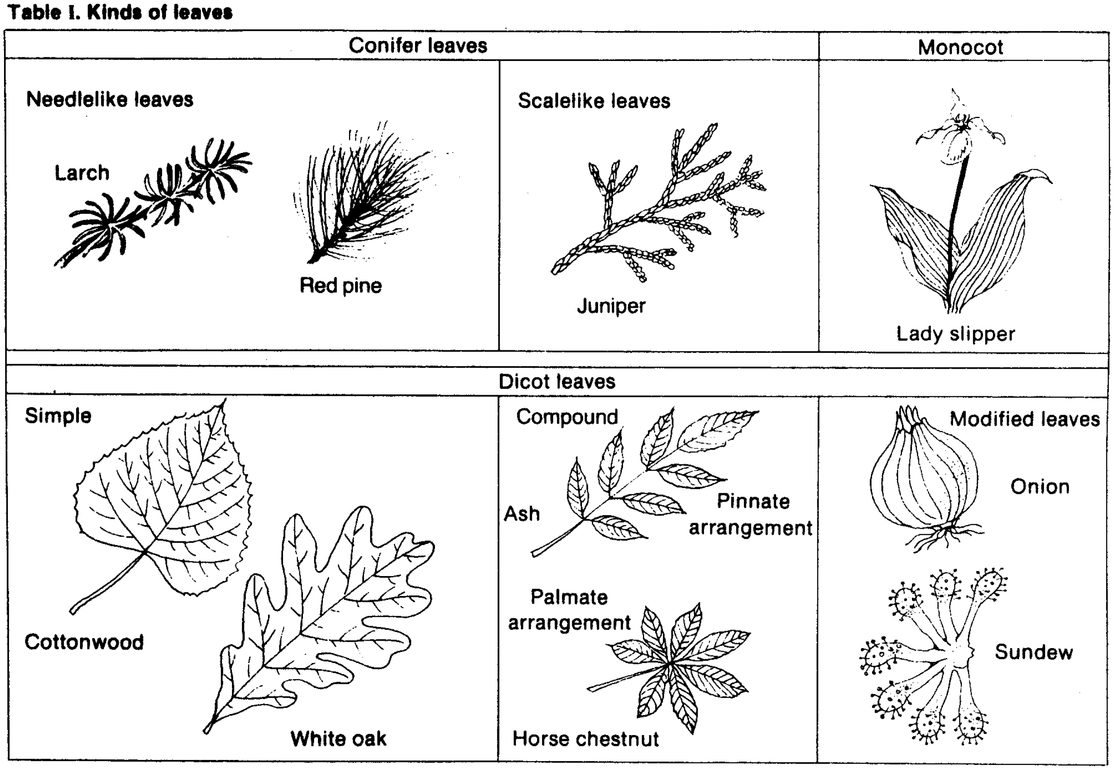


a. Monocot leaf

b. Dicot leaf

4. Obtain samples of several different kinds of leaves. Compare your leaves to the leaf pictures in Table I. Examine different kinds of simple monocot and dicot leaves. Identify *pinnate* and *palmate* compound leaves. Notice that compound leaves are composed of leaflets that resemble simple leaves. Observe the structure of several kinds of modified leaves. Examine examples of scalelike and needlelike leaves.

Table I. Kinds of leaves



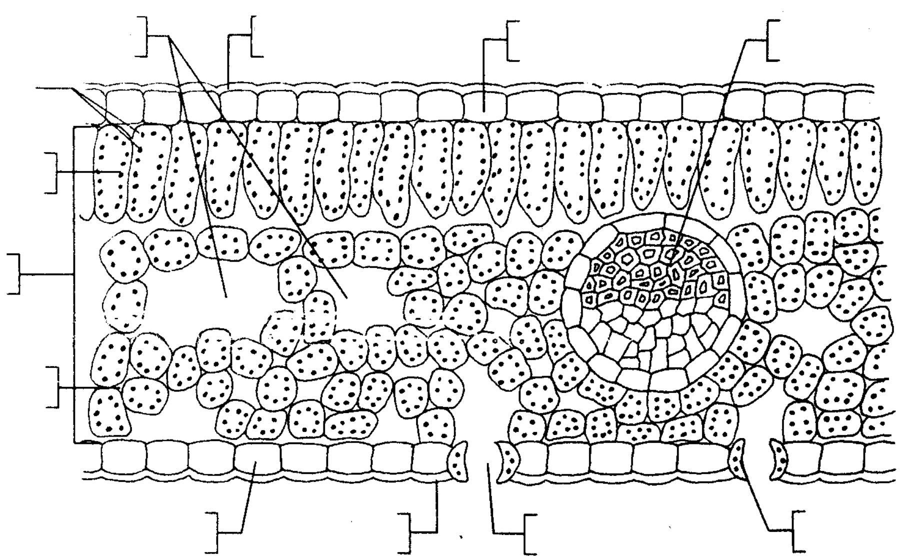
Part II: Examining the Internal Structure of Leaves

1. Obtain a prepared slide of a cross section of an angiosperm leaf. Examine the slide under low power of a compound microscope. Identify the structures listed in Table II.

TABLE II. Leaf structures

Structure	Description	Structure	Description
Upper cuticle	Thin, clear waxy coating that helps prevent water loss from the leaf surface	Veins	Fibrovascular bundles scattered throughout the mesophyll; contain xylem and phloem tubes, which transport substances and support the leaf
Upper epidermis	A single layer of brick-shaped cells with few openings to the surface	Lower epidermis	Located below the spongy layer, a single layer of cells similar to cells that make up the upper
Mesophyll	Leaf layers between the upper and lower epidermis where most photosynthesis occurs	Stomata	Openings in the epidermis that allow for gas exchange with the environment
Palisade layer	Long, narrow cells located just below the upper epidermis; chloroplasts near the edges of the cells	Guard cells	Pair of sausage-shaped cells that surround the stomata; contain chloroplasts
Spongy layer	Irregularly-shaped, loosely packed cells below the palisade layer; air spaces between these cells allow for transfer of gases	Lower cuticle	Identical in structure and function to the upper cuticle

2. Review the internal structure of a leaf by labeling the tissues in c. Draw in the chloroplasts with a green pencil.



c. Leaf cross section

3. Obtain a prepared slide of a cross section of a conifer leaf, such as a pine needle. Identify the structures listed In Table II. Notice that the stomata are sunk below the leaf surface. Are the stomata concentrated on one part of the epidermis as they are on angiosperm leaves?

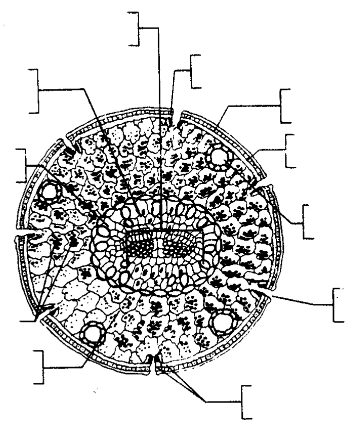
d. ____

Locate the *hypodermis*, one or more layers of thick-walled cells directly below the epidermis. The hypodermis helps prevent evaporation of water from the mesophyll. Notice the *resin ducts* found just inside the hypodermis. Resin is released from the needle when a leaf is injured. Where are vascular bundles located in pine needles?

e. ____

The vascular bundles are surrounded by photosynthetic parenchyma cells and nonliving conduction cells similar to those found in the xylem. Together these cells make up *transfusion tissue*. The *endodermis* separates the transfusion tissue from the surrounding mesophyll.

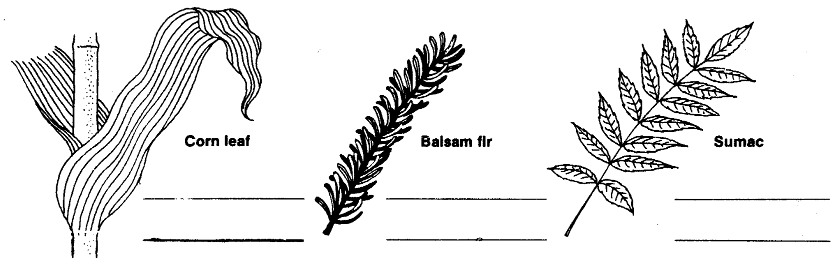
4. Review the structure of a conifer leaf by labeling d. Draw in chloroplasts with a green pencil.



d. Pine leaf cross section

Part III: Analysis

1. Study the kinds of leaves shown below. On the line below each drawing, identify the leaf as a monocot, dicot or conifer. Then, name the structures that allowed you to classify the leaf as you did. If the leaf is a dicot, further identify it as simple, pinnate or palmate. If the leaf is a conifer, further identify it as needlelike or scalelike.



2. Fill in Table III to describe the functions of tissue that make up a leaf.

Table III. Structure of leaf tissue

Tissue	Function	Tissue	Function
Cuticle			Transport substances to and from leaf; support leaf tissue
Palisade layer		Stomata	
	Loosely packed cells with air spaces that allow for the transfer of gases		Sausage-shaped cells that control the size of a stoma

3. How does the long, narrow shape of cells in the palisade layer adapt the cells to their major function? How does cyclosis, the movement of cytoplasm, in these cells further contribute to this function?

____

____

____

4. The needlelike leaves of conifers help adapt these plants to environments that contain little available water. Name four ways conifer leaves are adapted to conserve water.

____

____

____

5. A water lily is adapted to life in a freshwater environment. How is the location of the stomata on the upper epidermis an adaptation to life in this aquatic environment?

____

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

LABORATORY EXERCISE #2--RELATIONSHIP OF LEAF STRUCTURE TO FUNCTION

Name____ Score_________________________________

Materials needed

Prepared slide of leaf cross section (Ligustrum)
Microscope

Part I: Internal Leaf Structure and Photosynthesis

Examine a prepared slide of a leaf cross section under low power of your microscope. Be sure to observe the top to the lower surface and from one margin to the other. Observe that the leaf is composed of three tissues: epidermis, mesophyll and conducting tissue. Study the upper epidermis.

a. How many cells thick is it? ____

b. Are any chloroplasts present? ____

The cells of the epidermis are covered by a waxy layer called a cuticle.

c. Suggest its function. ____

____

The mesophyll is the largest area of the leaf and is composed of two regions. The first of these is made up of palisade cells which lie just below the upper epidermis. Study this area under high power.

d. Describe the cells and their orientation to the upper epidermis.

____

____

Locate some chloroplasts in the palisade cells.

e. Suggest a function of the palisade cells. ______________________________________

____

f. Why is the shape of the palisade cells important?

____

Study the second region of the mesophyll. Locate the *spongy layer* of cells below the palisade cells.

g. Of the two, which layer is more compact? ____

h. Are chloroplasts as numerous in the spongy cells as they are in the palisade cells?

____

i. Account for any difference you find. ____

____

Note the numerous spaces among the spongy cells. These are the *air spaces*.

j. On the basis of their relationship to other tissues in the leaf, what do you think their function is?

____

____

The spongy layer is penetrated by numerous *veins*. Move the slide until you are able to locate a vein.

k. How can you tell a vein from other structures in a leaf? ____

____

____

Examine the vein closely. Locate empty cells with thick walls in the upper parts of the section. These are the *xylem cells*.

l. Suggest two functions of the xylem cells. ____

____

The thin-walled cells that form a cluster below the xylem cells are the *phloem cells.*

m. What is the function of the phloem cells? ____

____

Find a small vein in your section near the leaf margin.

n. What kind of cell composes the small vein? ____

Examine the lower *epidermis*.

o. How many cell layers compose it? ____

Closely examine the lower epidermis. Try to find tiny pores with small, rounded cells on either side. The pores are the stomata and the rounded cells are the guard cells.

p. Determine the relationship between the stomata and the air spaces of the spongy tissue. ________

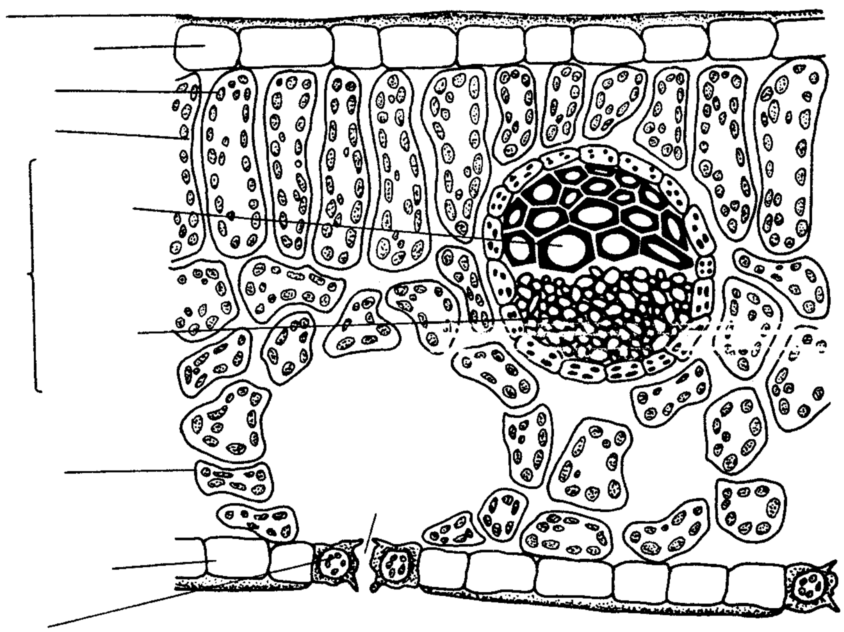
____

q. Suggest a function of the stomata.____

____

____

On the following diagram, label**: cuticle, upper epidermis, palisade cells, chloroplasts, spongy cells, vein, xylem cells, phloem cells, lower epidermis, air space, stoma, guard cells**.



Cross section of a leaf

Part II: Summary

a. Write a brief paragraph discussing how the internal structure of a leaf adapts it to the process of photosynthesis and the movement of water through the plant. ____________________

____

____

____

____

____

____

____

Review what you have learned by filling in the blanks of the following statements.

b. The layer of cells which lacks chloroplasts is the ____

c. The __________________________ is the largest area of a leaf.

d. The __________________________ layer is composed of cells which are oriented at right angles to the epidermis.

e. The presence of __________________________ is typical of the spongy layer.

f. The __________________________ is a waxy layer which prevents the loss of water from leaf tissues.

g. __________________________ are composed of tissues which carry materials to and from leaf tissues.

h. Pores found on the underside of leaves are known as __________________________.

i. Conducting tissues in a leaf are __________________________ and _________________________.

j. The only cells that contain chloroplasts in the epidermis are __________________________.

k. The three basic tissues of a leaf are __________________________, _________________________,

and __________________________.

Part III: Investigations On Your Own

Select fresh leaves (tulip, geranium or *Tradescantia* are good). Remove a small area of the lower epidermis by tearing through the blade, twisting slightly as you tear. The epidermis will appear as a thin, transparent skin. Using a razor blade, cut off a small portion of this skin. Mount it in a drop of water and add a cover glass. Examine it under low power. Compare the epidermal cells, guard cells and stomata of several kinds of leaves. Make drawings of each. Label the drawings where appropriate.

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

ANSWERS TO LABORATORY EXERCISES

Lab #1

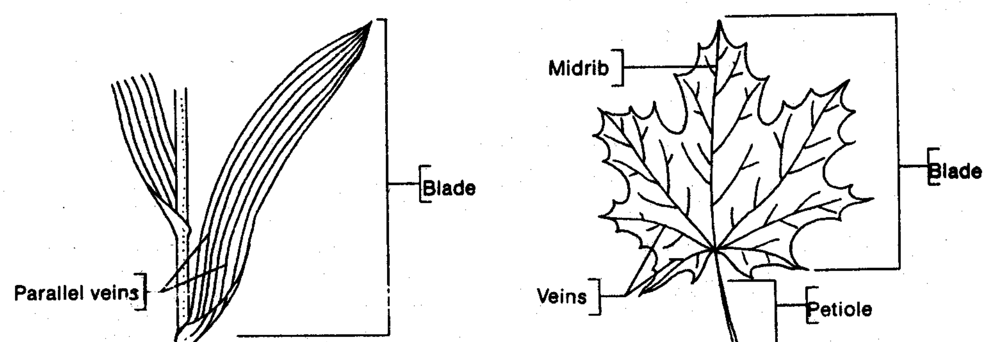
Part I:

1. a. Answers will depend on leaf examined.

2. b. Answers will depend on leaf examined.

   c. Monocot has parallel veins; dicot has branching veins.

3.

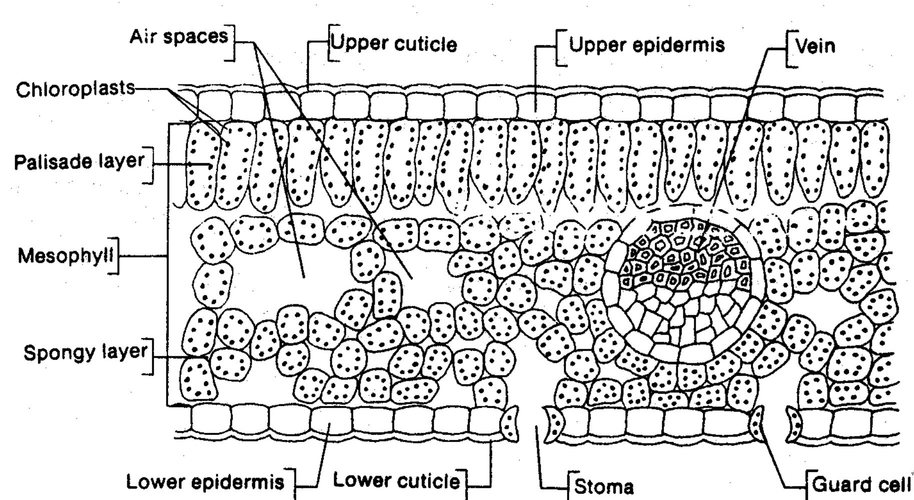


a. Monocot leaf

b. Dicot leaf

Part II:

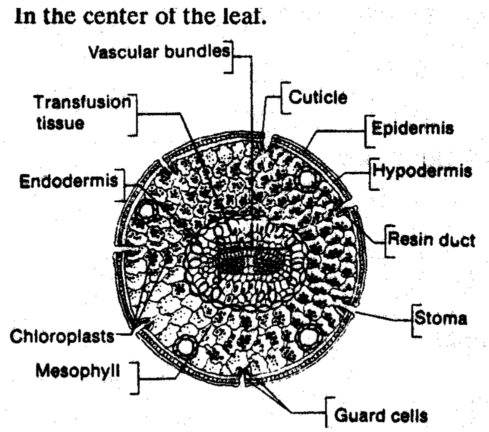
2.



c. Leaf cross section

3. d. No, they are spaced evenly on epidermal surfaces.
   e. In the center of the leaf.

4.



Part III:

1. Corn leaf: Monocot; Parallel veins; no petiole
   Balsam fir: Conifer; Needlelike leaves
   Sumac: Dicot; Branching veins; Pinnate

2. **Table III. Structure of leaf tissue**

Tissue	Function	Tissue	Function
Cuticle	Prevents water loss from leaf surface	Veins	Transport substances to and from leaf; support leaf tissue
Palisade layer	Contains long, narrow cells with chloroplasts that are major site of photosynthesis	Stomata	Openings in epidermis that allow for gas exchange with the environment
Spongy layer	Loosely packed cells with air spaces that allow for the transfer of gases	Guard cells	Sausage-shaped cells that control the size of a stoma

3. Chloroplasts move from upper layers of cells where maximum exposure to sunlight occurs to lower layers where gases from photosynthesis and respiration are exchanged. Shape and cyclosis allow for efficient exposure to both sunlight and air spaces.

4. The limited surface area exposed to direct sunlight due to the needle's shape; the cuticle covering, sunken stomata and the hypodermis all prevent evaporation of water.

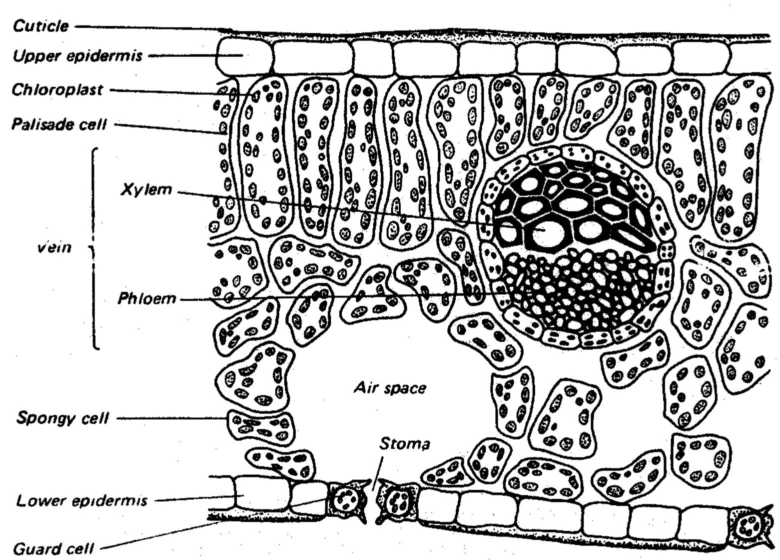
5. Stomata location allows excess water that might diffuse into the leaf to evaporate.

<u>**Lab #2**</u>

Part I:

a. One
b. No
c. Prevent evaporation of water from tissues
d. Thin-walled, numerous chloroplasts, lie at right angles to upper epidermis

e. Primary location for photosynthesis
f. Permits greatest transmission of light throughout the cell
g. Palisade
h. No
i. Spongy cells do not receive as much light as the palisade cells
j. They allow gases to diffuse through the internal portion of the leaf
k. Veins are composed of thick-walled cells and the cells are found in clusters
l. Conduction of water and minerals, and support
m. Conduction of food
n. Xylem
o. One
p. They open into the air spaces
q. Exchange of gases (carbon dioxide for photosynthesis and oxygen for respiration); regulation of loss of water vapor to outside air



Cross section of a leaf

Part II:

a. The leaf is a broad, flat, green structure permitting the maximum exposure of this photosynthetic structure to light. The palisade cells compose the upper layer of mesophyll and contain numerous chloroplasts. The upper epidermis (and lower epidermis) contains no chloroplasts. This allows light to penetrate to the palisade cells where the process of photosynthesis is primarily carried out. The stomata and guard cells allow for the passage of water, evaporated from the surface of the spongy cells, to escape from the air space to the atmosphere. This allows for the movement of water through the plant.
b. Epidermis
c. Mesophyll
d. Palisade
e. Air spaces
f. Cuticle
g. Veins
h Stomata
i. Xylem and phloem
j. Guard cells
k. Epidermis, mesophyll, conducting tissue

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

UNIT TEST

Name_____________________________________ Score______________________________

1. Match terms associated with the identification of plants and weed pests to the correct definitions. Write the correct numbers in the blanks.

_____a. The part of a stem between two nodes

_____b. Not opposite; one leaf at a node

_____c. A plant with no persistent woody stem above ground

_____d. Any plant that interferes with human affairs

_____e. The expanded, usually flat portion of a leaf

_____f. The main or central rib of a leaf

_____g. Lying flat on the ground

_____h. A plant that climbs on some support, the stem cannot stand upright by itself

_____i. A leaf completely separated into two or more leaflets

_____j. Leaves two at a node and situated across the stem from each other

_____k. A perennial woody plant of considerable stature at maturity with a main trunk

_____l. Compound leaf with the leaflets on opposite sides

_____m. Place on a stem where leaves are attached

_____n. Any plant which is determined by a state agency to be injurious to public health, crops, livestock, land or other property

_____o. A dense, basal cluster of leaves arranged in a circular fashion

_____p. Of only one part; leaf not completely divided into separate segments

1. Weed
2. Noxious weed
3. Shrub
4. Herb
5. Vine
6. Tree
7. Rosette
8. Prostrate
9. Evergreen
10. Deciduous
11. Alternate
12. Opposite
13. Simple leaf
14. Compound leaf
15. Midrib
16. Vein
17. Blade
18. Petiole
19. Pinnate
20. Internode
21. Node

_____q. The stalk of a leaf blade or compound leaf

_____r. Bearing green leaves throughout the year

_____s. A woody perennial plant smaller than a tree

_____t. Plants that shed their leaves annually

_____u. Threads of vascular tissue in a leaf

2. Discuss the importance of plant identification.

____

____

____

____

____

____

3. Select from the following list reasons plant identification cannot be made easily. Write an "X" in the blank before each correct answer.

_____a. Microscopic detail is often necessary

_____b. Constant practice is necessary

_____c. Descriptive terms must be mastered

_____d. Plants to identify are difficult to obtain

_____e. Information on plant identification not available

_____f. Most plants look alike

4. Arrange in order the binomial system of plant classification. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Order

_____b. Species

_____c. Class

_____d. Genus

_____e. Division

_____f. Family

5. Name three classifications of plants by life cycle.

a______________________________

b______________________________

c______________________________

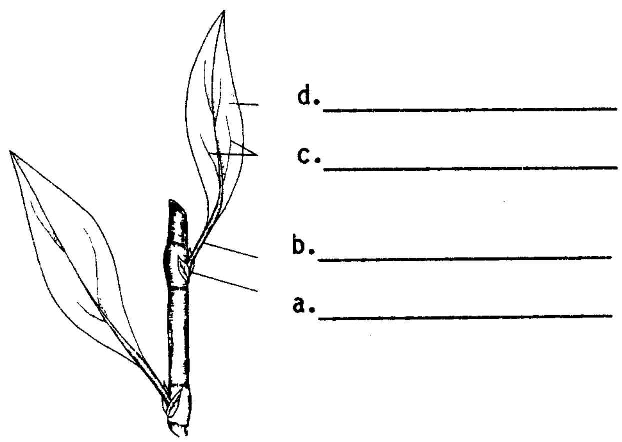
6. Name three classifications of plants by difficulty of control.

a______________________________

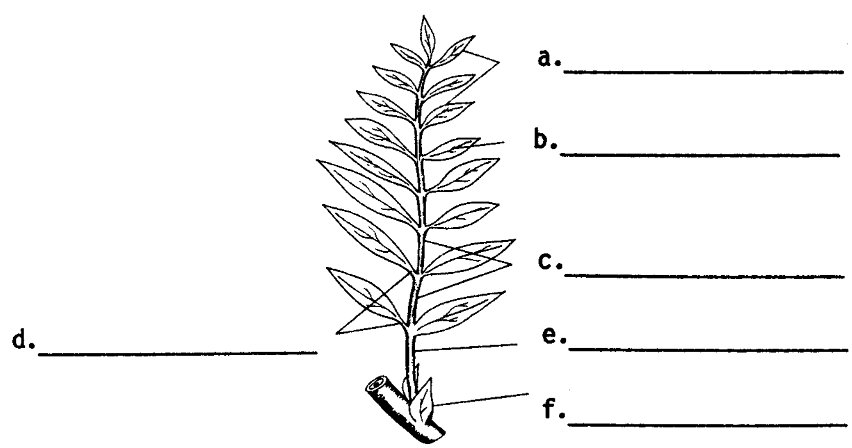
b______________________________

c______________________________

7. Label the parts of a simple leaf. Write the correct names in the blanks.

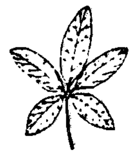


8. Label the parts of a compound leaf. Write the correct names in the blanks.

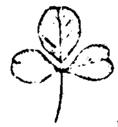


9. Identify types of compound leaves. Write the correct names in the blanks.

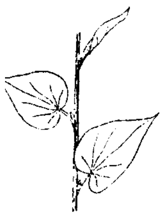

a. ____________________

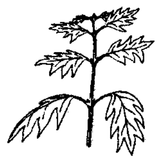

c. ____________________


b. ____________________


d. ____________________

10. Identify types of leaf arrangement. Write the correct names in the blanks.

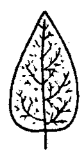

a. ____________________


b. ____________________

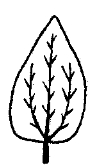

c. ____________________

11. Identify types of leaf veination. Write the correct names in the blanks.

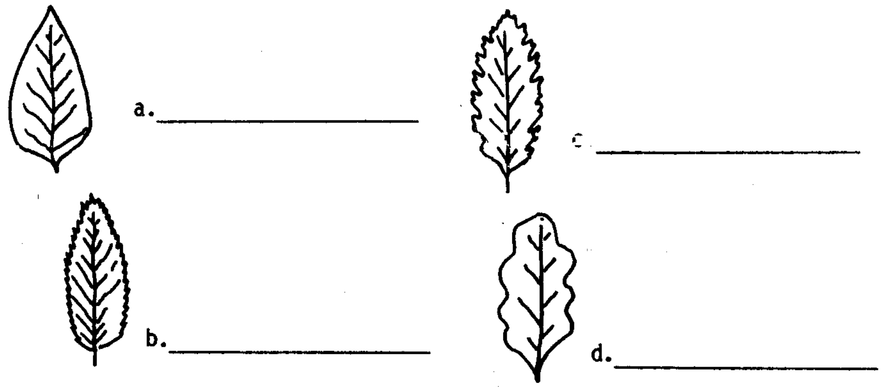

a. ____________________


c. ____________________

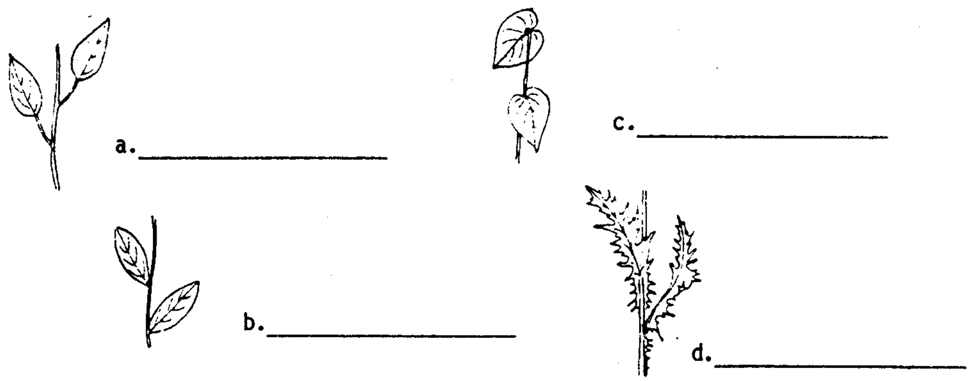

b. ____________________


d. ____________________

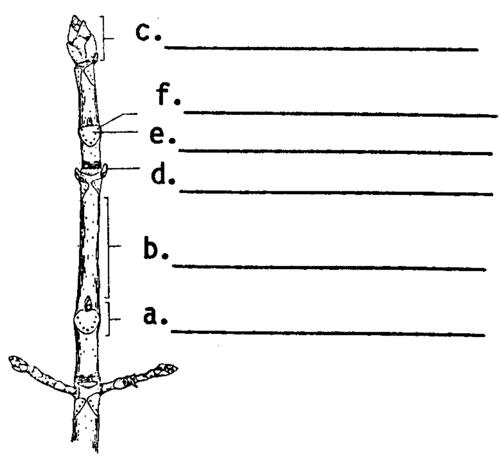
12. Identify types of leaf margins. Write the correct names in the blanks.



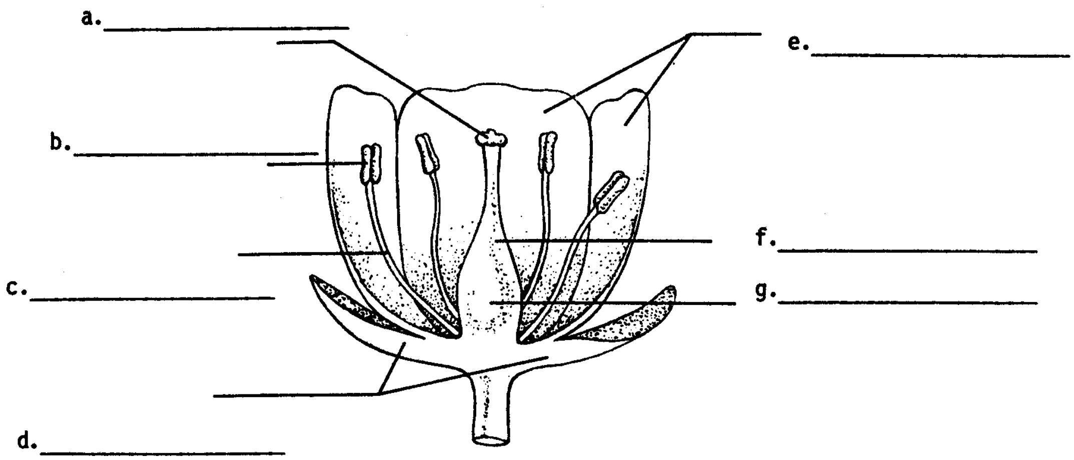
13. Identify types of leaf attachment to the stem. Write the correct names in the blanks.



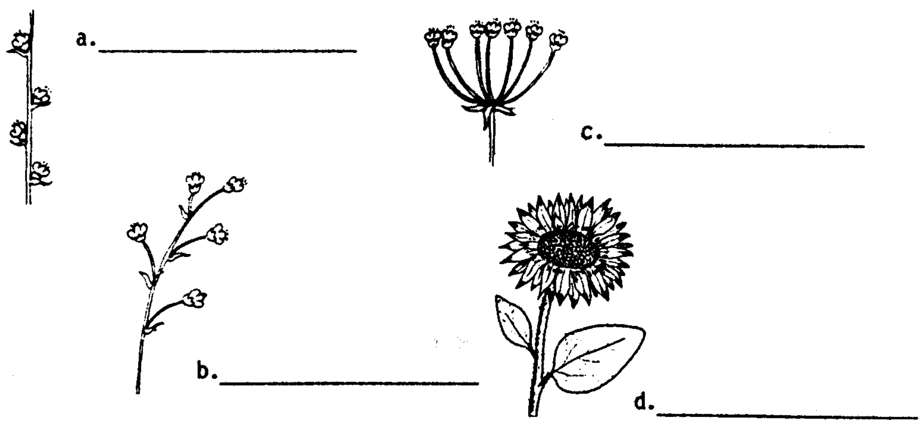
14. Label the parts of a stem. Write the correct names in the blanks.



15. Label the parts of a complete flower. Write the correct names in the blanks.



16. Identify types of inflorescence. Write the correct names in the blanks.



17. Select the correct plant family when given the common name of the plant. Write the correct numbers in the blanks.
(Note: Plant families will be used more than once.)

_____a.	Potato	1.	Graminae
_____b.	Canada thistle	2.	Compositae
_____c.	Wild oats	3.	Chenopodiaceae
_____d.	Lambsquarter	4.	Solanaceae
_____e.	Buckhorn plantain	5.	Polygonaceae
_____f.	Quackgrass	6.	Plantaginaceae

_____g. Prickly lettuce

_____h. Wheat

_____i. Hairy nightshade

_____j. Curly dock

18. Name three natural resources crops and weeds are in competition for.

a. ____

b. ____

c. ____

19. Name three losses caused by weeds.

a____

b____

c____

20. Select from the following list ways that weeds spread. Write an "X" in the blank before each correct answer.

_____a. Irrigation water

_____b. Livestock

_____c. Manure

_____d. Wildflower gatherers

_____e. Farm machinery

_____f. Wind

_____g. Fill soil

_____h. Planting of weed seed

21. Match the general categories of weed control to the correct description. Write the correct numbers in the blanks.

_____a.	Complete elimination of a given weed species so that it will not reappear in a given area	1.	Prevention
		2.	Eradication
_____b.	Practices where weed populations are kept at a level that does not seriously interfere with crop production or yield	3.	Control

_____c. Practices to prevent the establishment of specific weed species in an area not currently infested

22. Select from the following list methods of cultural weed control. Write an "X" in the blank before each correct answer.

_____a. Cultivation

_____b. Crop rotation

_____c. Burning

_____d. Smother crops

_____e. Use of selective herbicide

_____f. Use of weed-free crop seed

23. Select from the following list methods of mechanical weed control. Write an "X" in the blank before each correct answer.

_____a. Crop rotation

_____b. Discing

_____c. Burning

_____d. Use of contact herbicide

_____e. Use of weed-free crop seed

_____f. Mowing

_____g. Mulching

_____h. Hoeing

24. Match the classifications of herbicides to the correct description. Write the correct numbers in the blanks.

_____a. Kills only part of plant to which it is applied; not translocated

_____b. Applied to soil before crop is planted

_____c. Absorbed by roots or foliage and translocated throughout plant

_____d. Kills all plants present if applied at an adequate rate

_____e. Applied after emergence of the crops or weeds

_____f. Applied prior to emergence but after crop planting

1. Selective
2. Non-selective
3. Contact
4. Systemic
5. Preplant
6. Preemergence
7. Postemergence

_____g. Used to kill weeds without significant damage to crop

25. Discuss biological weed control.

____

____

____

____

____

____

26. Describe the conditions necessary to obtain effective biological control.

a. ____

____

b. ____

____

c. ____

____

27. List the advantages of biological control.

a. ____

b. ____

c. ____

d. ____

e. ____

28. Discuss four limitations of biological control.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

29. Identify the following weed seeds as either prohibitive noxious weed seeds or restricted noxious weed seeds. If the seed is prohibitive noxious, write an "X" in the blank. If it is restricted noxious, write an "O" in the blank.

_____a. Hoary Cress

_____b. Spotted Knapweed

_____c. Dodder

_____d. Canada Thistle

_____e. Buckhorn Plantain

_____f. Quackgrass

_____g. Blue Lettuce

_____h. Medusahead Rye

_____i. Russian Knapweed

_____j. Dalmation Toadflax

_____k. Field Bindweed

_____l. Yellow Starthistle

_____m. Perennial Sowthistle

_____n. Goatgrass

IDENTIFICATION OF PLANTS AND WEED PESTS

AG 510 - G

ANSWERS TO TEST

1.

a.	20	g.	8	m.	21	s.	3
b.	11	h.	5	n.	2	t.	10
c.	4	i.	14	o.	7	u.	16
d.	1	j.	12	p.	13		
e.	17	k.	6	q.	18		
f.	15	l.	19	r.	9		

2. To recognize a problem, to seek a solution, to diagnose a condition; To be able to talk or write about the plant; To be able to look up information about the plant

3. a, b, c

4.

a.	3	d.	5
b.	6	e.	1
c.	2	f.	4

5. Annual; Biennial; Perennial

6. Common; Secondary noxious; Primary noxious

7.
a. Stipules
b. Petiole
c. Veins
d. Blade

8.

a.	Leaflets	d.	Petiolule
b.	Veins	e.	Petiole
c.	Rachis	f.	Stipules

9.

a.	Pinnate	c.	Palmate
b.	Bipinnate	d.	Trifoliate

10. a. Alternate   b. Opposite   c. Whorled

11.

a.	Parallel	c.	Netted
b.	Pinnate	d.	Palmate

12.

a.	Entire	c.	Incised
b.	Serrate	d.	Lobed

13.

a.	Petiolate	c.	Clasping
b.	Sessile	d.	Decurrent

14.

a.	Node	d.	Lateral bud
b.	Internode	e.	Leaf scar
c.	Terminal bud	f.	Vascular bundle scar

15. a. Stigma d. Sepal g. Ovary
b. Anther e. Petal
c. Filament f. Style

16. a. Spike c. Umbel
b. Raceme d. Head

17. a. 4 e. 6 i. 4
b. 2 f. 1 j. 5
c. 1 g. 2
d. 3 h. 1

18. Water; Nutrients; Light

19. Decreased crop yields; Decreased crop quality; Cost of control activities

20. a, b, c, d, e, f, g, h

21. a. 2 b. 3 c. 1

22. b, d, f

23. b, c, f, g, h

24. a. 3 d. 2 g. 1
b. 5 e. 7
c. 4 f. 6

25. Biological weed control--Involves the introduction of a natural enemy to weaken or destroy a particular weed species; insects have achieved the most success, but microorganisms, parasitic plants, animals, birds and fish are also used. The goal is not eradication, but reduction of the weed population to an acceptable level

26. Insect or biotic agent must be specific to the weed that is to be controlled (or it may attack the crop species); The weed must be abundant enough to provide sufficient food to maintain the insect or biotic agent; The insect or biotic agent must be free of natural enemies

27. Economical; Well adapted for use on low-value uncultivated land where mechanical control is uneconomical or impossible; Eliminates residue problems; More permanent than other methods; Does not require fossil fuel energy

28. Answer should include four of the following:

Not well suited to croplands because it can't respond quickly enough to check seasonal weed control before yield reduction occurs; Doesn't reduce the weed population to an acceptable level for the production of some crops; Not effective on a stand of mixed weed species; Not adapted for use on weeds that are closely related to crop plants; A plant considered to be a weed to some may be regarded as a valuable plant by others

29. a. X e. O i. X m. X
b. X f. X j. X n. X
c. O g. O k. X
d. X h. O l. X

INSECT PESTS OF CROPS

AG 510 - H

UNIT OBJECTIVE

After completion of this unit, students should be able to list ways that insects cause losses to crops, as well as their beneficial effects. Students should also be able to identify the body regions of an insect and classify insects according to feeding habits. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with insect pests of crops to the correct definition.
2. Name three ways insects cause losses to crops.
3. Discuss beneficial effects of insects.
4. Discuss the economic importance of insect control.
5. Label a drawing showing the body regions of an insect.
6. Name two characteristics which aid in distinguishing one insect from another.
7. Name three identifying characteristics of mites, ticks and spiders.
8. Describe the four insect classifications by feeding habits and give two examples of each.
9. Label a drawing showing the three and four stage life cycles of insects.
10. List six cultural control practices for insects.
11. Describe biological control practices for insects.
12. List three chemical control practices for insects.
13. Describe the three classifications of insecticides.

INSECT PESTS OF CROPS

AG 510 - H

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Insect Identification Manual*, available from VEP, Cal Poly State University, San Luis Obispo, California 93407; approximate cost $8.25.

b. *Insect Pest Identification of Corn, Soybeans and Alfalfa*, 50-page manual; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland, Urbana, Illinois 61801; approximate cost $3.50.

c. *Insect Pests of Field Crops and Stored Grains, manual;* available from Ohio Agriculture Education Curriculum Materials Center, Ohio State University, Columbus, Ohio 43210; approximate cost $4.00; order no. 1016M.

2. Filmstrips, slideshows, etc.

a. *Identification and Control of Common Crop Insects*, 49 slides and cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $62.40; order no. D12.

b. *Identifying Common Insect Pests*, filmstrip or slide set, cassette and study guide; available from Vocational Agriculture Service, University of Illinois, 1401 S. Maryland, Urbana, Illinois 61801.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information sheet and discuss.

E. Review and give test.

F. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Insects Cause Losses to Crops

2. TM 2--Insect Damage

3. TM 3--Adult Insects

4. TM 4--Wings and Mouthparts

5. TM 5--Mite, Tick and Spider

6. TM 6--Insect Classification According to Feeding Habits

7. TM 7--Four Stage Life Cycle

8. TM 8--Three Stage Life Cycle

E. Test

F. Answers to test

III. Unit references

A. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publishers, Inc., Albany, New York 12212, 1990.

B. Farrington, William S., et al., *Fertilizer, Chemicals and Seed*, McGraw-Hill Book Company, New York, 1980.

C. Homan, H.W., et al., *Insects Affecting Idaho Agriculture*, University of Idaho, Moscow, Idaho, 1982.

D. Hughes, H.A., *Crop Chemicals*, 2nd edition, John Deere Technical Services, Moline, Illinois, 1982.

E. *Insect and Disease Control*, Vo-Ag II, Unit IV-D, Teaching Materials Center, Agriculture Education Department, Texas A & M University, College Station, Texas.

F. Romoser, W.S., *The Science of Entomology*, MacMillan Publishing Co., Inc., New York, New York, 1973.

G. Westcott, C., *The Gardener's Bug Book*, 3rd edition, Doubleday and Company, Inc., Garden City, New York, 1964.

INSECT PESTS OF CROPS

AG 510 - H

INFORMATION SHEET

I. Terms and definitions

A. Insect--Small, boneless animal whose body is divided into three sections and has six legs

B. Spider--A small, eight-legged animal having a body composed of two divisions (cephalothorax and abdomen); the spider is an arachnid, not an insect

C. Mite--Any of a large number of tiny arachnids, many of which live as parasites upon plants

D. Entomology--A branch of science that deals with the study of insects

E. Life cycle--Stages in the life development of an insect

F. Metamorphosis--A change in form, either gradual or sudden

G. Complete metamorphosis--Having four distinct growth stages in development in which a major change in structure and appearance of the insect occurs; each feeding life stage may eat different diets and occupy different environments

H. Incomplete metamorphosis--Gradual change in appearance as growth proceeds; the immature forms are called nymphs and eat the same as the adults

I. Larva--Immature form of an insect having complete metamorphosis

J. Pupa--Stage between the larva and adult in insects with complete metamorphosis

K. Cocoon--A silken case inside which the pupa is formed

L. Nymph--The immature stage of an insect with incomplete metamorphosis

M. Damage--Associated with crop loss and/or reduction in crop yield or crop quality

N. Injury--Deviation from normal appearance of the plant, from which it may recover and not depress yield and/or quality

O. Pesticide--Chemical used to control pests

P. Insecticide--A pesticide used to kill or control insects

Q. Acaricide--Pesticide used to kill or control mites, ticks and spiders

II. Ways insects cause losses to crops (Transparencies 1, 2)

A. Reduce crop yield

B. Reduce quality of the crop

C. Cost of control practices

D. Transmit plant diseases

(Note: Insects may cause damage or injury depending on seriousness of infestation and the effectiveness of control measures.)

III. Beneficial effects of insects

A. Carry pollen for pollination which is essential to seed production of many crops

B. Natural enemies which control pest insects

C. Production of useful products

1. Honey

2. Beeswax

3. Silk

IV. Economic importance of insect control

A. $1 billion spent annually on insect control

B. $5 billion estimated losses

C. Estimated 5% - 10% of total crop damaged

D. Over $100 million spent yearly on cotton alone

V. Body regions of an insect (Transparency 3)

A. Head--Bears one pair of antennae and mouth parts

B. Thorax--Bears three pairs of legs and often bears wings

C. Abdomen--Has as many as eleven segments, but never bears legs

(Note: Characteristics common to all adult insects include six jointed legs and three body regions.)

VI. Characteristics which distinguish one insect from another (Transparency 4)

A. Wings

(Note: Some insects have no wings; others have two or four. The wings vary in shape, size, thickness and structure.)

B. Mouthparts

(Note: Insects with chewing mouthparts have toothed jaws that bite and tear the food. Insects with piercing-sucking mouthparts have tube-like beaks which they force into a plant to suck out fluids.)

VII. Characteristics of mites, ticks and spiders (Transparency 5)

A. Eight jointed legs

B. Two body regions

C. No wings

VIII. Insect classification by feeding habits (Transparency 6)

A. Chewing

(Note: These insects bite off, chew and swallow plant parts. This results in ragged, deformed or stunted plants that may be more susceptible to disease and may die due to excessive damage.)

1. Grasshopper
2. Armyworm
3. Potato beetle
4. Blister beetle

B. Sucking

(Note: These insects pierce the outer layer of the plant tissue with their "coke straw" beak and feed on the plant sap.)

1. Aphid
2. Leafhopper
3. Thrips
4. Hessian Fly
5. Greenbug

C. Internal (borers and miners)

(Note: This group includes mostly chewing insects that enter the plant and feed from within.)

1. European corn borer
2. Cotton boll weevil larva

3. Wheat stem sawfly

D. Subterranean

(Note: This group includes both chewing and sucking insects which enter the plant below the soil surface.)

1. Corn rootworm

2. Wireworm

IX. Life cycles of insects

(Note: Because insects live inside a chitinous exoskeleton which cannot be expanded as they grow, they progress by a series of molts, splitting and casting off the old shell. Between the time the insect pulls free from its old covering and before the new form is solidified, there is a chance for expansion in size. There may be 3, 4, 5 or even 20 molts depending on the species. The adult insect never increases in size; growth is always in the immature life stage.)

A. Four stage group (complete metamorphosis) (Transparency 7)

(Note: Insects in this group include beetles, flies, moths, bees and butterflies.)

1. Egg

2. Larva

3. Pupa

4. Adult

B. Three stage group (incomplete metamorphosis) (Transparency 8)

(Note: Insects in this group include grasshoppers, aphids, termites, dragonflies and mayflies.)

1. Egg

2. Nymph

3. Adult

X. Cultural control practices for insects

A. Crop rotation

B. Trap crops

(Note: Small plots of a host plant the insect favors near susceptible crop. After insects have been attracted to the "trap", they can be killed by burning or with an insecticide.)

C. Tillage

D. Residue management

(Note: Shredding and incorporating of crop residue helps eradicate plant-borne insects.)

E. Timing of operations

(Note: Proper timing of planting or harvesting operations can be used to control insect damage if the host plant is resistant or susceptible for a brief period or if the damaging stage of the insect's life cycle is out of synchronization with the plant's development.)

F. Resistant varieties

(Note: This involves selection of plants less damaged by the insects and plants that are more vigorous so it is better able to resist insect attacks.)

XI. Biological control practices for insects--Natural enemies to a particular insect

(Note: The use of natural enemies, for example: predators, parasites and insect disease, sometimes can be used to control a pest.)

XII. Chemical control practices for insects

(Note: Chemicals may be applied to seeds, growing plants or soil. Effectiveness depends on the characteristics of the chemical, susceptibility of the insect, plus the timing and method of application.)

A. Poison the insects

B. Repel the insects from specific areas

C. Attract insects to a place where they can be killed

XIII. Classifications of insecticides

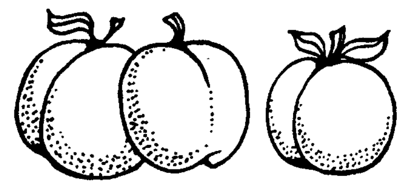
A. Fumigant poison--Enters the insect's body through the respiratory system in the form of a gas

B. Stomach poison--Eaten and digested by the insect

C. Contact poison--Absorbed through the insect's skin or body wall and acts upon the pest's nervous system

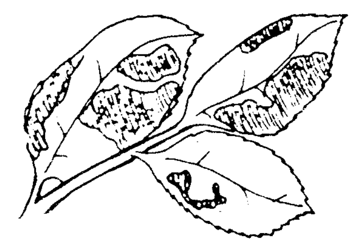
Insects Cause Losses to Crops

Reduce Crop Yield



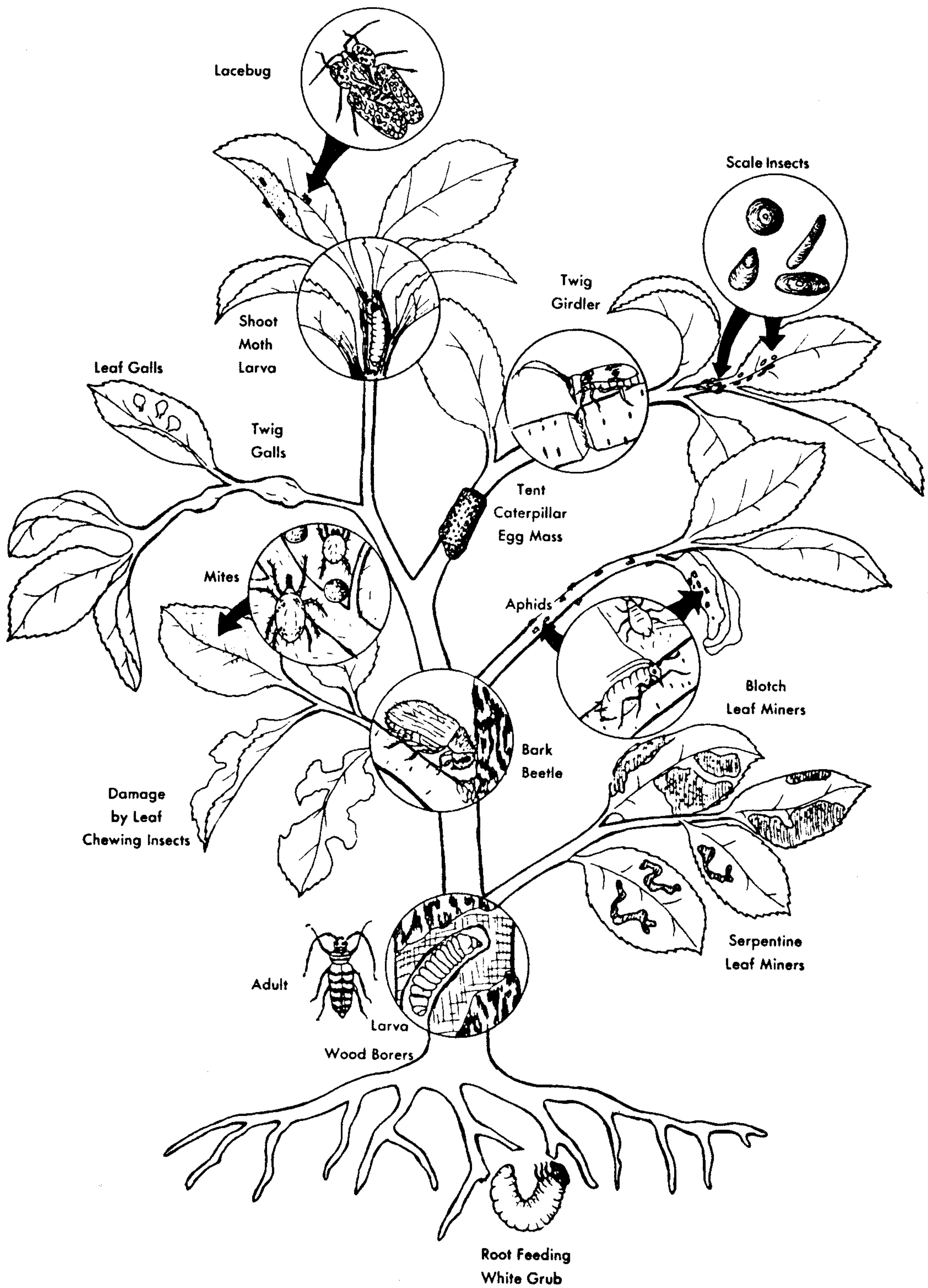
Reduce Quality of the Crop

Cost of Control Activities

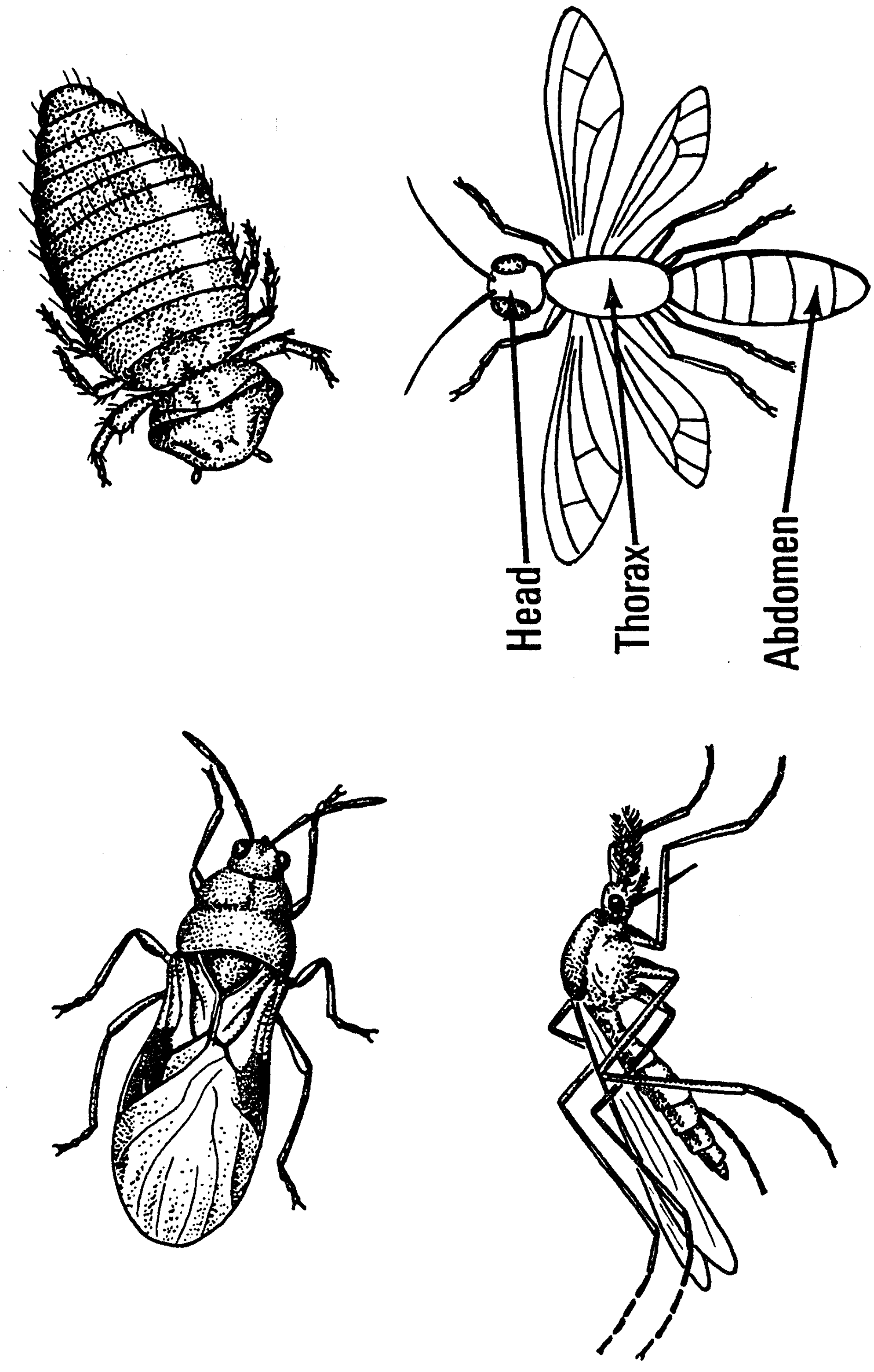


Transmit Plant Disease

Insect Damage

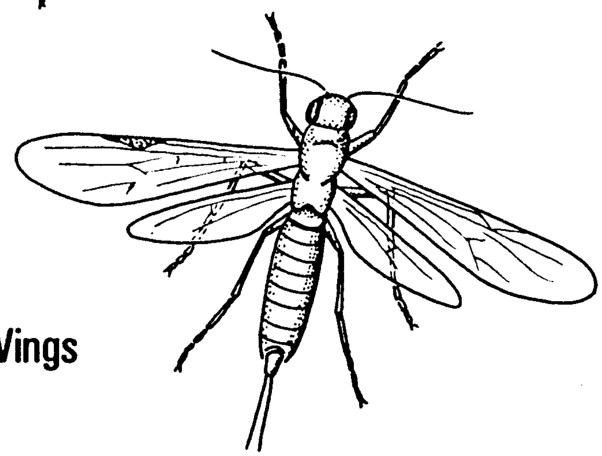


Adult Insects



Wings and Mouthparts

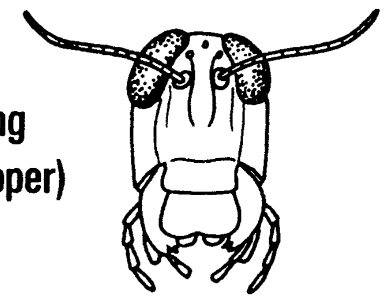
Two Wings



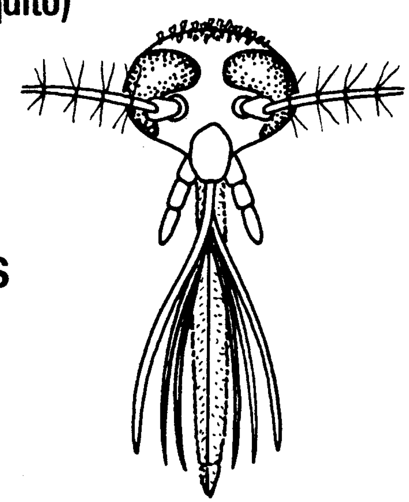
Four Wings

Wings

Chewing
(Grasshopper)

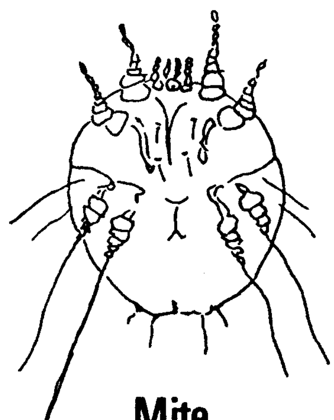


Sucking
(Mosquito)

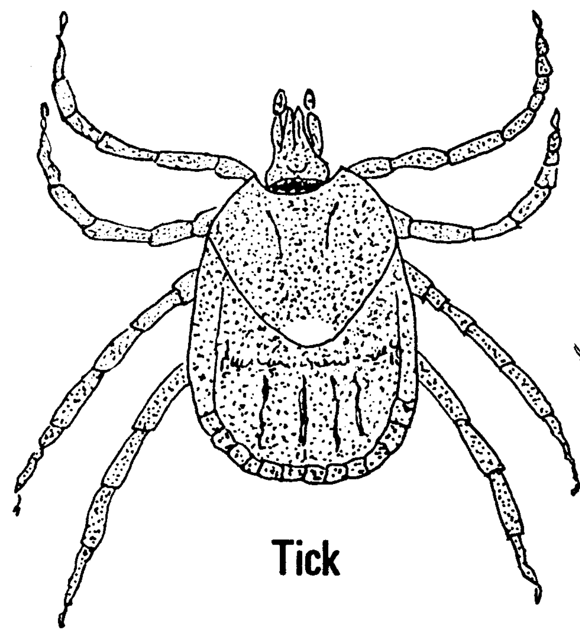


Mouthparts

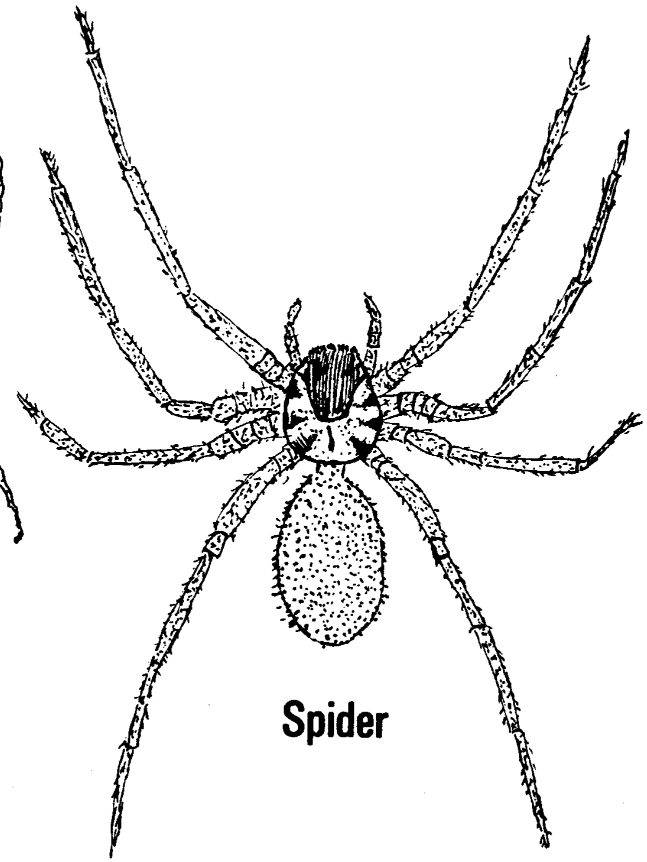
Mite, Tick, and Spider



Mite

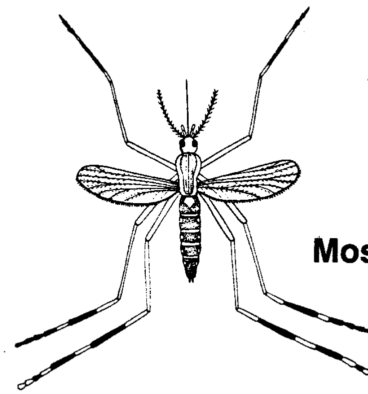


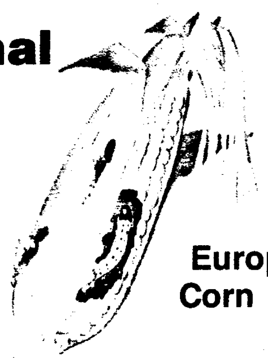
Tick

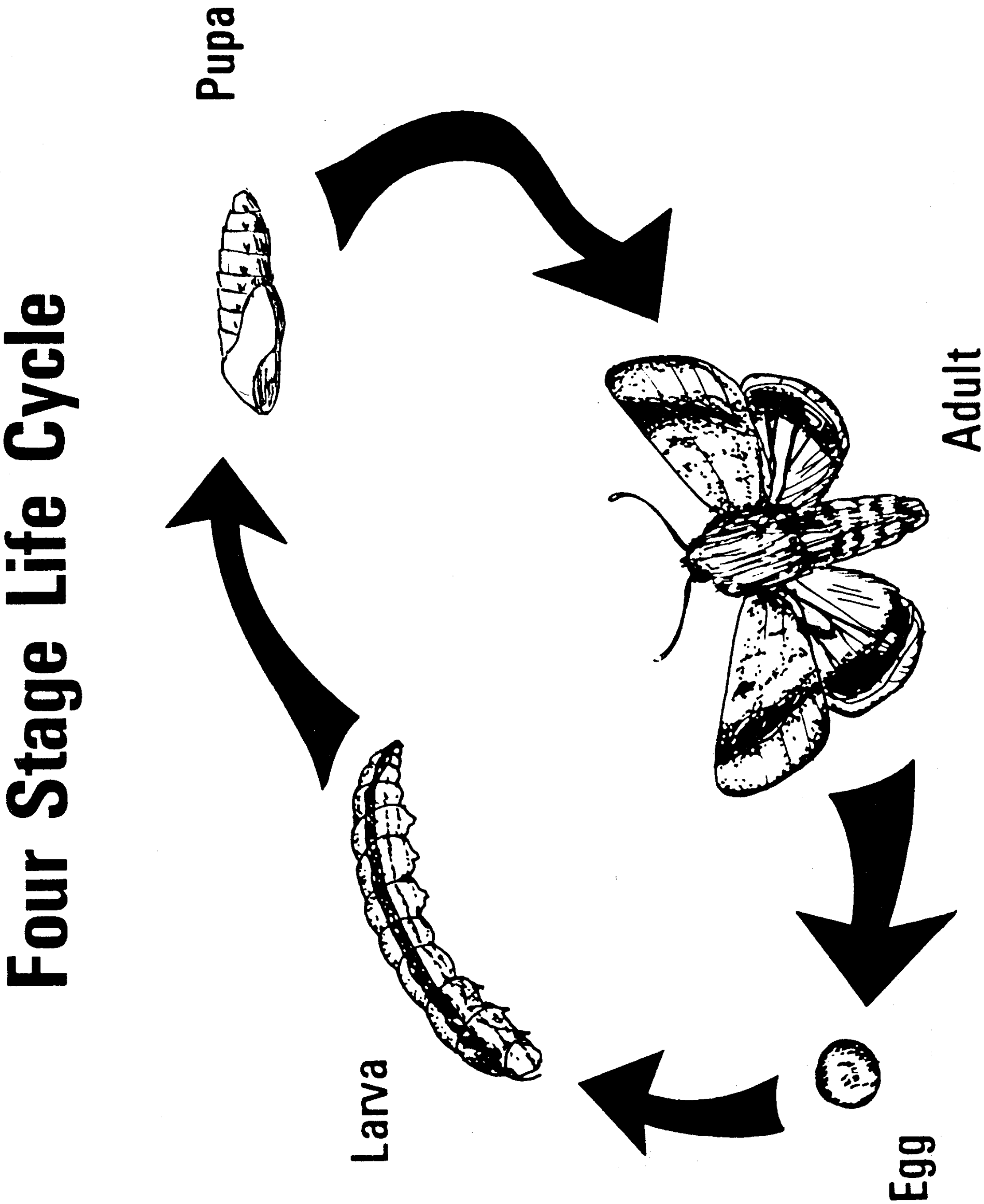


Spider

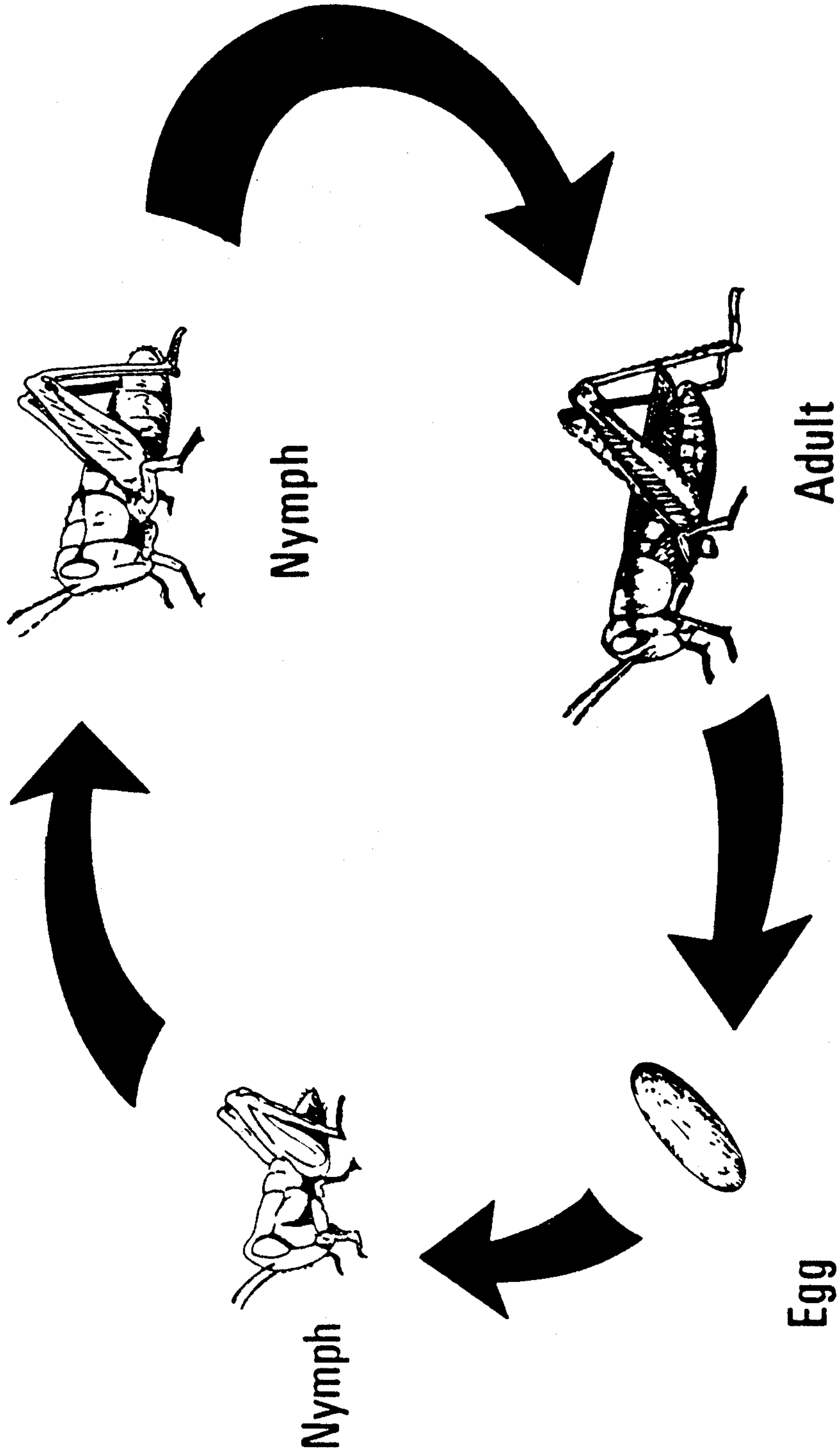
Insect Classification According to Feeding Habits






Four Stage Life Cycle
Pupa
Adult
Egg
Larva

Three Stage Life Cycle



INSECT PESTS OF CROPS

AG 510 - H

UNIT TEST

Name___________________________________ Score_________________________________

1. Match terms associated with insect pests of crops to the correct definition. Write the correct numbers in the blanks.

_____a.	A change in form, either gradual or sudden	1.	Insect
_____b.	A silken case inside which the pupa is formed	2.	Spider
_____c.	Stages in the development of an insect	3.	Mite
_____d.	Chemical used to control pests	4.	Entomology
_____e.	Any of a large number of tiny arachnids, many of which live as parasites upon plants	5.	Life cycle
		6.	Metamorphosis
_____f.	Immature form of an insect having complete metamorphosis	7.	Complete metamorphosis
_____g.	Associated with crop loss and/or reduction in crop yield or crop quality	8.	Incomplete metamorphosis
_____h.	A branch of science that deals with the study of insects	9.	Larva
_____i.	A small, eight legged arachnid having a body composed of two divisions	10.	Pupa
		11.	Cocoon
_____j.	Gradual change in appearance as growth proceeds	12.	Nymph
_____k.	Stage between the larva and adult in insects with complete metamorphosis	13.	Damage
_____l.	A pesticide used to kill or control insects	14.	Injury
_____m.	Having four distinct growth stages in development in which a major change in structure and appearance of the insect occurs	15.	Pesticide
		16.	Insecticide
_____n.	The immature stage of an insect with incomplete metamorphosis	17.	Acaricide
_____o.	Deviation from normal appearance of the plant, from which it may recover and not depress yield and/or quality		

_____p. Pesticide used to control mites, ticks and spiders

_____q. Small, boneless animal whose body is divided into three sections and has six legs

2. Name three ways insects cause losses to crops.

   a. ____

   b. ____

   c. ____

3. Discuss beneficial effects of insects.

   ____

   ____

   ____

   ____

4. Discuss the economic importance of insect control.

   ____

   ____

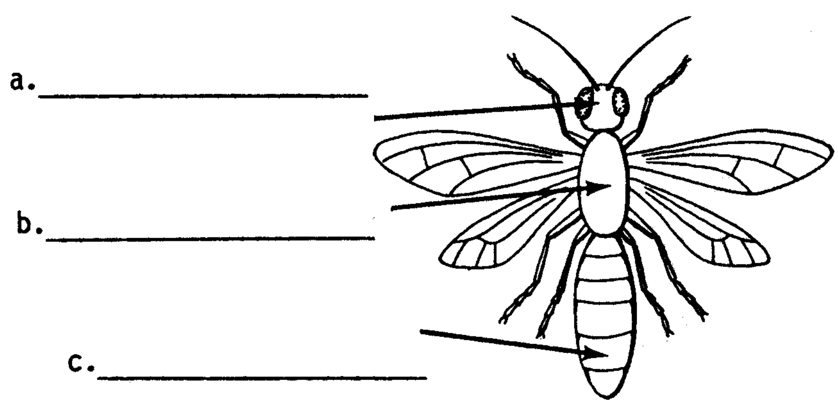
   ____

   ____

   ____

   ____

5. Label the body regions of an insect. Write the correct names in the blanks.



6. Name two characteristics which aid in distinguishing one insect from another.

a. ______________________________

b. ______________________________

7. Name three identifying characteristics of mites, ticks and spiders.

a. ______________________________

b. ______________________________

c. ______________________________

8. Describe the four insect classifications by feeding habits and give two examples of each.

Chewing ______________________________

____

a. ______________________________

b. ______________________________

Sucking ______________________________

____

a.. ______________________________

b. ______________________________

Internal ______________________________

____

a. ______________________________

b. ______________________________

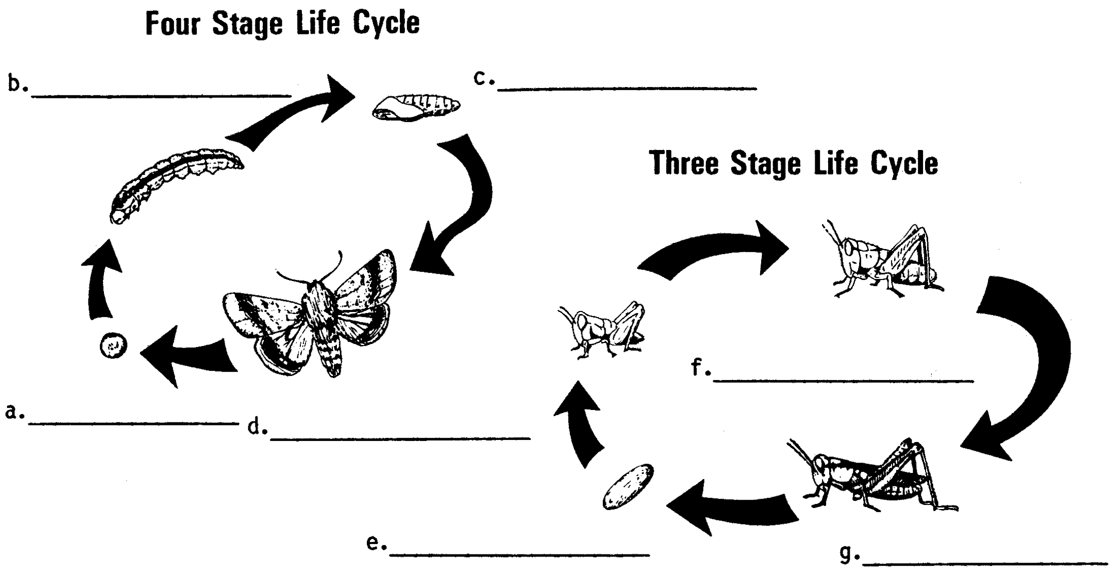
Subterranean ______________________________

____

a. ______________________________

b. ______________________________

9. Label the life cycles of insects. Write the correct names in the blanks.



10. List six cultural control practices for insects.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

11. Describe biological control practices for insects.

____

____

____

12. List three chemical control practices for insects.

a. ______________________________

b. ______________________________

c. ______________________________

13. Describe the three classifications of insecticides.

    a. Fumigant poison ____

    ____

    b. Stomach poison____

    ____

    c. Contact poison ____

    ____

INSECT PESTS OF CROPS

AG 510 - H

ANSWERS TO TEST

1.

a.	6	f.	9	k.	10	p.	17
b.	11	g.	13	l.	16	q.	1
c.	5	h.	4	m.	7		
d.	15	i.	2	n	12		
e.	3	j.	8	o.	14		

2. Answer should include three of the following:

   Reduce crop yield; Reduce crop quality; Cost of control activities; Transmit plant disease

3. Discussion should include information from the following:

   Carry pollen for pollination which is essential to seed production of many crops; Natural enemies which control pest insects; Production of useful products such as honey, beeswax and silk

4. Answer may include information from the following:

   $1 billion spend annually on insect control; $5 billion estimated losses; Estimated 5% - 10% of total crop damaged; Over $100 million spent yearly on cotton alone

5. a. Head
   b. Thorax
   c. Abdomen

6. Wings; Mouthparts

7. Eight jointed legs; Two body regions; No wings

8. Answers should include the following information and two examples for each:

   Chewing: These insects bite off, chew and swallow plant parts. This results in ragged, deformed or stunted plants that may be more susceptible to disease and may die due to excessive damage; Examples: Grasshopper; Armyworm; Potato beetle; Blister beetle
   Sucking: These insects pierce the outer layer of the plant tissue with their "coke straw" beak and feed on the plant sap; Examples: Aphid; Leafhopper; Thrips; Hessian Fly; Greenbug
   Internal (borers and miners): This group includes mostly chewing insects that enter the plant and feed from within; Examples: European corn borer; Cotton boll weevil larva; Wheat stem sawfly
   Subterranean: This group includes both chewing and sucking insects which enter the plant below the soil surface; Examples: Corn rootworm; Wireworm;

9.

a.	Egg	e.	Egg
b.	Larva	f.	Nymph
c.	Pupa	g.	Adult
d.	Adult		

10. Crop rotation; Trap crops; Tillage; Residue management; Timing of operations; Resistant varieties

11. Natural enemies to a particular insect; The use of natural enemies, for example: predators, parasites and insect disease, sometimes can be used to control a pest

12. Poison the insects; Repel the insects from specific areas; Attract insects to a place where they can be killed

13. Fumigant poision--Enters the insect's body through the respiratory system in the form of a gas; Stomach poison--Eaten and digested by the insect; Contact poison--Absorbed through the insect's skin or body wall and acts upon the pest's nervous system

PLANT DISEASES

AG 510 - I

UNIT OBJECTIVE

After completion of this unit, students should be able to match terms and definitions, list the five groups of biological pathogens and discuss methods of prevention and control of plant disease. This knowledge will be demonstrated by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with plant disease to the correct definitions.
2. Name three ways diseases cause economic loss in plants.
3. List the five groups of biological pathogens.
4. List and define the two types of fungi.
5. List four methods by which pathogens spread.
6. Describe the six general approaches to disease control.
7. List three primary disease control methods available to the farmer.
8. List five practices used to control plant diseases.
9. Select diseases caused by fungal infection.
10. Select diseases caused by bacterial infection.
11. Select diseases caused by viral infection.
12. Select diseases caused by nematode infection.
13. Select diseases caused by mycoplasm infection.

PLANT DISEASES

AG 510 - I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *Field Crop Diseases*, manual available from Ohio Agriculture Education Curriculum Materials Center, Ohio State University, Columbus, Ohio 43210; approximate cost $3.00; order no. 1017M.

2. Filmstrips, slideshows, etc.

a. *Symptomology and Control of Common Crop Disease*, 107 slides and cassette; available from Hobar Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112; approximate cost $145.60; order no. D12.

B. Make transparencies and necessary copies of materials.

C. Provide students with objective sheet and discuss.

D. Provide students with information sheet and discuss.

E. Invite local extension agent or crop specialist to speak to class on local diseases and control practices.

F. Review and give test.

G. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Biological Pathogens

2. TM 2--Means by Which Pathogens Spread

3. TM 3--Symptoms of Diseases

4. TM 4--Fungi

5. TM 5--Fungi

6. TM 6--Bacterial Diseases

7. TM 7--Bacterial Diseases - Cotton Leaf Blight

8. TM 8--Viruses

9. TM 9--Nematodes

E. Test

F. Answers to test

III. Unit references

A. Delorit, R.J., et al., *Crop Production*, 5th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1984.

B. Hartmann, Hudson T., et al., *Plant Science - Growth, Development, and Utilization of Cultivated Plants*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1988.

C. *Insect and Disease Control*, Vo-Ag II, Unit IV-D, Vocational Instructional Services, Texas A & M University, College Station, Texas.

D. *Plant Diseases*, Ag II, Unit VIII, Oklahoma State Board for Vocational-Technical Education, Oklahoma State University, Stillwater, Oklahoma.

PLANT DISEASES

AG 510 - I

INFORMATION SHEET

I. Terms and definitions

A. Plant disease--An abnormal plant condition caused by a pathogen or improper environmental condition

B. Pathogen--A disease-producing agent

C. Host--Plant that is susceptible to a pathogen

D. Fungi--Small filamentous organisms that lack chlorophyll and which cause rots, mildews and other diseases

E. Bacteria--A single-celled microscopic organism

F. Nematode--Tiny, tubular, unsegmented, eel-like worms that feed on plant parts

G. Nematicide--Pesticide used to control nematodes

H. Virus--A submicroscopic entity consisting of nucleic acids and amino acids capable of causing mosaic and other diseases

I. Blight--Rapid discoloration and death of tissue over certain portions of the plant

J. Fungicide--Chemical or biological material used to kill or destroy fungi

K. Resistant--Inherited ability of a plant to retard growth of disease-causing organisms

L. Scab--Crust-like, diseased lesion produced as a result of disease infection

M. Lesion--A localized area of discolored diseased tissue

N. Wilt--Loss of freshness and drooping leaves

O. Gall--Knob on the plant parts produced by certain nematodes, bacteria or fungi causing stunting, chlorosis, necrosis, malformations and may result in reduction of yield or quality

P. Chlorosis--Loss of green color (yellowing or whitening) in foliage

Q. Symptom--Evidence or indicator of disease; reaction of a plant to a pathogen

R. Necrosis--Death of plant parts

S. Sign--Visible evidence of the pathogen

II. Diseases cause economic loss in plants

A. Reduced yield

B. Reduced crop quality

C. Spoilage in storage and transportation

D. Render food unfit for use

E. Cost of control activities

III. Groups of biological pathogens (Transparency 1)

A. Fungi

B. Bacteria

C. Virus and viroids

D. Nematodes

E. Mycoplasmas

IV. Types of fungi

A. Saprophytic fungi--Fungi that live on dead or decaying organic matter

(Note: They are important because they eventually release the nutrients they take from dead plants and animals, thus contributing to soil fertility. Some species, such as mushrooms and truffles, are edible and of considerable economic importance.)

B. Parasitic fungi--Fungi that live on or in a living host plant; may be obligate or non-obligate parasites

(Note: About 7500 parasitic fungi are of economic importance because of the damage and yield reduction in affected crops.)

V. Means by which pathogens spread (Transparency 2)

A. Wind

B. Rain

C. Insects, mites

D. Machinery

VI. General approaches to disease control (Transparency 3)

(Note: Satisfactory control of most plant diseases requires the application of several control measures and usually involves an integrated program of environmental, biological and chemical factors. Correct diagnosis is essential to plant disease control. Then, control involves the application of one or more of the following principles.)

A. Avoidance--Avoiding disease by planting when and/or where pathogens are ineffective or absent

B. Exclusion--Keeping pathogens out of a "clean" area

C. Eradication--Eliminating the pathogen source, whether an infected plant, field or region

D. Protection--Preventing an infection by using a chemical or physical barrier to keep pathogens out

E. Resistance--Using plants that tolerate, resist or are immune to the disease

F. Therapy--Reducing the severity of disease in an infected plant

VII. Primary disease control methods available to the farmer

A. Cultural practices

(Note: Crop management to minimize development of disease is the oldest and most applicable approach. A pathogen and its host must be brought together under proper environmental conditions for a disease to develop. Cultural practices are used to alter the environment, the condition of the host or the behavior of the pathogen to prevent an infection.)

B. Control through disease resistance

(Note: Resistant varieties have been one of the major factors in maintaining high levels of crop productivity in the United States. For many diseases of forage and field crops with relatively low values per acre, chemical controls often cannot be used because the profit margin is too low. For these cases, resistant varieties provide the only means of ensuring continued protection.)

C. Chemical control

(Note: The use of fungicides is dependent on the crop, the disease and the specific conditions for use. For specific recommendations, contact your county extension agent or chemical supplier. For best results, the chemicals should be used with other control methods in a planned strategy.)

VIII. Practices used to control plant diseases

A. Use of resistant varieties

B. Eradication of alternate host plants

C. Treatment of soil

D. Rotation of crops

E. Destruction of plant residue

F. Use of disease-free seed

G. Applications of fungicides

IX. Diseases caused by fungal infection (Transparencies 4, 5)

A. Rusts--Wheat, oats, barley, rye

B. Powdery mildew--Grains, legumes

C. Downey mildew--Grains, alfalfa, onions, cucumbers

D. Smuts--Corn, wheat, oats, barley, grasses

E. Ergot--Rye, wheat, barley and other grasses

F. Scab--Barley, wheat, rye

G. Seed decay, damping off, root rots--All plants

H. Wilts--Potatoes, alfalfa, trees

I. Soft rots, dry rots--Fleshy organs, potatoes, onions, carrots, etc.

J. Scab--Potatoes

K. Cankers--Woody plants

X. Diseases caused by bacterial infection (Transparencies 6, 7)

A. Bacterial wilts--Corn, alfalfa, potatoes

B. Galls--Crown gall on many crops, trees

C. Leaf spot--Cotton, beans, peas, trees

D. Blights--Vegetable crops, fruit trees

E. Cankers--Woody plants

F. Soft rots--Fleshy or succulent plant parts

XI. Diseases caused by viral infection (Transparency 8)

A. Mosaic--Tomatoes, potatoes, beans, corn, small grains, forage, legumes, peas, sugarbeets, cucurbits

B. Curly top--Tomato, beans, sugarbeets

C. Yellows--Barley yellow dwarf, potato leaf roll, sugarbeet yellows

XII. Diseases caused by nematode infections (Transparency 9)

A. Galls--Root-knot nematodes; over 2,000 hosts

B. Hairy root--Cyst nematodes; sugarbeets, soybeans, potatoes

C. Root lesions--Lesion nematodes; over 2,000 hosts

D. Necrosis, stunting--Foliar nematodes; alfalfa, clover, onions

XIII. Diseases caused by mycoplasmas

A. Aster yellows--Several hosts

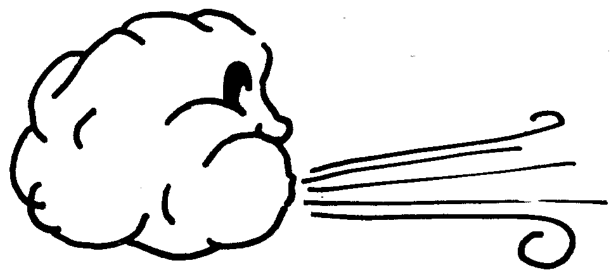
B. Pear decline--Pears

C. Western X--Stone fruit trees

Biological Pathogens

1. Fungi
2. Bacteria
3. Virus and viroids
4. Nematodes
5. Mycoplasmas

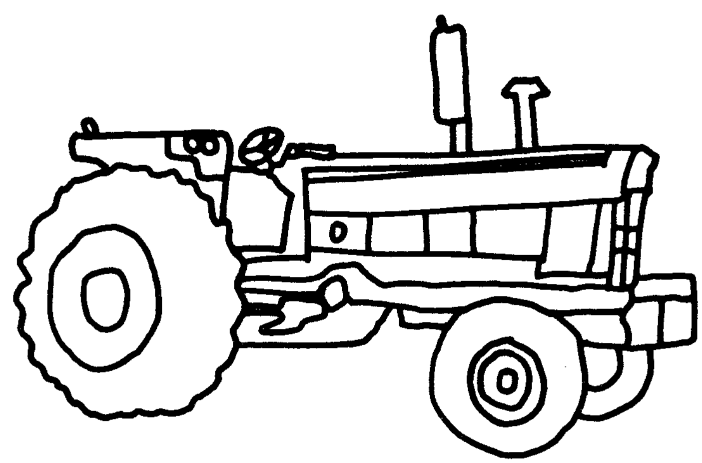
Means by Which Pathogens Spread



Wind

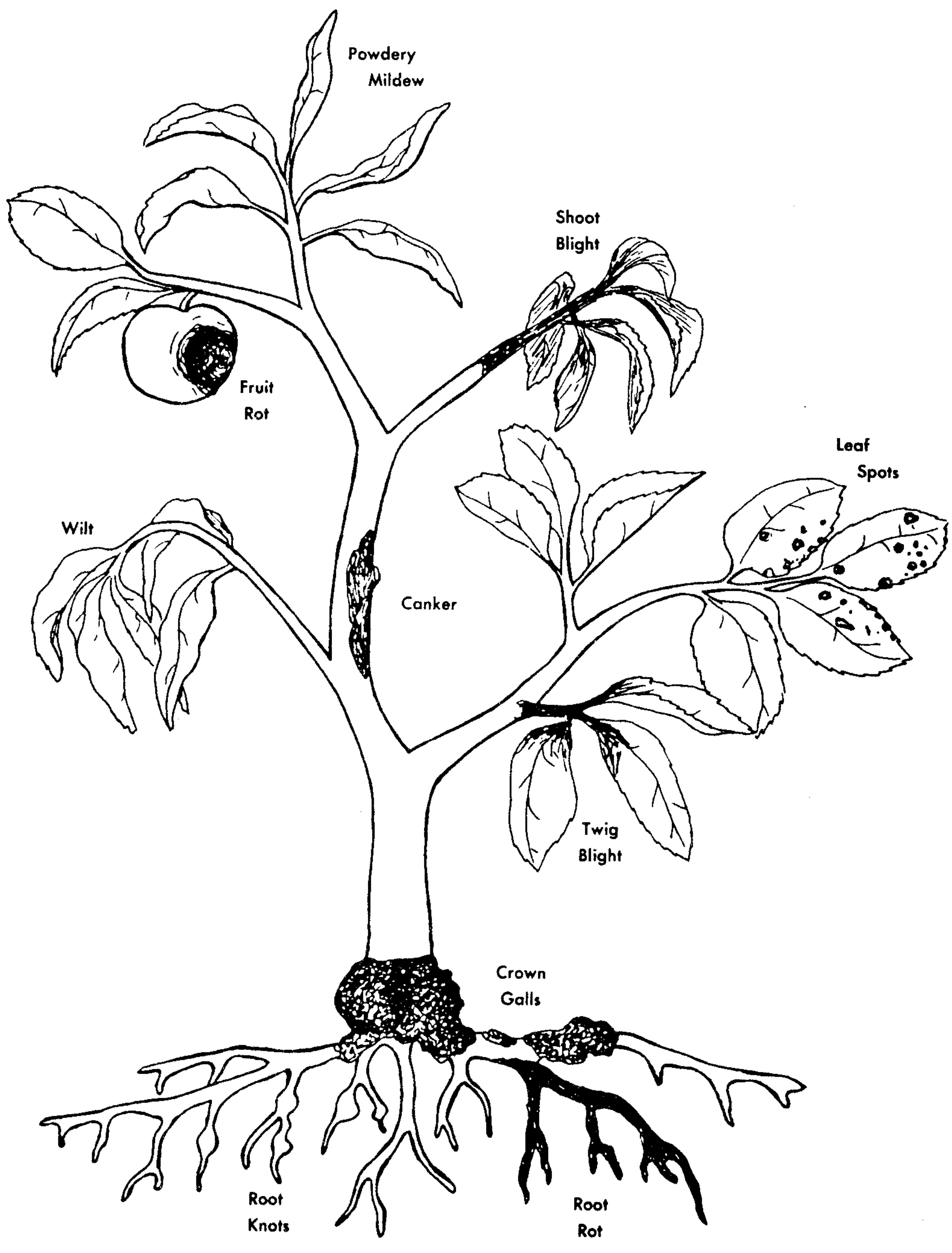
Insects

Rain

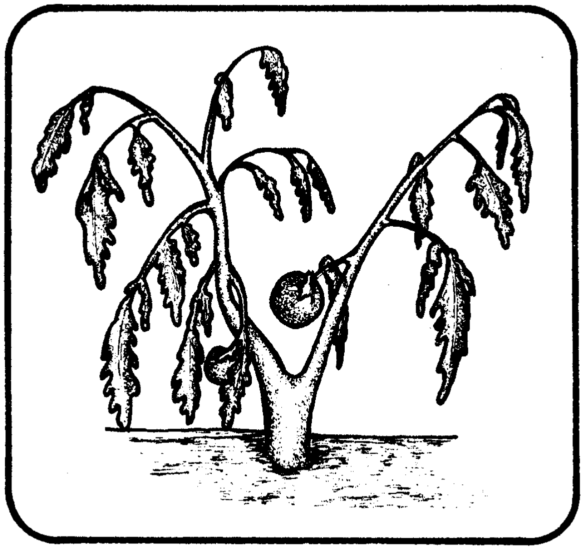


Machinery

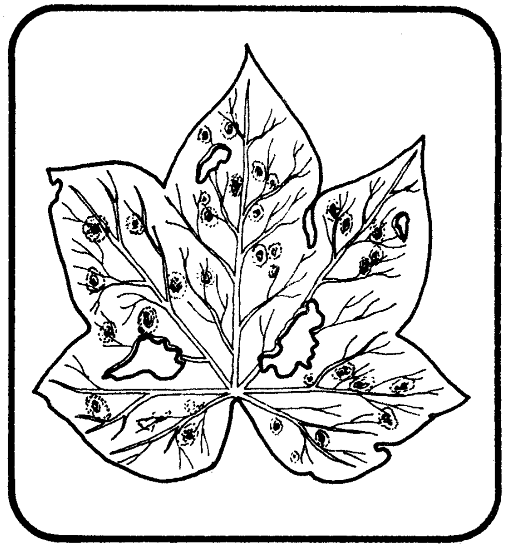
Symptoms of Diseases



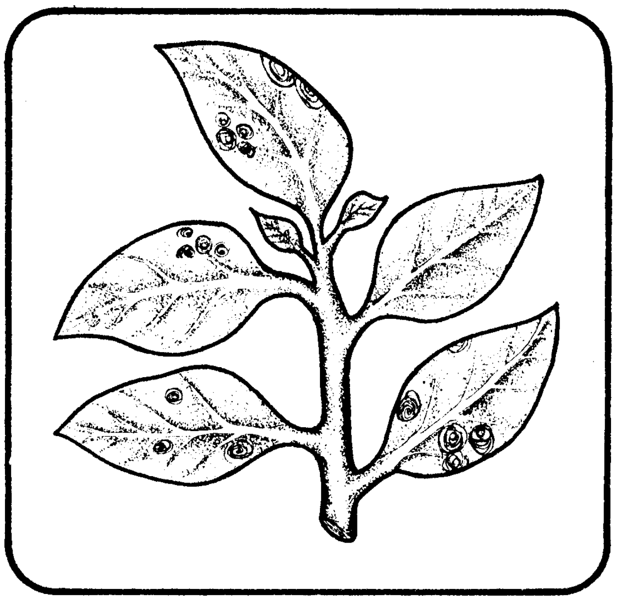
FUNGI



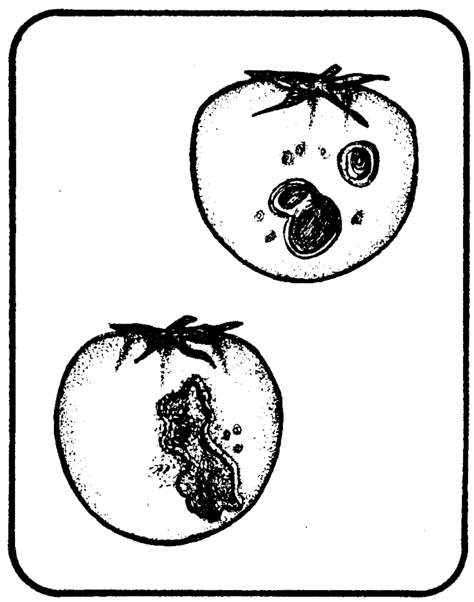
WILT - CAUSED BY FUNGI ENTERING ROOT AND STEM



RUST ON COTTON

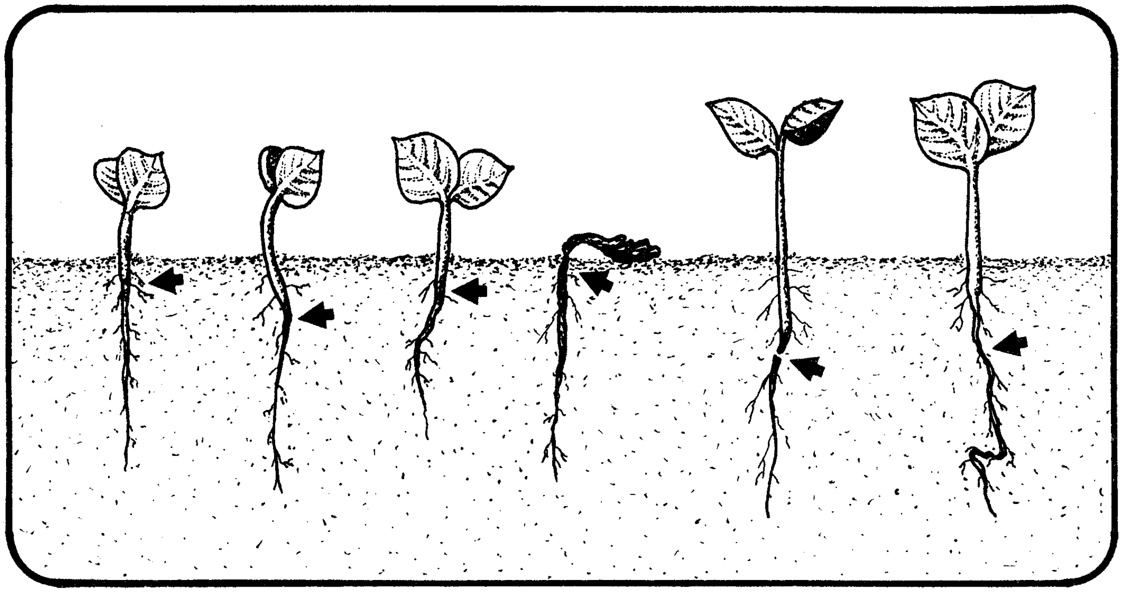


LEAF SPOT - OR EARLY BLIGHT

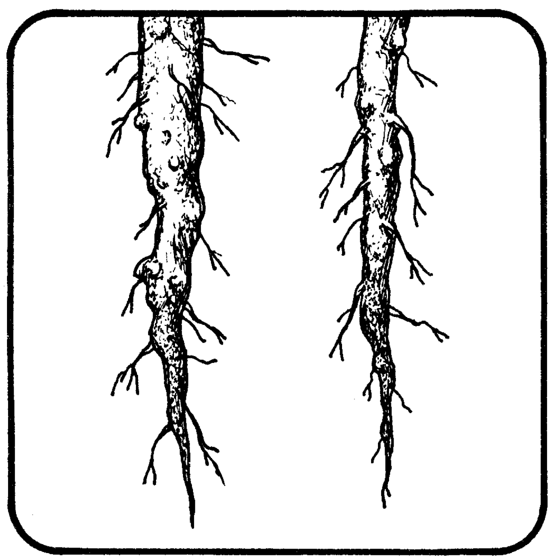


SOIL ROT IN WET SOIL

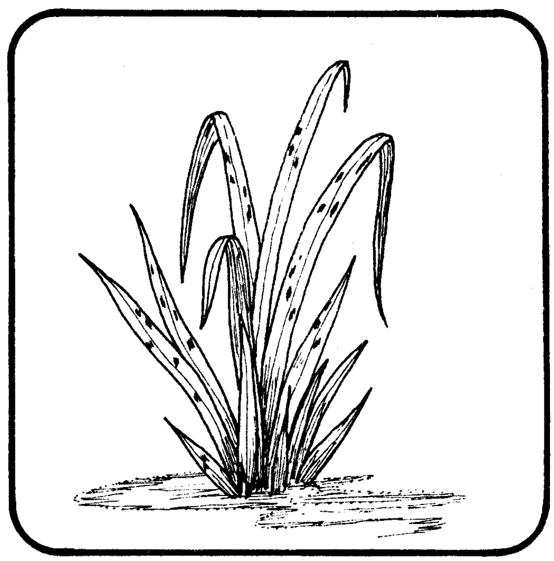
FUNGI



YOUNG PLANT ROOTS DESTROYED BY FUNGI

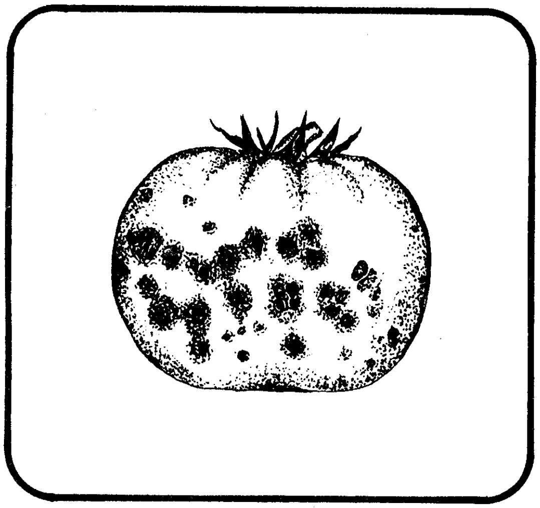


COTTON ROOT ROT

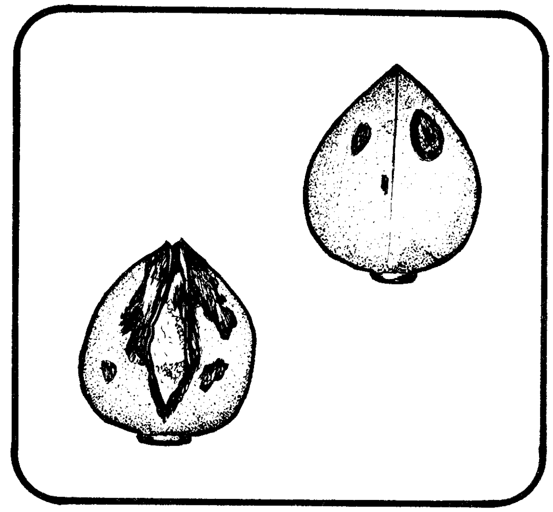


RUST FUNGUS ON GRASS

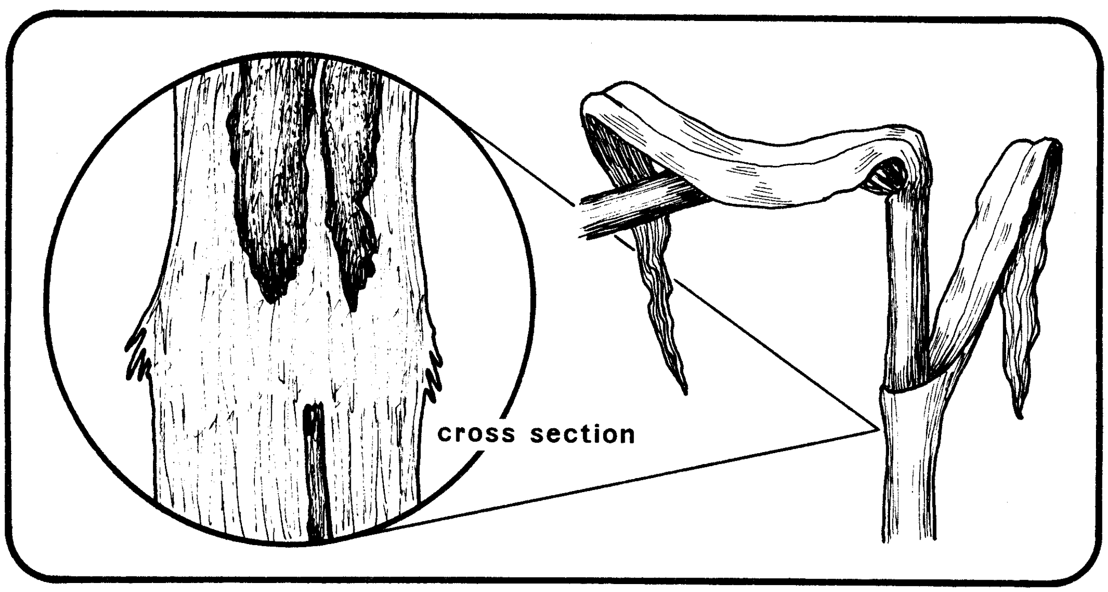
BACTERIAL DISEASES



BACTERIAL SPOT
ON TOMATO



BACTERIAL BLIGHT
ON COTTON BOLLS

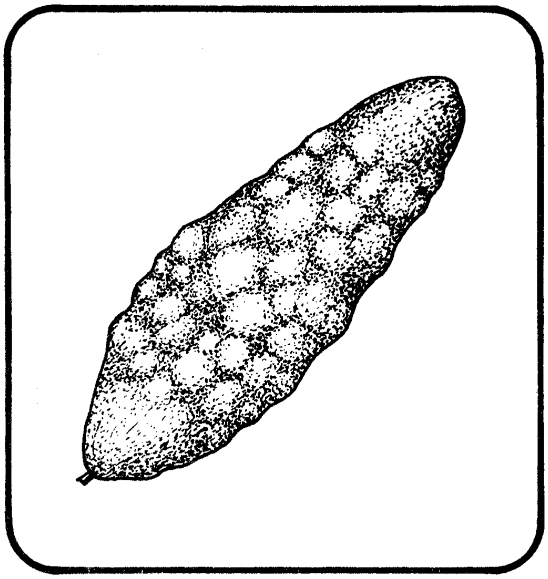


STALK ROT DISEASE IN CORN PLANT

Bacterial Diseases

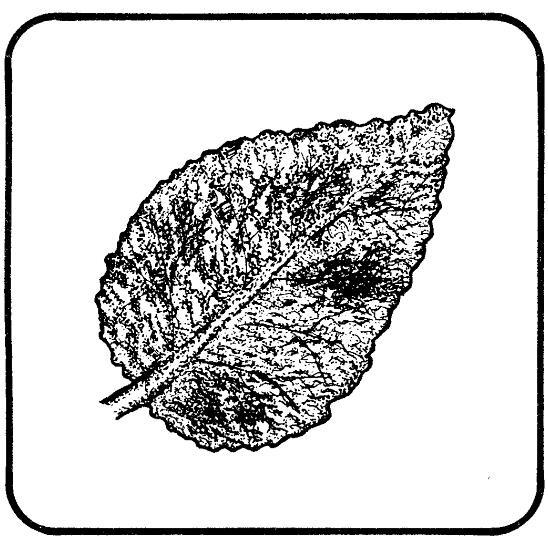
Cotton Leaf Blight

VIRUSES

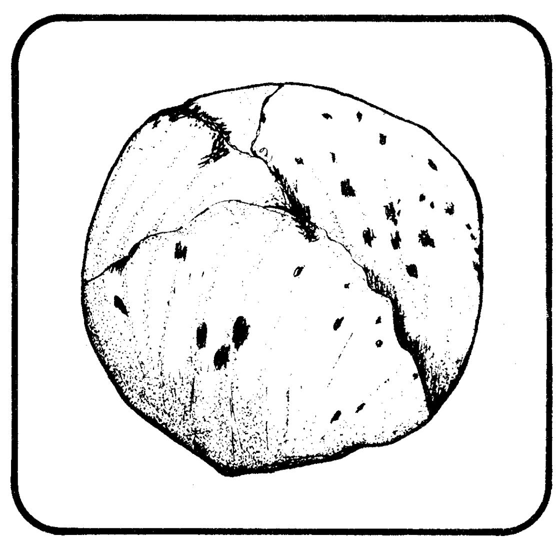


CUCUMBER WITH DARK GREEN WARTS - MOSAIC VIRUS

DARK GREEN MOTTLING DUE TO MOSAIC VIRUS

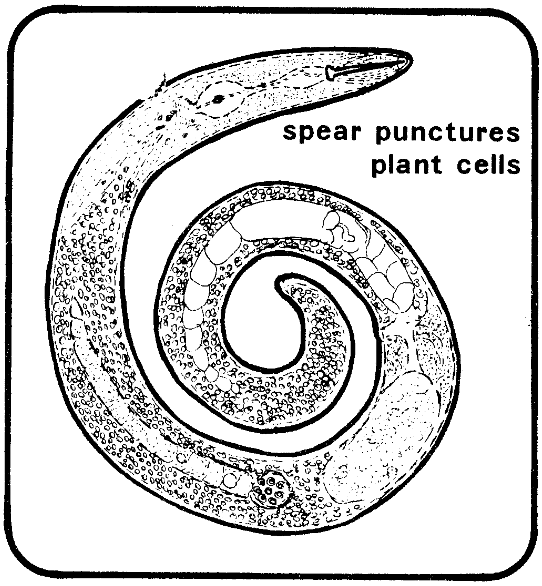


LEAF WRINKLED DUE TO VIRUS

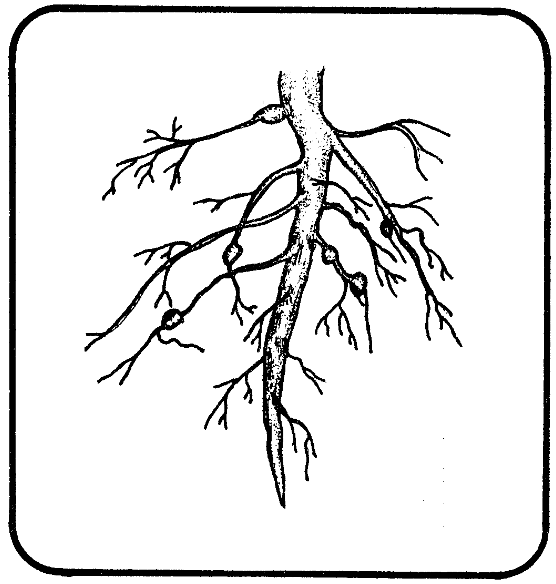


MOSAIC VIRUS ON CABBAGE

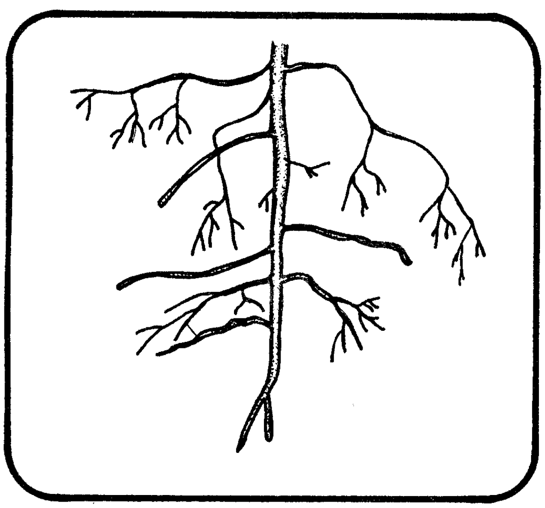
NEMATODES



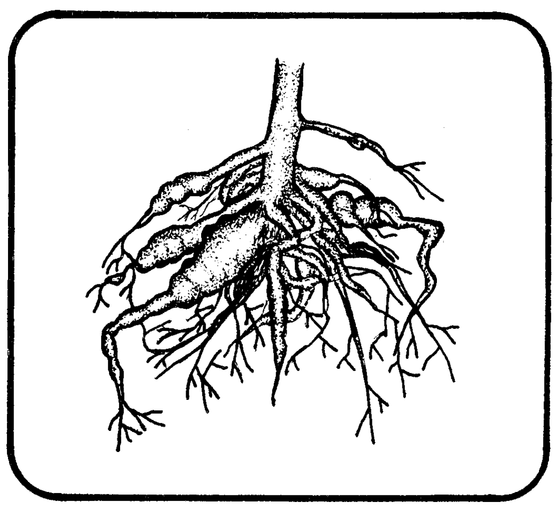
NEMATODE
(size less than 2.0 mm)



GALLS OR KNOTS ON ROOTS



STUBBY ROOT OR
PENIFORM NEMATODE



ROOT KNOT DISEASE

PLANT DISEASES

AG 510 - I

UNIT TEST

Name____ Score_______________________________

1. Match terms associated with plant disease identification and control to the correct definitions. Write the correct numbers in the blanks.

_____a.	Knob on the plant parts produced by certain nematodes, bacteria or fungi; may result in reduction of yield or quality		1.	Plant disease
			2.	Pathogen
_____b.	Chemical material used to kill or destroy fun		3.	Host
_____c.	A single-celled microscopic organism		4.	Fungi
_____d.	A disease-producing agent		5.	Bacteria
_____e.	Inherited ability of a plant to retard growth of disease-causing organisms		6.	Nematode
			7.	Nematicide
_____f.	Loss of green color in foliage		8.	Virus
_____g.	Death of plant parts		9.	Blight
_____h.	Crust-like, diseased lesion produced as a result of disease infection		10.	Fungicide
_____i.	An abnormal plant condition caused by a pathogen or improper environmental condition		11.	Resistant
			12.	Scab
_____j.	Evidence or indicator of disease; reaction of a plant to a pathogen		13.	Lesion
_____k.	Small, filamentous organisms that lack chlorophyll and which cause rots, mildews and other diseases		14.	Wilt
			15.	Gall
_____l.	Pesticide used to control nematodes		16.	Chlorosis
_____m.	Loss of freshness and drooping leaves		17.	Symptom
_____n.	Visible evidence of the pathogen		18.	Necrosis
_____o.	Tiny, tubular, unsegmented, eel-like worms that feed on plant parts		19.	Sign
_____p.	A submicroscopic entity consisting of nucleic acids and amino acids capable of causing mosaic and other diseases			

_____q. A localized area of discolored diseased tissue

_____r. Rapid discoloration and death of tissue over certain portions of the plant

_____s. Plant that is susceptible to a pathogen

2. Name three ways diseases cause economic loss in plants.

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Name the five groups of biological pathogens.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

4. List and define the two types of fungi.

   a. ______________________________

   ____

   b. ______________________________

   ____

5. List four methods by which pathogens spread.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

6. Describe the six general approaches to disease control.

   a. Avoidance ______________________________

   ____

b. Exclusion ____

____

c. Eradication ____

____

d. Protection ____

____

e. Resistance ____

____

f. Therapy ____

____

7. Name three primary disease control methods available to the farmer.

a. ____

b. ____

c. ____

8. List five practices used to control plant diseases

a. ____

b. ____

c. ____

d. ____

e. ____

9. Select from the following list diseases caused by fungal infection. Write an "X" in the blank before each correct answer.

_____a. Bacterial blight

_____b. Dry rots

_____c. Mosaic

_____d. Seed decay

_____e. Ergot

_____f. Rusts

10. Select from the following list diseases caused by bacterial infection. Write an "X" in the blank before each correct answer.

_____a. Smuts

_____b. Galls

_____c. Cankers

_____d. Hairy root

_____e. Curly top

_____f. Bacterial wilts

11. Select from the following list diseases caused by viral infection. Write an "X" in the blank before each correct answer.

_____a. Mosaic

_____b. Curly top

_____c. Yellows

_____d. Hairy rot

_____e. Powdery mildew

_____f. Blights

12. Select from the following list diseases caused by nematode infection. Write an "X" in the blank before each correct answer.

_____a. Rusts

_____b. Pear decline

_____c. Root lesions

_____d. Western X

_____e. Mosaic

_____f. Hairy root

_____g. Necrosis

13. Select from the following list diseases caused by mycoplasm infection. Write an "X" in the blank before each correct answer.

_____a. Aster yellows

_____b. Downey mildew

_____c. Western X

_____d. Blights

_____e. Pear decline

_____f. Root lesions

PLANT DISEASES

AG 510 - I

ANSWERS TO TEST

1.

a.	15	f.	16	k.	4	p.	8
b.	10	g.	18	l.	7	q.	13
c.	5	h.	12	m.	14	r.	9
d.	2	i.	1	n.	19	s.	3
e.	11	j.	17	o.	6		

2. Answer should include three of the following:

   Reduced yield; Reduced crop quality; Spoilage in storage and transportation; Render food unfit for use; Cost of control activities

3. Fungi; Bacteria; Virus and viroids; Nematodes; Mycoplasmas

4. Saprophytic fungi--Fungi that live on dead or decaying organic matter; Parasitic fungi--Fungi that live on or in a living host plant; May be obligate or non-obligate parasites

5. Wind; Rain; Insects, mites; Machinery

6. <u>Avoidance</u>--Avoiding disease by planting when and/or where pathogens are ineffective or absent; <u>Exclusion</u>--Keeping pathogens out of a "clean" area; <u>Eradication</u>--Eliminating the pathogen source, whether an infected plant, field or region; <u>Protection</u>--Preventing an infection by using a chemical or physical barrier to keep pathogens out; <u>Resistance</u>--Using plants that tolerate, resist, or are immune to the disease; <u>Therapy--</u>Reducing the severity of disease in an infected plant

7. Cultural practices; Control through disease resistance; Chemical control

8. Answer should include five of the following:

   Use of resistant varieties; Eradication of alternate host plants; Treatment of soil; Rotation of crops; Destruction of plant residue; Use of disease-free seed; Application of fungicides

9. b, d, e, f

10. b, c, f

11. a, b, c

12. c, f, g

13. a, c, e

BIOTECHNOLOGY

AG 510 - J

UNIT OBJECTIVE

After completion of this unit, students should be able to define biotechnology and list four broad applications of biotechnology in agriculture. Students should also be able to describe current genetic research projects in plants and animals of major impact on agriculture. This knowledge will be demonstrated by completion of assignment sheets, a laboratory exercise and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms related to biotechnology to their correct definitions.
2. Define biotechnology.
3. List four broad applications of biotechnology in agriculture.
4. List four common uses of biotechnology in agricultural science that have been around for some time.
5. List and explain the three major techniques of biotechnology.
6. Describe five current genetic research projects in plants of major impact on agriculture.
7. Describe five current genetic research projects in animals of major impact on agriculture.
8. List four areas of biotechnology applications in food processing.
9. Describe four areas of public concern about biotechnology.
10. Match the occurrence in the history of genetic engineering to the correct year of occurrence.
11. List eight areas of career opportunities in biotechnology.
12. List eight specific occupational titles in agricultural biotechnology.
13. Discuss in detail the process of using tissue culture for plant development.
14. Determine the ethics of biotechnology.
15. Research a career in biotechnology.
16. Make yogurt.

BIOTECHNOLOGY

AG 510 - J

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

A. Order materials to supplement unit.

1. Literature

a. *AgBiotechnology: Agricultural Research/Business News*, magazine published bimonthly by Freiberg Publishing, Box 7, Cedar Falls, Iowa 50613; $65 for one year subscription.

b. *Biotechnology*, available from Agricultural Communications Center, Ag Publications Building, University of Idaho, Moscow, Idaho 83843-4196 (208-885-7982); no charge; order no. MS 96.

c. *Careers in Biotechnology*, available from Industrial Biotech Association, Suite 1100, 1625 K St. NW, Washington, DC 20006; free.

d. *The Science Workbook*--Experiments in Ag Science, available from Ohio State University, College of Agriculture, 206 Ag Administrations, Columbus, Ohio 43210.

2. Films

a. *Biotechnology - Breaking New Ground*, available from North Carolina Biotech Center, Box 13547, Research Triangle Park, North Carolina 27709.

b. *Biotechnology - The New Biology and Agriculture*, available from Industrial Biotech Association, Suite 1100, 1625 K St. NW, Washington, DC 20006.

c. *Connections: Animal, Man and Biotechnology*, 17 minutes; available from New Dimension Media, Inc., 85895 Lorane Hwy., Eugene, Oregon 97405 (503-487-7125); rental fee $30/day; purchase price $250.

d. *Genetic Engineering*, videotape; available from Modern Talking Picture Service, 5000 Park Street N., St. Petersburg, Florida 33709.

e. *Of the Earth: Agriculture and the New Biology*, 28 minutes; available from New Dimension Media, Inc., 85895 Lorane Hwy, Eugene, Oregon 97405 (503-487-7125); rental fee $30/day; purchase price $250.

B. Make transparencies and necessary copies of materials.

C. Provide students with objectives and discuss.

D. Provide students with information and discuss.

E. Have students clip newspaper and magazine articles on biotechnology and briefly summarize them to the class.

F. Provide students with assignment sheets and laboratory exercise.

G. Discuss assignment sheets.

H. Demonstrate and discuss procedures outlined in laboratory exercise.

I. Review and give test.

J. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM 1--Biotechnology Applications for Plant Agriculture: Present and Future

2. TM 2--Biotechnology Applications for Animal Agriculture: Present and Future

3. TM 3--Biotechnology Applications in Food Processing

E. Assignment sheets

1. AS 1--Determining the Ethics of Biotechnology

2. AS 2--Research a Career in Biotechnology

F. Instructor notes for laboratory exercise

G. Laboratory exercise

1. LE 1--Making Your Own Yogurt

H. Test

I. Answers to test

III. Unit references

A. *Agricultural Education Curriculum*, College of Agriculture, University of Illinois, Urbana, Illinois.

B. *Animal Biotechnology*, Upjohn, Kalamazoo, Michigan 49001.

C. Barrick, R. and Harmon, H., *Animal Production and Management*, McGraw-Hill Book Company, New York, 1988.

D. Bearden and FuQuay, *Applied Animal Production*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1980.

E. Bundy, C.E., et al., *Livestock and Poultry Production*, 5th edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1982.

F. Ensminger, M.E., *Animal Science*, Interstate Publishers, Danville, Illinois, 1983.

G. *Idaho Agriscience Workshop* - Secondary Agriculture Instructors, Department of Agricultural and Extension Education, University of Idaho, Moscow, Idaho 83843, October, 1989.

H. *Idaho State Board for Vocational Education Curriculum Guide in Livestock Production*, University of Idaho and the Idaho State Board for Vocational Education.

I. *IMAGE - Institute for Molecular and Agricultural Genetic Engineering*, University of Idaho, Moscow, Idaho 83843.

J. Lasley, John F., *Genetics of Livestock Improvement*, 3rd edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1978.

K. *Of the Earth: Agriculture and the New Biology*, Monsanto Company, 800 N. Lindbergh Boulevard, St. Louis, Missouri 63167.

L. *Plant Biotechnology*, Upjohn, Kalamazoo, Michigan 49001.

M. Sorensen, A.M., *Animal Reproduction Principles and Practices*, McGraw-Hill Book Company, New York, 1979.

IV. Additional sources for information

A. *Biotechnology Education*, Monsanto Company, 800 N. Lindbergh Blvd., St. Louis, Missouri 63167.

B. *Biotechnology Information Center*, National Agricultural Library, Room 301, Beltsville, Maryland 20705 (301-344-1215).

C. *Biotechnology Strategies for Life* (1986), MIT Press, Cambridge, Massachusetts 02142.

D. *Biotechnology: The Challenge* (1987), United States Department of Agriculture, Washington, DC 20250-1300.

E. *California Agricultural Lands Project*, 4244 20th Street, San Francisco, California 94114.

F. *Genetic Engineering: A Natural Science* (booklet), Monsanto Company, 800 N. Lindbergh Boulevard, St. Louis, Missouri 63167, 1988.

G. *Genetic Engineering in Food and Agriculture*, Report No. 110, Council for Agricultural Science and Technology.

H. *Industrial Biotechnology Association*, Suite 1100, 1625 K Street NW, Washington, DC 20006.

I. *North Carolina Biotechnology Center*, Box 13547, Research Triangle Park, North Carolina 27709.

J. Olson, Steve, *Biotechnology: An Industry Comes of Age*, National Academy Press, Washington, DC, 1986.

K. *Public Affairs*, Cold Spring Harbor Laboratory, Box 100, Cold Spring Harbor, New York 11724.

L. *Public Affairs Office*, Agricultural Division, American Cyanamid Company, One Cyanamid Plaza, Wayne, New Jersey 07470.

M. *U.S. Department of Agriculture*, Office of Public Liaison, 241-E. Administration Building, Washington, DC 20250.

BIOTECHNOLOGY

AG 510 - J

INFORMATION SHEET

I. Terms and definitions

A. Chromosome--A thread-like structure containing DNA; composed of many genes

B. DNA--Deoxyribonucleic acid; a complex chemical molecule that contains hereditary genetic information

C. Gene--A unit of heredity composed of DNA

D. Gene splicing--A procedure in which an additional gene is inserted into a chromosome

E. Recombinant DNA technology--The insertion of foreign genes into DNA (also called genetic engineering)

F. RNA--Ribonucleic acid; a complex family of chemical molecules, some of which carry a copy of the coded instructions needed to make a particular kind of protein molecule

G. Tissue culture--The process or technique of making plant or animal tissue grow in a sterile culture medium outside the organism

H. Technology--Applied science

I. Microbe--A microscopic animal or vegetable organism; for example: Bacteria, protozoans, viruses

II. Biotechnology

A. The application of living organisms to improve, modify or produce industrial products or processes

B. Four broad applications in agriculture

1. Plant and animal production

2. Food processing and manufacturing

3. Environmentally-secure animal waste disposal

4. Conversion of agricultural residues to new products

C. Common uses in agricultural science that have been around for some time

1. Use of microorganisms to produce fermented food substances and antibiotics

2. Selection of animals to produce desired traits in offspring

3. Hybridization in plants

4. Artificial insemination

D. Three major techniques

1. Genetic engineering--Involves the division and recombination of cell DNA (the material which controls the passing of specific characteristics from one generation to the next)

a. DNA can be divided and restructured in combinations which would never occur in nature

b. Can reconstruct totally synthetic genes to cause organisms to perform desired functions or exhibit desired traits

c. Also called Recombinant DNA technology

2. Monoclonal antibody technology

a. Scientists fuse an antibody-producing cell to a cancer cell to create a hybrid cell (called a hybridoma)

b. Screen the hybridomas for those that produce the desired antibodies

c. Clone and culture selected cells to secrete large quantities of highly concentrated monoclonal antibodies

3. Bio-processing

a. A living cell is cultured in a vessel, then the desired protein is extracted

b. Necessary to harvest the fruits of monoclonal antibody and genetic engineering technologies

c. Raising bread; mass producing an animal protein from genetically engineered bacteria

III. Current genetic research of major impact on agriculture (Transparencies 1, 2)

A. Plants (Transparency 1)

1. Higher protein-content seed (higher nutritional quality)

2. Plants to withstand extreme heat and cold

3. Improved milling and baking properties in wheat

4. Plants to grow in over-irrigated, salty soil, or that can be irrigated with salt water

5. Plants to tolerate too much or too little water

6. Oil crops that produce less saturated, edible oils

7. Plants immune to diseases

8. Feed crops with higher nutritional quality and better digestive qualities

9. Others??

B. Animals (Transparency 2)

1. Pregnancy testing kit for detection as early as 17th day of gestation (Bovine Pregnancy Specific Protein B)

2. Natural growth hormones

   a. Regulate milk production

   b. Regulate muscle growth

3. Embryo splitting and transfer

a. Birth of identical twins

b. Increase selection accuracy and intensity

4. Preserve fish germ plasm (cryopreservation of embryos--freezing under special conditions)

5. New vaccines

   a. Stimulate specific components of the immune system

   b. Composed of specific molecules from the pathogenic microbe

   c. No undesirable side effects

   d. Excellent protection

6. Others??

IV. Biotechnology applications in food processing (Transparency 3)

A. Food additives

1. Amino acids

2. Natural forms of vitamins

B. Fermentation processes

1. Add bacteria to meat to "outcompete" pathogens which may speed spoilage

2. This technology already exists in the cheese-making industry

C. Enzyme production

D. Product transformation

1. Low calorie foods

2. Altered fatty acid structure (no-calorie ice cream!!)

E. Others??

V. Areas of public concern about biotechnology

A. Cloning

1. Not understood (public thinks that whole human beings can and will be cloned)

2. Actually refers to gene cloning

B. Playing `God'

1. Many feel that man has no right to be involved with the hereditary materials of animals and humans

2. Many question if we are responsible enough to use this technology without abusing it

C. Environmental

1. Many question whether or not we know what the long-term effects of biotechnology on the environment might be

2. Many question whether or not there is even any way to predict long-` term effects

D. Overproduction

1. Producers are concerned about overproduction, which will drive prices down

2. Many are concerned that the new technology will only be available to the very large producers, which will force the smaller ones out of business

VI. History of genetic engineering

A. 1944--DNA identified as genetic material

B. 1953--Double strand DNA structure identified

C. 1973--First transgenic bacteria prepared

D. 1976--First genetic engineering company (Genetech) established

E. 1980--First patent for genetically engineered microbe

F. 1982--Approval of first genetically engineered drug

G. 1986--First field test of genetically engineered plant

H. 1987--Genetic engineering patent extended to higher life forms

VII. Areas of career opportunities in biotechnology

A. Scientists and engineers

B. Business and finance (new business opportunities created)

C. Producers

D. Communication specialists (interpreting and transferring information)

E. Natural resources (dealing with environmental concerns)

F. Sales personnel

G. Lawyers

H. Professional managers

I. Marketing personnel

J. Regulatory specialists

K. Financial analysts

L. Others??

VIII. Specific occupational titles in agricultural biotechnology

A. Scientific/Research Director

B. Molecular Biologist

C. Enzymologist

D. Immunology Specialist

E. Food Additive Biochemist

F. Pesticide and Herbicide Researcher

G. Statistician

H. Genetics Engineer

I. Soil Biologist

J. Plant Breeding Specialist

K. Plant Physiologist

L. Bacterial Geneticist

M. Microbial Biotechnician

N. Fertilizer and Microbial Nitrogen Fixation Specialist

O. Vaccine Biologist

P. Soil Biochemist

Q. Genetic Sequence Computer Analyst

R. Cytobiologist

S. Endocrinologist

T. Bioproducts Developer

U. Animal Cell Culture Biochemist

V. Plant Tissue Culture Technician/Propagator

W. Embryo Transplant Researcher

X. Plant and Animal Disease Diagnostician

Y. Others??

IX. Tissue culture for plant development

A. Tissue culture is the process of regenerating a new plant from a single cell or from vegetative tissue

B. 3 - 5 million plant cells (each of which can become a plant) can be grown in a 6 square inch enclosed glass dish

C. Each plant cell is totipotent (each cell carries all the genetic information it needs to become a plant)

D. The process of tissue culture

1. Engineered cells or vegetative tissue are placed on a media containing special hormones and nutrients to encourage the formation of callus (undifferentiated tissue)

2. When callus forms, the medium is changed and other hormones are added to encourage the formation of leaves and roots

3. The plantlet is potted in soil and grown to maturity in the greenhouse

4. The seeds are harvested, grown into a second generation and analyzed for the presence of the new gene

5. Plants are tested in a natural field environment

6. Engineered plants are then bred with existing hybrid varieties by classical means

E. Uses

1. Hybrids produced by fusing cells from leaf and tuber tissue of different potato varieties

2. Obtain new varieties of lentils that are salt tolerant, herbicide resistant and possibly disease resistant

3. Develop new wheat genotypes

BIOTECHNOLOGY APPLICATIONS FOR PLANT AGRICULTURE: PRESENT AND FUTURE

PHOTOSYNTHESIS

Genetically changed photosynthetic enzymes will be more efficient

Plant make-up will be genetically altered to cause it to put more photosynthetic energy into grain, fruit or vegetable production

NITROGEN FIXATION IN NON-LEGUMINOUS PLANTS

79% of the earth's atmosphere is nitrogen

Transfer of nitrogen-fixing genes to non-leguminous plants such as corn

Reduced need for supplemental nitrogen

HERBICIDE RESISTANCE

Decrease plant stress from herbicide use or carryover

Build in a resistance in plant seeds

DISEASE RESISTANCE

Alter plant makeup so specific diseases have no effect

Cause plants to produce their own resistant chemicals

PEST RESISTANCE

Transfer resistance which is controlled by one gene

Cause plant to stop producing whatever attracts the pest

Reduced need for chemical pesticides

STRESS TOLERANCE

Genetically alter the plant so that it will automatically adjust to any weather

PRODUCT QUALITY

Eliminate negative side effects of product processing

UNIQUE HYBRIDS

Perennial grain or vegetable crops

BIOTECHNOLOGY APPLICATIONS FOR ANIMAL AGRICULTURE: PRESENT AND FUTURE

REPRODUCTION

Saving and storing of valuable embryos

Sexing of animals

Cloning of valuable animals (reproducing genetically identical copies)

ANIMAL HEALTH

Build in disease resistance

Eliminate harmful side effects of vaccines

ANIMAL NUTRITION

Implant bacteria for non-ruminants to fully utilize cellulose (allow monogastric animals such as hogs to use more roughages)

Improve nutritional value of feeds

BY-PRODUCT UTILIZATION

Transfer livestock waste through bioprocessing into useful and beneficial products such as vitamins

GROWTH/LEAN MEAT PRODUCTION/MILK PRODUCTION

Growth hormones to speed weight gain and feeding efficiency

Develop vaccines to suppress growth-inhibiting hormones

Make animal products more nutritionally desirable (red meat, for example)

BIOTECHNOLOGY APPLICATIONS IN FOOD PROCESSING

FOOD ADDITIVES

Amino acids

Natural forms of vitamins

FERMENTATION PROCESSES

Add bacteria to meat to "outcompete" pathogens which may speed spoilage

This technology already exists in the cheese-making industry

PRODUCTION OF ENZYMES

PRODUCT TRANSFORMATION

Low calorie foods

Altered fatty acid structure (no-calorie ice cream!)

BIOTECHNOLOGY

AG 510 - J

ASSIGNMENT SHEET #1--DETERMINING THE ETHICS
OF BIOTECHNOLOGY

Name____ Score____________________________

Question: Should biotechnology research be actively pursued? Applied?

Activity: Class discussion/debate/position paper

Value Assessment Criteria:

1. Reciprocity--What choice would you support if you were a: (1) farmer, (2) seed dealer, (3) chemical dealer, (4) consumer.

2. Consistency--Would your choice be different if addressing a group of: (1) farmers, (2) environmentalists, or (3) consumers.

3. Coherence--How will the choice affect the relationship between farmers and agribusinessmen? Farmers and non-farmers? U.S. and foreign agriculture? How will biotechnology applications affect government agricultural policy?

4. Comprehensiveness--Where will biotechnology research lead? Will all farmers adopt the technology? What will happen if they do?

5. Adequacy--Will biotechnology solve the farm economy problems? The grain surpluses? Will it lead to further problems? How will it affect food prices?

6. Duration--Will biotechnology solve world hunger? What will the long-term effects be? Will biotechnology benefit or hurt the environment? Why must the research be carefully controlled?

BIOTECHNOLOGY

AG 510 - J

ASSIGNMENT SHEET #2--RESEARCH A CAREER IN BIOTECHNOLOGY

Name_______________________________________ Score____________________________

Choose one career in agricultural biotechnology that is of interest to you. Research for information in the areas below and write a paper on your findings.

Career/Job Title

Responsibilities

Education/Training/Background Needed

Location of Employment

(This may be general or specific, such as: the Northwest, Chicago, Boise, a foreign country, etc.)

Salary Range

Why you would or would not be interested in pursuing this career.

BIOTECHNOLOGY

AG 510 - J

INSTRUCTOR NOTES FOR LABORATORY EXERCISE

Discuss with the students that the microscopic bacteria were at work for the 6 to 8 hours, multiplying and causing the mixture to thicken. Explain that scientists use this process extensively in biotechnology when they multiply microorganisms using flasks and petri dishes in the laboratory.

BIOTECHNOLOGY

AG 510 - J

LABORATORY EXERCISE #1--MAKING YOUR OWN YOGURT

Name____ Score___________________________

Introduction

An example of a microbial process similar to those used by the scientist working in the biotechnology field is the process using bacteria to make yogurt. Yogurt is a form of sour milk. Originally prepared from whole milk boiled down to half its volume, yogurt can also be made by adding dry-milk solids to boiled milk to achieve a custard-like consistency. Two microscopic bacteria used as starter cultures are *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Large amounts of these bacteria are inoculated into the milk, and lactic acid develops rapidly. Evaporation thickens the yogurt and some proteins coagulate under the acidic conditions. In a few hours the yogurt is ready for consumption.

Materials needed

1 quart milk
1 cup powdered milk
1/3 cup unflavored commercial yogurt
Fresh or frozen fruit (optional)
1 cooking thermometer
Small containers (styrofoam coffee cups) with lids (old cottage cheese or yogurt containers would also work)
Small cooler

Procedure

1. Heat 1 quart of milk to about 170^o F, stirring often and using a thermometer to check the temperature.

2. Let the milk cool to about 130^o F then add 1 cup of powdered milk and 1/3 cup of unflavored commercial yogurt. This yogurt serves as the source of the bacteria necessary for the process to take place (fresh or frozen fruit may be added).

3. Mix thoroughly and pour into small containers with lids. Be sure to observe the liquid at this stage.

4. Use a small cooler for the incubation step. Fill the cooler with several inches of water at 130^{o}F.

5. Place the containers of the mixture in the cooler, close the lid tightly and let the containers stand for 6 to 8 hours.

6. During this time bacteria will multiply and yogurt will thicken. Refrigerate and enjoy.

7. You may want to purchase some yogurt and compare tastes.

BIOTECHNOLOGY

AG 510 - J

UNIT TEST

Name____ Score_________________________

1. Match terms related to biotechnology to the correct definitions. Write the correct numbers in the blanks.

_____a.	A unit of heredity composed of DNA	1. Chromosome
_____b.	The process or technique of making plant or animal tissue grow in a sterile culture medium outside the organism	2. DNA
		3. Gene
_____c.	Applied science	4. Gene splicing
_____d.	A thread-like structure containing DNA; composed of many genes	5. Recombinant DNA technology
_____e.	The insertion of foreign genes into DNA	6. RNA
_____f.	A microscopic animal or vegetable organism	7. Tissue culture
_____g.	A complex family of chemical molecules, some of which carry a copy of the coded instructions needed to make a particular kind of protein molecule	8. Technology
		9. Microbe
_____h.	A procedure in which an additional gene is inserted into a chromosome	
_____i.	A complex chemical molecule that contains hereditary genetic information	

2. Define biotechnology.

3. List four broad applications of biotechnology in agriculture.

a. ____

b. ____

c. ____

d. ____

4. List four common uses of biotechnology in agricultural science that have been around for some time.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

5. List and explain the three major techniques of biotechnology.

a. ______________________________

____

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____

b. ______________________________

____

____

____

c. ______________________________

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____

6. Describe five current genetic research projects in plants of major impact on agriculture.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

e____

____

7. Describe five current genetic research projects in animals of major impact on agriculture.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

e. ____

____

8. List four areas of biotechnology applications in food processing.

a. ____

b. ____

c. ____

d. ____

9. Describe four areas of public concern about biotechnology.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

10. Match the occurrence in the history of genetic engineering to the correct year of occurrence.

1.	1944	5.	1980
2.	1953	6.	1982
3.	1973	7.	1986
4.	1976	8.	1987

_____a. Genetic engineering patent extended to higher life forms

_____b. First transgenic bacteria prepared

_____c. First patent for genetically engineered microbe

_____d. DNA identified as genetic material

_____e. Approval of first genetically engineered drug

_____f. Double strand DNA structure identified

_____g. First field test of genetically engineered plant

_____h. First genetic engineering company (Genetech) established

11. List eight areas of career opportunities in biotechnology.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

12. List eight specific occupational titles in agricultural biotechnology.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

13. Discuss in detail the process of using tissue culture for plant development.

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BIOTECHNOLOGY

AG 510 - J

ANSWERS TO TEST

1. a. 3 d. 1 g. 6
   b. 7 e. 5 h. 4
   c. 8 f. 9 i. 2

a.	3	d.	1	g.	6
b.	7	e.	5	h.	4
c.	8	f.	9	i.	2

2. The application of living organisms to improve, modify or produce industrial products or processes

3. Plant and animal production; Food processing and manufacturing; Environmentally-secure animal waste disposal; Conversion of agricultural residues to new products

4. Use of microorganisms to produce fermented food substances and antibiotics; Selection of animals to produce desired traits in offspring; Hybridization in plants; Artificial insemination

5. <u>Genetic engineering</u>: Involves the division and recombination of cell DNA; DNA can be divided and restructured in combinations which would never occur in nature; Can reconstruct totally synthetic genes to cause organisms to perform desired functions or exhibit desired traits; Also called recombinant DNA technology
   <u>Monoclonal antibody technology</u>: Scientists fuse an antibody-producing cell to a cancer cell to create a hybrid cell (called a hybridoma); Screen the hybridomas for those that produce the desired antibodies; Clone and culture selected cells to secrete large quantities of highly concentrated monoclonal antibodies
   <u>Bio-processing</u>: A living cell is cultured in a vessel, then the desired protein is extracted; Necessary to harvest the fruits of monoclonal antibody and genetic engineering technologies; Raising bread; Mass producing an animal protein from genetically engineered bacteria

6. Answer should include five of the following:

   Higher protein content seed (higher nutritional quality); Plants to withstand extreme heat and cold; Improved milling and baking properties in wheat; Plants to grow in over-irrigated, salty soil, or that can be irrigated with salt water; Plants to tolerate too much or too little water; Oil crops that produce less saturated, edible oils; Plants immune to diseases; Feed crops with higher nutritional quality and better digestive qualities; Others??

7. a. Pregnancy testing kit for detection as early as 17th day of gestation (Bovine Pregnancy Specific Protein B)
   b. Natural growth hormones: Regulate milk production; Regulate muscle growth
   c. Embryo splitting and transfer: Birth of identical twins; Increase selection accuracy and intensity
   d. Preserve fish germ plasm (cryopreservation of embryos - freezing under special conditions)
   e. New vaccines: Stimulate specific components of the immune system; Composed of specific molecules from the pathogenic microbe; No undesirable side effects; Excellent protection
   f. Others??

8. Food additives; Fermentation processes; Enzyme production; Product transformation; Others??

9. a. Cloning: Not understood (public thinks that whole human beings can and will be cloned); Actually refers to gene cloning

   b. Playing `God': Many feel that man has no right to be involved with the hereditary materials of animals and humans; Many question if we are responsible enough to use this technology without abusing it

   c. Environmental: Many question whether or not we know what the long-term effects of biotechnology on the environment might be; Many question whether or not there is even any way to predict long-term effects

   d. Over-production: Producers are concerned about overproduction, which will drive prices down; Many are concerned that the new technology will only be available to the very large producers, which will force the smaller ones out of business

10.

a.	8	e.	6
b.	3	f.	2
c.	5	g.	7
d.	1	h.	4

11. Answer should include eight of the following:

    Scientists and engineers; Business and finance; Producers; Communication specialists; Natural resources; Sales personnel; Lawyers; Professional managers; Marketing personnel; Regulating specialists; Financial analysts; Others?

12. Answer should include eight of the following:

    Scientific/Research Director; Molecular Biologist; Enzymologist; Immunology Specialist; Food Additive Biochemist; Pesticide and Herbicide Researcher; Statistician; Genetics Engineer; Soil Biologist; Plant Breeding Specialist; Plant Physiologist; Bacterial Geneticist; Microbial Biotechnician; Fertilizer and Microbial Nitrogen Fixation Specialist; Vaccine Biologist; Soil Biochemist; Genetic Sequence Computer Analyst; Cytobiologist; Endocrinologist; Bioproducts Developer; Animal Cell Culture Biochemist; Plant Tissue Culture Technician/Propagator; Embryo Transplant Researcher; Plant and Animal Disease Diagnostician; Others?

13. Answer should include information from the following:

    Tissue culture is the process of regenerating a new plant from a single cell or from vegetative tissue; 3 - 5 million plant cells (each of which can become a plant) can be grown in a 6 square inch enclosed glass dish; Each plant cell is totipotent (each cell carries all the genetic information it needs to become a plant); The process of tissue culture: Engineered cells or vegetative tissue are placed on a media containing special hormones and nutrients to encourage the formation of callus (undifferentiated tissue); When callus forms, the medium is changed and other hormones are added to encourage the formation of leaves and roots; The plantlet is potted in soil and grown to maturity in the greenhouse; The seeds are harvested, grown into a second generation and analyzed for the presence of the new gene; Plants are tested in a natural field environment; Engineered plants are then bred with existing hybrid varieties by classical means; Uses: Hybrids produced by fusing cells from leaf and tuber tissue of different potato varieties; Obtain new varieties of lentils that are salt tolerant, herbicide resistant and possibly disease resistant; Develop new wheat genotypes

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

UNIT OBJECTIVE

After completion of this unit, students should be able to discuss the areas of employment in plant and soil science and the methods of preparing for a career. Students should also be able to list careers in plant and soil science and obtain information on one of these areas. This knowledge will be demonstrated by the completion of a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. List and discuss the six areas of employment in plant and soil science.
2. List fifteen careers in plant and soil science.
3. Discuss methods of preparing for a career in plant and soil science.
4. Research and prepare a report on a specific career in plant and soil science.

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

   A. Make transparencies and necessary copies of materials.

   B. Provide students with objective sheet and discuss.

   C. Provide students with information and assignment sheets and discuss.

   D. Review and give test.

   E. Reteach and retest if necessary.

II. Instructional materials

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Transparency masters

      1. TM 1--Where are Most of the Jobs in Plant and Soil Science?

      2. TM 2--Careers in Plant and Soil Science

      3. TM 3--Careers in Plant and Soil Science (continued)

      4. TM 4--Careers in Plant and Soil Science (continued)

      5. TM 5--Careers in Plant and Soil Science (continued)

      6. TM 6--Preparing for a Career in Plant and Soil Science

   E. Assignment sheets

      1. AS 1--Word Search: Careers in Plant and Soil Science

      2. AS 2--Research a Career

   F. Answers to assignment sheets

   G. Test

   H. Answers to test

III. Unit references

A. *Agricultural Education Curriculum*, College of Agriculture, University of Illinois, Urbana, Illinois, 1989.

B. Cooper, Elmer L., *Agriscience Fundamentals and Applications*, Delmar Publications, Inc., Albany, New York 12212, 1990.

C. *Exploring Careers in Agronomy, Crops and Soils,* American Society of Agronomy, Crop Science Society of America and Soil Science Society of America, 677 South Segoe Road, Madison, Wisconsin 53711.

D. Rosenblum, John W., ed., *Agriculture in the Twenty-First Century*, Wiley-Interscience Publication, John Wiley and Sons, New York, New York, 1983.

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

INFORMATION SHEET

I. Areas of employment in plant and soil science (Transparency 1)

A. Research and development

1. Fertilizers
2. Pesticides
3. Seeds
4. Equipment and machinery
5. Production practices

B. Customer-oriented agribusiness firms

1. Product information
2. Management information
3. Liaison between agriculturist and the company

C. Sales

1. Sale of agricultural products
2. Recommend new technology to customer
3. Training ground to move into other areas

a. Advertising
b. Marketing
c. Technical service
d. Administration
e. Management of sales firm

D. Consulting services--Advise agriculturists

E. Farmers, ranchers and agriculturists

F. Miscellaneous

1. Farm managers

2. Bank loan specialists

3. Golf course superintendents

4. Forest superintendents

5. Industry administrators

6. University instructors

II. Careers in plant and soil science (Transparencies 2, 3, 4, 5)

Administrator
Agricultural Climatologist
Agronomist
Conservation Agronomist
County Agent
Crop Biochemist
Crop Breeder
Crop Chemist
Crop Cytogeneticist
Crop Cytologist
Crop Ecologist
Crop Geneticist
Land Use Specialist
Pedologist
Plant Biochemist
Plant Breeder
Plant Chemist
Plant Cytogeneticist
Plant Cytologist
Plant Ecologist
Plant Geneticist
Plant Physiologist
Range Management Specialist
Range Soil Scientist
Reclamation Specialist
Resource Conservationist
Seed Production Specialist
Seed Technologist
Soil and Water Conservationist
Soil and Water Management Specialist
Soil and Water Specialist
Soil Biochemist
Soil Chemist
Crop Marketing Specialist
Crop Physiologist
Crop Production Specialist
Crop Protection Specialist
Crop Quality Specialist
Crop Scientist
Crop Utilization Specialist

District Conservationist
Edaphologist
Erosion and Sediment Control Specialist
Fertilizer Technologist
Fertilizer Technology Specialist
Fertilizer Use Specialist
Forest Soil Scientist
Forest Soil Specialist
Forester
Geneticist
Irrigation Specialist
Irrigationist
Land Management Specialist
Soil Classifier
Soil Conservationist
Soil Fertility Specialist
Soil Genesis Specialist
Soil Interpretation Specialist
Soil Management Specialist
Soil Microbiologist
Soil Mineralogist
Soil Morphologist
Soil Physicist
Soil Resource Specialist
Soil Scientist
Soil Specialist
Soil-Plant Analyst
Soil-Plant Nutrition Specialist
Soil-Water-Plant Specialist
Station Superintendent
Statistician
Surface Mine Reclamation Specialist
Turfgrass Manager
Turfgrass Specialist
Weed Scientist
University Instructor
Farmer
Rancher
Crop Specialist

III. Preparing for a career in plant and soil science (Transparency 6)

A. Background--Agronomists are men and women with many types of backgrounds from both urban and rural areas. Many agronomy graduates have no farm background whatsoever

B. High school education

1. Agriculture--A foundation of courses emphasizing the basic agronomic science principles

2. Science

a. Biology

b. Chemistry

c. Mathematics

d. Physics

3. English--A strong knowledge is important

4. Foreign languages--Experience with other languages is beneficial if overseas work is desired

C. College

1. Basics

a. English

b. Math

c. Biology and natural sciences

2. Expansion of sciences learned in high school

3. Advanced sciences

a. Geology

b. Botany

c. Microbiology

d. Genetics

e. Plant pathology

f. Soil chemistry

g. Plant physiology

h. Entomology

i. Biochemistry

j. Meteorology

k. Other applied science

D. Advanced degrees

(Note: Numerous positions in teaching, research or extension require training beyond the bachelor's degree.)

E. Work experience

1. Farming/Ranching

2. Internship

3. Related job experience

Where are Most of the Jobs in Plant and Soil Science?

Research and development

Customer-oriented agribusiness firms

Sales

Consulting services

Farmers, ranchers and agriculturists

Miscellaneous

Careers in Plant and Soil Science

Administrator

Agricultural Climatologist

Agronomist

Conservation Agronomist

County Agent

Crop Biochemist

Crop Breeder

Crop Chemist

Crop Cytogeneticist

Crop Cytologist

Crop Ecologist

Crop Geneticist

Land Use Specialist

Pedologist

Plant Biochemist

Plant Breeder

Plant Chemist

Plant Cytogeneticist

Plant Cytologist

Plant Ecologist

Careers in Plant and Soil Science

Plant Geneticist

Plant Physiologist

Range Management Specialist

Range Soil Scientist

Reclamation Specialist

Resource Conservationist

Seed Production Specialist

Seed Technologist

Soil and Water Conservationist

Soil and Water Management Specialist

Soil and Water Specialist

Soil Biochemist

Soil Chemist

Crop Marketing Specialist

Crop Physiologist

Crop Production Specialist

Crop Protection Specialist

Crop Quality Specialist

Crop Scientist

Crop Specialist

Careers in Plant and Soil Science

Crop Utilization Specialist

District Conservationist

Edaphologist

Erosion and Sediment Control Specialist

Fertilizer Technologist

Fertilizer Technology Specialist

Fertilizer Use Specialist

Forest Soil Scientist

Forest Soil Specialist

Forester

Geneticist

Irrigation Specialist

Irrigationist

Land Management Specialist

Soil Classifier

Soil Conservationist

Soil Fertility Specialist

Soil Genesis Specialist

Soil Interpretation Specialist

Soil Management Specialist

Careers in Plant and Soil Science

Soil Microbiologist

Soil Mineralogist

Soil Morphologist

Soil Physicist

Soil Resource Specialist

Soil Scientist

Soil Specialist

Soil-Plant Analyst

Soil-Plant Nutrition Specialist

Soil-Water-Plant Specialist

Station Superintendent

Statistician

Surface Mine Reclamation

Turfgrass Manager

Turfgrass Specialist

Weed Scientist

University Instructor

Farmer

Rancher

PREPARING FOR A CAREER IN PLANT AND SOIL SCIENCES

Background

High school education
Agriculture
Science
English
Foreign languages

College
Basics
Expansion of basic sciences
Advanced sciences

Advanced college degrees

Work experience
Farming/Ranching
Internship
Related job experience

CAREERS IN PLANT AND SOIL SCIENCE
AG 510 - K
ASSIGNMENT SHEET #1--WORD SEARCH: CAREERS IN PLANT AND SOIL SCIENCE

Name____ Score ____________________________

Find and circle the following words which are related to careers in plant and soil science. Words will be found in any direction.

Agronomist	Challenging	Ecologist	Future	Science
Agronomy	Chemistry	Feed	Genetics	Scientists
Biochemist	Conservation	Fiber	Physics	Soils
Careers	Crops	Food	Research	Specialist

Q	Q	Y	Q	G	L	X	X	O	L	I	T	M	T	K	M	U	Q	M
X	J	K	P	H	Y	S	I	C	S	S	R	S	X	R	U	E	X	O
T	R	F	H	E	R	W	J	C	I	A	I	R	L	J	C	S	I	R
L	E	Y	M	G	L	F	B	G	S	L	Q	L	F	N	I	W	C	T
M	S	R	Z	H	S	T	O	T	A	L	D	Y	E	U	D	G	V	P
P	E	G	A	X	B	L	S	I	A	R	R	I	J	E	T	F	G	Z
N	A	C	M	T	O	I	C	E	Z	S	C	N	D	S	I	U	D	F
I	R	E	O	C	T	E	C	L	T	S	C	E	V	B	W	D	R	M
Q	C	B	E	N	P	B	P	H	D	S	E	A	E	X	S	N	J	E
H	H	E	E	S	S	N	C	N	A	F	I	R	R	O	X	G	K	G
R	W	I	Y	Y	C	E	Y	N	A	L	C	M	I	E	V	U	L	E
W	C	G	X	R	M	E	R	G	N	H	L	L	E	K	E	N	P	Z
S	X	R	O	J	L	O	R	V	E	F	S	E	O	H	P	R	H	B
B	U	P	D	I	B	O	N	M	A	B	U	C	N	G	C	U	S	Q
T	S	J	B	P	N	R	I	O	K	T	S	T	I	G	H	O	M	T
W	E	S	C	O	Q	S	B	V	R	T	I	Z	F	T	I	Y	I	Y
T	S	R	M	B	T	X	T	Z	F	G	V	O	W	C	E	N	Y	B
M	Q	I	J	R	E	R	M	O	O	Q	A	N	N	R	F	N	G	G
Q	S	V	Y	E	L	C	O	C	V	H	B	S	Q	X	F	M	E	Y
T	M	K	C	O	W	D	J	E	X	M	T	K	E	Y	Q	H	F	G

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

ASSIGNMENT SHEET #2--RESEARCH A CAREER

Name____ Score___________________________

Prepare a research paper on a specific career in plant and soil science. Be sure to include information on:

1. Job responsibilities

2. Required background, education and/or training

3. Prospects for future employment

4. Working conditions

5. Location--be as specific as possible
(for example: Idaho, Western United States, foreign country, Washington D.C., Land-grant universities, etc.)

6. Salary

Sources of references could include:

1. Library

2. Colleges or universities

3. Magazines, books, etc.

4. Guidance counselor

5. College or university course catalogs or degree program catalogs

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

Q	Q	Y	Q	G	L	X	X	O	L	I	T	M	T	K	M	U	Q	M
X	J	K	P	H	Y	S	I	C	S	S	R	S	X	R	U	E	X	O
T	R	F	H	E	R	W	J	C	I	A	I	R	L	J	C	S	I	R
L	E	Y	M	G	L	F	B	G	S	L	Q	L	F	N	I	W	C	T
M	S	R	Z	H	S	T	O	T	A	L	D	Y	E	U	D	G	V	P
P	E	G	A	X	B	L	S	I	A	R	R	I	J	E	T	F	G	Z
N	A	C	M	T	O	I	C	E	Z	S	C	N	D	S	I	U	D	F
I	R	E	O	C	T	E	C	L	T	S	C	E	V	B	W	D	R	M
Q	C	B	E	N	P	B	P	H	D	S	E	A	E	X	S	N	J	E
H	H	E	E	S	S	N	C	N	A	F	I	R	R	O	X	G	K	G
R	W	I	Y	Y	C	E	Y	N	A	L	C	M	I	E	V	U	L	E
W	C	G	X	R	M	E	R	G	N	H	L	L	E	K	E	N	P	Z
S	X	R	O	J	L	O	R	V	E	F	S	E	O	H	P	R	H	B
B	U	P	D	I	B	O	N	M	A	B	U	C	N	G	C	U	S	Q
T	S	J	B	P	N	R	I	O	K	T	S	T	I	G	H	O	M	T
W	E	S	C	O	Q	S	B	V	R	T	I	Z	F	T	I	Y	I	Y
T	S	R	M	B	T	X	T	Z	F	G	V	O	W	C	E	N	Y	B
M	Q	I	J	R	E	R	M	O	O	Q	A	N	N	R	F	N	G	G
Q	S	V	Y	E	L	C	O	C	V	H	B	S	Q	X	F	M	E	Y
T	M	K	C	O	W	D	J	E	X	M	T	K	E	Y	Q	H	F	G

Assignment Sheet #2

Evaluated to the satisfaction of the instructor.

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

UNIT TEST

Name____ Score_______________________________

1. List and discuss the six areas of employment in plant and soil science.

a. ____

____

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b. ____

____

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c. ____

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d. ____

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e. ____

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f. ____

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2. List 15 careers in plant and soil science.

a. ____

b. ____

c. ____

d____

e____

f ____

g____

h____

i ____

j ____

k____

l ____

m ____

n____

o____

3. Discuss methods of preparing for a career in plant and soil science.

CAREERS IN PLANT AND SOIL SCIENCE

AG 510 - K

ANSWERS TO TEST

1. Research and development: Fertilizers; Pesticides; Seeds; Equipment and machinery; Production practices
   Customer-oriented agribusiness firms: Product information; Management information; Liaison between agriculturist and the company
   Sales: Sale of agricultural products; Recommend new technology to customer; Training ground to move into other areas--Advertising; Marketing; Technical service; Administration; Management of sales firm
   Consulting services--Advise agriculturists
   Farmers, ranchers and agriculturists
   Miscellaneous: Farm managers; Bank loan specialists; Golf course superintendents; Forest superintendents; Industry administrators; University instructors

2. Answer should include 15 careers in plant and soil science. For specific careers, refer to page 510K-5.

3. Answer should include information from the following:

   Background--Agronomists are men and women with many types of backgrounds from both urban and rural areas. Many agronomy graduates have no farm background whatsoever
   High school education: Agriculture--A foundation of courses emphasizing the basic agronomic science principles; Science--Biology, Chemistry, Mathematics, Physics; English--A strong knowledge is important; Foreign languages--Experience with other languages is beneficial if overseas work is desired
   College: Basics--English, Math, Biology and natural sciences; Expansion of sciences learned in high school; Advanced sciences--Geology, Botany, Microbiology, Genetics, Plant pathology, Soil chemistry, Plant physiology, Entomology, Biochemistry, Meteorology, Other applied science; Advanced degrees
   Work experience: Farming/Ranching; Internship; Related job experience

AG. 510 Botany / Plant and Soil Science

L. Scientific Method Term Project

Based on: Idaho Science Content Guide and Framework. Grades 9 - 12.
Standard II. Science Themes. Goal B. Systems and Interactions.

Goal. Understand that soil is a collection of entities and processes that interact to support plant growth, development and maintenance.

Objectives. All students will:

- Identify that soil is a system (edaphic) connected to other systems (atmospheric and biotic) both internally and externally.
- Identify a solution to the problem of plant production in stressful environments through an analysis of the relationship between plants and their optimal growth environs.
- Identify the stability of plant growth based on the appropriate feedback mechanisms from the plant's internal and external media.
- Recognize that living and non-living systems obey the laws of nature; e.g. plants that are not adapted to sandy soil and minimal rainfall cannot be sustained in those conditions without additional water and nutrients.
- Appreciate the interconnectedness of mineral, plant and animal life necessary to the development and function of the soil cycle.
- Appreciate the interconnectedness of soil and climate necessary for the development and function of plants.

Progress Indicator. All students will:

- Conduct a study of plant growth by measuring plant response to certain soils and climates.
- Design three growing experiments comparing:

    1. Plants adapted to a specific soil and climate.
    2. Plants induced to adapt to a specific soil and climate through nutrient and cultural adjustment.
    3. Plants not adapted to the soil and climate.

- Measure the growth of the plants and observe and record plant reactions to their environment within an equally-sized planted space.
- Design each sample growing plot for:
    - ◊ A climate zone
    - ◊ A soil type representative of the climate zone
    - ◊ An agricultural crop or landscape plant grown in the represented soil type and zone.

- Record the amount of plants and the rate of growth produced in each representative area.
- Document each manipulation to each plot, including amendments and culture.
- Record your results at the end of the specified time period for all three plots.
- Document the scientific methods of the study:

    - ♦ **State the Problem:** Write a statement describing the question posed with this study.
    - ♦ **Gather Information.**

        - ⇒ On growing seasons for selected climate zones;
        - ⇒ Recommended landscaping plants, vegetable plants or agricultural crops for selected climate zones;
        - ⇒ Primary soils and amendments needed for selected plants / crops in selected climate zones;

- ⇒ Potential problems and solutions.

- ♦ **Form an Hypothesis.** Generate an educated guess or idea of the results of the study based on the problem statement.
- ♦ **Collect the Data through Experimentation.** Record the materials that went into the samples. Start by planting the samples at the same time. Set a time to end the experiment. Observe and record the growth rates and the amount of plants produced at set intervals between the start and end dates of the experiment. Record any developments, changes, or differences between the three samples.
- ♦ **Analyze Data and Form a Conclusion.** Judge if the results agree with your hypothesis, and why they did or did not. Write a paper summarizing your project, your methods used, and your results. Create hand-drawn or computer-generated graphs summarizing the results of your research.
- ♦ **Report the Results.** Give your class a brief presentation on your study. State the purpose of your study, describe how the research was conducted, and the results. Display the plot samples (if possible, or take pictures) and display your graphs.
- ♦ **Propose a Theory.** Propose an explanation for the results of the research and . . .
- ♦ **Identify Variables for Further Research.** Isolate individual characteristics of the study for further experiments.

SCIENTIFIC METHOD MATRIX

AG. 510 BOTANY / PLANT AND SOIL SCIENCE

ACTIVITIES MEETING GOALS PER STANDARD

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IDAHO K-12 SCIENCE CONTENT GUIDE AND FRAMEWORK

Standard I. Habits of the Mind	Goal A. Science Processes
Elementary Study of Soils	
General Laboratory Procedures, Equipment, and Report Writing	X
Using a Compound Microscope	X
Determine Soil Textural Class by Mechanical Analysis	X
Determine Soil Textural Class by Feel	X
Studying Soil Samples	X
Origin and Meaning of Color in Soil	X
Soil Fertility	
Calculate # of Pounds of Actual Nitrogen, Phosphorus and Potassium Available from Different Fertilizer Analyses	X
Calculate Cost per Pound of Nitrogen for Different Fertilizer Analyses	X
Calculate application Rates of Fertilizers	X
Formulate a Fertilizer Blend, Calculate Total Cost and Cost per Acre	X
Complete a Soil Test Report Form	X
Basic Plant Processes	
Studying the Movement of Substances Across Membranes	X
Plant Anatomy, Growth and Development	
What are Cells?	X
Studying Cell Parts	X
Animal and Plant Cell Differences	X
How Monocot Stems Differ from Dicot Stems	X
Examining Roots and Stems	X
Root Growth	X
Observing the Structure and Function of Flowers	X

Standard I. Habits of the Mind	Goal A. Science Processes
Plant Anatomy, Growth and Development	
Development of Seed Parts into Young Plants	X
Plant Growth	X
Growing a Bean Plant	X
Plant Propagation from Seed	X
Produce Rooted Cuttings	X
Identification of Plants and Weed Pests	
Examining the Structure of Leaves	X
Relationship of Leaf Structure to Function	X
Standard II. Habits of the Mind	**Goal B. Values**
Soil Conservation	
Conserving Soil Crossword Puzzle	X
Locating Good and Poor Conservation Practices	X
Biotechnology	
Making Your Own Yogurt	X
Careers in Plant and Soil Science	
Word Search - Careers in Plant and Soil Science	X
Standard II. Science Themes	**Goal A. Change and Constancy**
Soil Conservation	
How Much Water Will Soil Hold?	X
Basic Plant Processes	
Effect of Light on Dry Weight	X
How Does Light Affect Photosynthesis?	X
Water Movement Through Plants	X
Standard II. Science Themes	**Goal B. Systems and Interactions**
Basic Plant Processes	
Demonstrating Photosynthesis, Respiration, and Fermentation	X
What Factors Affect Respiration?	X
When Does Osmosis Occur in Living Cells?	X
Measuring Loss from Transpiration	X
Measuring Rates of Photosynthesis in Different Environments	X
Plant Anatomy, Growth and Development	
Flower Functions in Reproduction	X
Plant Reproduction Without Seeds	X

Standard II. Science Themes	Goal C. Models, Scale, and Structure
Elementary Study of Soils	
Using the Textural Triangle	X
Standard III. Nature of Science	**Goal A. Science and Technology in Society**
Biotechnology	
Determining the Ethics of Biotechnology	X
Standard III. Nature of Science	**Goal B. History and Cultural Perspective**
Soil Conservation	
How Do You Rate as an FFA Conservationist?	X
Biotechnology	
Research a Career in Biotechnology	X
Careers in Plant and Soil Science	
Research a Career	X

AGRICULTURAL SCIENCE AND TECHNOLOGY CURRICULUM
SCIENTIFIC METHOD MATRIX

AG. 510 BOTANY / PLANT AND SOIL SCIENCE

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IDAHO K-12 SCIENCE CONTENT GUIDE AND FRAMEWORK

Key - 4	Standard I. Habits of the Mind		Standard II. Science Themes			Standard III. Nature of Science	
Section / Activity	**Goal A. Science Processes**	**Goal B. Values**	**Goal A. Change and Constancy**	**Goal B. Systems and Interactions**	**Goal C. Models, Scale, and Structure**	**Goal A. Science and Technology in Society**	**Goal B. History and Cultural Perspective**
Elementary Study of Soils							
Using the Textural Triangle					**X**		
General Laboratory Procedures, Equipment, and Report Writing	**X**						
Using a Compound Microscope	**X**						
Determine Soil Textural Class by Mechanical Analysis	**X**						
Determine Soil Textural Class by Feel	**X**						
Studying Soil Samples	**X**						
Origin and Meaning of Color in Soil	**X**						

Key - 4	Standard I. Habits of the Mind		Standard II. Science Themes			Standard III. Nature of Science	
Section / Activity	Goal A. Science Processes	Goal B. Values	Goal A. Change and Constancy	Goal B. Systems and Interactions	Goal C. Models, Scale, and Structure	Goal A. Science and Technology in Society	Goal B. History and Cultural Perspective
Soil Fertility							
Calculate # of Pounds of Actual Nitrogen, Phosphorus and Potassium Available from Different Fertilizer Analyses	X						
Calculate Cost per Pound of Nitrogen for Different Fertilizer Analyses	X						
Calculate Application Rates of Fertilizers	X						
Formulate a Fertilizer Blend, Calculate Total Cost and Cost per Acre	X						
Complete a Soil Test Report Form	X						
Soil Conservation							
How Do You Rate as an FFA Conservationist?							X
Conserving Soil Crossword Puzzle		X					
	Standard I.		Standard II.			Standard III.	

Key - 4	Habits of the Mind		Science Themes			Nature of Science	
Section / Activity	Goal A. Science Processes	Goal B. Values	Goal A. Change and Constancy	Goal B. Systems and Interactions	Goal C. Models, Scale, and Structure	Goal A. Science and Technology in Society	Goal B. History and Cultural Perspective
Soil Conservation							
Locating Good and Poor Conservation Practices		X					
How Much Water Will Soil Hold?			X				
Basic Plant Processes							
Effect of Light on Dry Weight			X				
Demonstrating Photosynthesis, Respiration, and Fermentation				X			
What Factors Affect Respiration?				X			
How Does Light Affect Photosynthesis?			X				
When Does Osmosis Occur in Living Cells?				X			
Studying the Movement of Substances Across Membranes	X						
Measuring Loss from Transpiration				X			

Key - 4	Standard I. Habits of the Mind		Standard II. Science Themes			Standard III. Nature of Science	
Section / Activity	Goal A. Science Processes	Goal B. Values	Goal A. Change and Constancy	Goal B. Systems and Interactions	Goal C. Models, Scale, and Structure	Goal A. Science and Technology in Society	Goal B. History and Cultural Perspective
Basic Plant Processes							
Measuring Rates of Photosynthesis in Different Environments				**X**			
Water Movement Through Plants			**X**				
Plant Anatomy, Growth and Development							
What are Cells?	**X**						
Studying Cell Parts	**X**						
Animal and Plant Cell Differences	**X**						
How Monocot Stems Differ from Dicot Stems	**X**						
Examining Roots and Stems	**X**						
Root Growth	**X**						
Observing the Structure and Function of Flowers	**X**						
Flower Functions in Reproduction				**X**			
Development of Seed Parts into Young Plants	**X**						
Plant Growth	**X**						

Key - 4	Standard I. Habits of the Mind		Standard II. Science Themes			Standard III. Nature of Science	
Section / Activity	**Goal A. Science Processes**	**Goal B. Values**	**Goal A. Change and Constancy**	**Goal B. Systems and Interactions**	**Goal C. Models, Scale, and Structure**	**Goal A. Science and Technology in Society**	**Goal B. History and Cultural Perspective**
Plant Anatomy, Growth and Development							
Plant Reproduction Without Seeds				X			
Growing a Bean Plant	X						
Plant Propagation from Seed	X						
Produce Rooted Cuttings	X						
Identification of Plants and Weed Pests							
Examining the Structure of Leaves	X						
Relationship of Leaf Structure to Function	X						
Biotechnology							
Determining the Ethics of Biotechnology						X	
Research a Career in Biotechnology							X
Making Your Own Yogurt		X					
Careers in Plant and Soil Science							
Word Search - Careers in Plant and Soil Science		X					
Research a Career							X