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ABSTRACT

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George A. Ball, Jr.
Gaston College
Dallas, North Carolina 28034

DEVELOPMENT AND TESTING OF INDIVIDUALIZED AUDIO-TUTORIAL INSTRUCTION IN SOPHOMORE-LEVEL PLANT MORPHOLOGY

January 1972

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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George A. Ball, Jr.
William J. Farrell, Jr.

Gaston College

Dallas, North Carolina 28034

February 11, 1972

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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Regional Research Program

PREFACE

The participants in this research project express their appreciation to the following men who served as consultants and reviewers. Without their advice and help, this project would never have been completed.

Dr. James F. Matthews
University of North Carolina
Charlotte, North Carolina

Dr. Ralph Morrison
University of North Carolina
Greensboro, North Carolina

Dr. David Husband
University of South Carolina
Columbia, South Carolina

Mr. Thomas Briley
RELCV
Durham, North Carolina

George A. Ball, Jr.
William J. Farrell, Jr.
Gaston College
January 3, 1972

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INTRODUCTION

Sophomore-level science courses in a small, two-year college present a difficult problem because of small numbers of majors and because of the economic difficulty of offering a course to a very few students. Some educators also feel that small classes are usually of poor quality, as well.

The project was begun as an attempt to develop and test a plant morphology course at the sophomore-level which could be offered as individualized instruction. The Audio-Tutorial technique was selected for the specific type of individualized instruction. If successful, this and other courses of this type could be used to provide sophomores with quality instruction in areas which it would be difficult to offer courses of the conventional type. It seems probable that programmed instruction will be more widely used in the future and this course might be offered as an alternative to conventional courses.

METHODS OR PROCEDURES

Existing material was surveyed and one existing Laboratory Syllabus was used. Audio scripts, examinations and behavorial objectives were developed and are included as the Appendixes of this report.

The Laboratory Syllabus is:

McKnight, Kent H., 1962. Plant Kingdom Laboratory Syllabus. Minneapolis: Burgess.

The textbook selected is:

Bold, Harold C. 1967. Morphology of Plants. 2nd edition New York: Harper and Row.

Behavioral objectives, audio-scripts and quizzes (Sections 1 through 7) were written by Mr. William J. Farrell, Jr. Sections 8 through 15 were written by Mr. George A. Ball, Jr.

The textbook and laboratory syllabus were selected on the basis of their content relevent to this course. Both were reviewed by the subject matter consultants and approved for this course. Audio-scripts were first dictated on tape with the text book, laboratory syllabus and available materials at hand. Throughout the audio-scripts, frequent reference is made to the textbook. The audio-script is specifically designed to be used with the laboratory syllabus named above. This laboratory syllabus consists of fifteen sections. The first fourteen were used. The fifteenth, which deals with the plant community is not included. The audio-scripts were transcribed, corrected and subsequently re-dictated on tapes for use during a pilot study. The pilot study was not planned in the original proposal but was added later for reasons described below. Behavioral objectives were constructed in a style suggested by Mager. (Mager, Robert F. 1968. Preparing Instructional Objectives. Palo Alto: Fearon.) At the same time audio-scripts were prepared. Unit or section quizzes were written to measure the stated objectives.

The audio-scripts were subsequently revised and re-written during the pilot study. The same can be said for the objectives and quizzes. Extensive use of interviews were made in this rewriting. Consultant help was obtained in the development of these materials and in the general set-up of the course. Three men were employed as consultants. These men are: Dr. James F. Matthews of the University of North Carolina at Charlotte, Dr. Ralph Morrison of the University of North Carolina at Greensboro and Dr. David Husband of the University of South Carolina. Drs. Matthews and Morrison are both botanists and have extensive training and experience. Dr. Husband is both a plant morphologist and a specialist in the audio-tutorial method of teaching. Dr. Husband studied and worked with Dr. S. N. Postelthwait who developed the system. The writing phase was completed at the beginning of the winter quarter, 1970. (December 1970).

On the advice of Mr. Thomas Briley of FELCV, educational research consultant, we ran a pilot study during the winter quarter 1970-71. Three students were enrolled in this pilot study. These students were interviewed and necessary revisions were made in the materials. All three were unable to complete the program during the winter quarter 1970-71 and were allowed an extension into the spring quarter. The pilot study was completed in May 1971.

It was planned to test the program during the fall quarter, 1971. Efforts were made to interest several of our sister community colleges to also test the materials. This, however, was not accomplished.

RESULTS

The final evaluation of the program was begun in September, 1971, with two students enrolled. One dropped out before the quarter began and the other finished the first half only. No numberical comparison was possible with our students and those of the participating senior institutions.

CONCLUSIONS

The conclusions which can be drawn are based largely on the opinions of our consultants and are, to some extent, anecdotal.

1. The sophistication of the course material is at a level to be acceptable as a sophomore-level course at the senior institutions.

2. It is felt that the course should be taught over <u>two</u> quarters (instead of one) or at least over a semester. No student has finished in one quarter. At this writing, three students are taking the first half of the course.

3. It is not possible to compare the level of achievement of our student with those in comparable courses in senior institutions.

RECOMMENDATIONS

It is recommended that an extensive study be done over several years to determine the relative effectiveness of this course.

PLANT MORPHOLOGY

Section 1: Bacteria and Cyanophyta

OBJECTIVES: At the completion of this section of material, you should be able to:

1. Identify the three morphological types of bacteria and at least three variations from each major type (one variation per type: example: staphlococcus)

2. Discuss or diagram the general structure of the bacterial cell.

3. Defend the present classification of bacteria as Monera rather than as fungi.

4. Discuss the economic and ecological importance of the bacteria; cite at least three examples of bacteria-induced human disease and give the causual agent.

5. Compare and contrast the blue-green algae and the bacteria.

6. Identify prepared slides or fresh mounts of Nostoc, Gleocapsa, Oscillatoria, Scytonoma, Gleotrichia, Microcystis, and Anabaena.

7. Define the following structures associated with the Cyanophyta: cyanophycan starch, trichome, heterocyst, hormogonium, and akinete.

8. Give examples of the basic body types: unicellular, colonial, and filamentous.

9. Distinguish between true branching and false branching.

10. Describe the ecological importance of the Cyanophyta.

MATERIALS TO BE STUDIED:

Bacterial types
bacterial flagellae
Bacillus anthracus
Clostridium tetani
C. botulinum
Streptococcus pyogenes
Chorynebacterium diptheriae
Mycobacterium tuberculosis

Gleocapsa
Microcystis
Nostoc
Anabaena
Oscillatoria
Scytonema
Gleotrichia

New Terms: refer to question 7

AUDIO SCRIPT

Hello! Welcome to Plant Morphology, Gaston College's first completely A-T course. If you have taken your introductory Biology at Gaston College in the past year, you should be thoroughly familiar with the operation of the equipment in this room. In this course, however, there will be no formal lecture time, and all instruction will come from the tape and the laboratory manual. This procedure is best suited to this course, since only by observing the plant materials can we actually learn about plant morphology. You should have an introductory sheet with a schedule of the packages in it. You may progress at your own rate through the packages but I would advise you not to work too slowly since we may not be here next summer to give you a final grade. At the completion of each package, you will be given both an oral and a written exam, scheduled for the end of the week, but hopefully at your convenience. You must pass both of these at the 75% level. If you do not reach this level, you should go back through the material, concentrating on your weak areas, and then take a make-up test. Your final grade will consist of the total of your individual grades and any other outside assignments, such as plant collections. If you finish any package in less time than the scheduled time, you may be tested and then go on to the next package.

The scheduled work time should be ten weeks, but the actual work time will be determined by your own interest and progress. Both Mr. Ball and myself will be available to aid you in working but I hope that the taped instruction and hand-out sheets are clear enough so that we will be unnecessary except at quiz time. Since these exams cover the actual material, your concentration will be required as you follow the tapes and perform the specific tasks. Emphasis is on observation and not on lab drawing, but you should make outline sketches in the lab manual where they are necessary. These will be to your benefit in reviewing for the exams. Taxonomy will be kept at a minimum, but you should become familiar with the general classification and vocabulary as we go through it. Most textbooks have glossaries, and you will probably have to refer to this frequently for the first few lessons till the terms become meaningful to you.

The most primative living organisms on earth today, if we exclude the viruses, are the PROKARYOTA. These are organisms which lack internal nuclear membranes, and are referred to taxonomically as the MONERA, according to some classifications. This group includes the bacteria, which have fungal-like characteristics, and the blue-green algae, frequently classified with the algae. The bacteria are both unique and diverse in their nature and are usually considered by themselves in a bacteriology course rather than in plant morphology. However, as an introduction let us give some attention to them, since they play a great ecological and economic role in our world.

To begin, you may recall from Biology 101 that a basic portion of the food pyramid is the decomposer level, consisting of those organisms which break down dead plant and animal tissues into units which may be reused by the ecosystem. The fungi, which we will consider later, are decomposers, but the bulk of this process is handled by the bacteria. These are probably the most widespread of organisms with regard to their habitat and niche. Many species occur as mutuals or commensals in the digestive tracts of animals, such as in our own large intestine, and aid in some processes of nutrition. Some species are pathogenic or parasitic, in causing many diseases in animals, although viruses probably have a more devestating effect in causing illness. Diseases such as the plague, cholora, diptheria, menengitis, gonorrhea, and TB were once great controls over human population growth and distribution. Some are still active in spite of our efficient means of control, as seen in the cholora outbreaks in Pakistan recently following a devestating typhoon. Not wishing to malign the entire group, I should mention that many are free living soil and aquatic forms that do not harm other forms of life.

Bacteria have been frequently classified with the fungi but are presently linked with the blue-green algae in a major taxon of their own, the kingdom Monera. If you recall from Biology 101, the acceptable four kingdom classification includes the MONERA, PROTISTA, METAPHYTA, AND METAZOA. Our course deals with the Monera, the plant-like Protista, and the Metaphyta, the multicellular green plants. The Monera are considered the most primative due to their lack of organized internal structure. Refer to the available electron photomicrographs of bacterial cells and observe the typical cell structure. BELL Those organelles which you memorized in introductory Biology, nucleus, mitochondria, plastids, are not present per-se in the bacterial cell. Rather, the nucleic acids and enzyme systems are scattered throughout the cytoplasm instead of being in distinct packages. Due to their ability to grow on specific nutritional sources and their rapid reproduction, bacteria can be cultured rather easily in the lab if certain techniques are followed. Refer to the demonstration area for some prepared agar plates and tubes, and then study the three film loops on techniques. Then return to the tape. BELL In working with bacteria, care must be taken to prevent contamination of sterile material by air-borne bacteria and fungi, not to mention the effects of self-contamination when working with pathogenic bacteria.

Bacteria occur as variations of three major forms: Coccus - small spherical types; BACILLUS - rod shaped; and SPIRILLUM - corkscrew shaped. A fourth type is the SPIROCHAETE which is spirillum-like but lacking a rigid cell wall characteristic of bacteria. This type is best exemplified by Treponema pallidum, the causitive agent of that well known social disease, SYPHILIS. That other popular contagion, gonorrhea, is caused by a coccus-form Neisseria gonorrhoeae.

Study the prepared slides labled THREE BACTERIAL TYPES, and then look at the specific slides for modifications from the basic forms. These are: bacterial flagellae, showing motile hair-like filaments; Bacillus anthracus, the causitive agent of ANTHRAX, a disease of farm animals that is infective to man; Clostridium tetani, which causes TETANUS, and C. botulinum, the cause of a highly toxic form of food poisoning termed BOTULISM. These three are capable of forming resistant spores which can survive environmental changes and render them highly infectuous. Look for these spores in these slides. BELL Streptococcus pyogenes is a chain-like arrangement of cocci, and is a pus-forming pathogen in man; Chorynebacterium diptheriae is a bacillus form, usually with a club-shaped end, and the cause of DIPTHERIA, a once deadly respiratory disease of children; and finally Mycobacterium tuberculosis, a bacterium which shows a fungal-type form, and the causual agent of tuberculosis. Study these slides for their variations in form, and then go to the slide projector to observe the demonstration slides. BELL. If this turns you on, there is a course in Microbiology, offered in the spring quarter, which will give you more information and working techniques. The library also has several good references in textbooks dealing specifically with bacteria. Now that you have completed this section, go on to the study of the CYANOPHYTA, the blue-green algae, which is a continuation of this tape.

The blue-green algae are referred to as the Cyanophyta or Cyanophycophyta, depending on the source of the classification. The stem terms mean "blue" and "plant", although many are not blue in color. If you refer to page 14 of BOLD, you will see the similarity of this micrograph with those of the bacteria in the procaryotic condition. Note also the absence of organized chloroplasts. Compare this picture with that of a cell containing chloroplasts, as seen on page 25. In the blue-greens, the lamellae of chlorophyll are scattered throughout the cytoplasm. If we consider internal organization as a characteristic of high development, then the bacteria and blue-greens are truly primative. The blue-green algae differ from the bacteria in possessing chlorophyll and having autotrophic nutrition, though certain of the bacteria are autotrophic but not photosynthetic. Another unique characteristic of the blue-greens is their storage product referred to as CYANOPHYCAN STARCH, meaning that it resembles starch but has a different chemical makeup. Refer to the chart on page 11 of BOLD for a comparison of the major groups of algae. BELL

There are approximately 1500 described species of blue-green algae, occurring in marine, fresh water, and terrestrial habitats. Aquatic forms occur as attached or free floating phytoplankton. As you may recall from Biology 101, the phytoplankton are the base of the aquatic food pyramid, the producer level, and are in turn generally fed upon by small herbivores such as zooplankton. When the environmental factors, such as temperature and nutrients, are favorable, the phytoplankton undergo rapid reproduction and subsequent increase in numbers, resulting in a BLOOM. Blooms of blue-green algae (certain species) and some other groups give water a characteristic and unpleasant odor and taste. Favorable temperatures and abundant nutrients, natural or added by man, lead to algal and bacterial increases, and reduction of dissolved oxygen as it is used up in respiration. The dead algal cells decompose and add further nutrients to the building pool. Eventually, oxygen depletion leads to the death of massive numbers of fish and increased fouling of the water. Blue-green algae are also ecologically important in their ability to fix atmospheric nitrogen and convert it to protein.

As a part of this course, you should collect material from local ponds and attempt to identify organisms using field keys. Any small jar of pond water from this locality should yield a variety of algal types, and by the end of our unit on algae, you should be able to place unknowns into major taxonomic groups and to recognize common genera.

Since we are not concentrating on classification within the Cyanophyta, let us consider them artifically as three basic morphological types: UNICELLULAR, COLONIAL, AND FILAMENTOUS. The unicellular are the most primative of body types, and the type organism is Gleocapsa. Obtain from the supply table some material, both living and preserved are available; place it on a microscope slide with a cover slip and begin observation using low power. BELL As you observe, the cells are extremely small and it is necessary to shift to higher powers. By adjusting the substage light and diaphragm, you should be able to get a good contrast between the cells and the background medium. Individual cells may be trapped as two or more in a gelatinous sheath, which is the outermost wall. Each cell is surrounded by its own cell wall, but cellular detail is absent due to the uniform distribution of the subcellular particles. Read the directions in the lab manual and make a sketch of Gleocapsa in the appropriate space. Also, observe the prepared slide of Gleocapsa, then return to the tape. BELL

Colonial genera are also considered primative, and vary in the shape of the colony. Merismopedia, a type which we do not have available but is pictured on page 16 in BOLD, occurs as a flat sheet. This type of arrangement would result from which direction of reproduction? Most likely reproduction is organized in a single plane along a rigidly fixed axis. Obtain from the supply table a slide of preserved fresh Microcystis. This type is an irregular colonial arrangement with a more random plane of reproduction. Observe this under the microscope and sketch a portion of the colony in area 2.a. and a single cell in 2.b. of the lab manual. Again, intracullular detail is not going to be seen. BELL

The advanced body form is the filamentous type, in which reproduction results in a chain of cells termed a TRICHOME. The trichome may be isolated or in a colonial form with other trichomes, as in Nostoc. Obtain some Nostoc from the supply table. Observe the intact colony and make a habit sketch in the space provided. BELL

Now place a small section on a clean glass slide and squash it with a cover slip. Observe this under low and high power. BELL Again the cells do not show great detail but we can see differences in the cells of the trichome. Under high power, certain cells appear larger and free of cellular material. These specialized cells are termed HETEROCYSTS. They are believed to arise from vegetative cells whose cytoplasm becomes disorganized and whose cell wall thickens. The heterocyst may be a weak link in the trichome chain, causing fragmentation and the formation of new chains. Such new chains formed by the splitting of a parent trichome are called HORMOGONIA, and may or may not be formed with the aid of heterocysts. Follow the directions in the lab manual and sketch a habit shot of Nostoc and a filament showing vegetative cells and heterocysts. BELL

A form closely related to Nostoc is Anabaena. Obtain some material, living or preserved, prepare a slide of it, and observe it under the microscope. BELL Again the trichomes consist of spherical vegetative cells and heterocysts, as in Nostoc. Another cell type may be observed; these are thick walled spores termed AKINETES, which arise from vegetative cells that develop thick walls and concentrations of storage granules. The presence of these granules distinguished akinetes from heterocysts. Akinetes may be spherical or oval, and serve the function of resistant spores, capable of surviving harsh environments for long periods of time (up to 70 years in air). They occur also in Nostoc but are better seen in Anabaena. The remainder of the filamentous genera which we will observe are Oscillatoria, Scytonema, and Gleotrichia.

Obtain some living Oscillatoria from the supply table and observe it under the microscope using low and high power. BELL Is there any differentiation in the cells of the filament? BELL Is there any apparent movement? BELL You may recall earlier from the algal chart that the Cyanophyta lack flageline and therefore should be immotile, but Osillatoria exhibits a definite movement. The nature of this movement has been explained on the basis of the cells secreting some gelatinous material through cellular pores, but this is not sufficient to explain the quantity of the movement. You should have observed that the trichomes are free of an enclosing sheath, as will be seen in other forms, and lacks skinetes and heterocysts. Fragmentation into hormogonia occurs at areas where vegetative cells die and weaken the trichomes. Sketch a trichome in the space provided in the lab manual. BELL

Obtain some preserved material of Scytonema, a form which occurs in moist soil and rocks. BELL Does this differ from the form of Oscillatoria? BELL The first observable difference is the presence of a sheath enclosing the cells of the trichome. Sheath and trichome are collectively referred to as a FILAMENT. Heterocysts should be present, as well as a characteristic form of branching in which trichomes growing rapidly in a certain area cause rupture of the sheath and the resultant branch. This is termed FALSE BRANCHING, and differs from TRUE BRANCHING, as occurs in a genus such as Haplosiphon (shown on page 21) in which the branch grows off a vegetative cell. Sketch a filament of Scytoenma showing the sheath and a area of false branching. BELL

Obtain a few filaments of preserved Gleotrichia from the supply area and observe it under the microscope. BELL Is there any difference between this and Oscillatoria or Scytonema? BELL The filaments are tapered and have a basal heterocyst, and akinetes are usually formed near the heterocyst. Sketch a few filaments in the lab manual and label them. BELL

You may have noticed in this discussion of the Cyanophyta that there was no mention of sexual reproduction. This is due to the fact that none has been observed yet in the blue-greens, although it may occur under conditions which we have yet to duplicate in studying them. This concludes the portion on the Cyanophyta. Read through the objective sheet once more and if there is a part that you cannot answer, run back through the tape to that area covered. Then proceed to the oral and written quizzes, and then on to the CHLOROPHYTA.

PLANT MORPHOLOGY

Section 2: Chlorophyta

OBJECTIVES: After completing all the work associated with this section, you will be able to:

1. Compare the Chlorophyta with the Cyanophyta as to their structure, pigments, and ecological importance.

2. Identify or describe the typical unicellular forms Protococcus and Chlamydomonas and discuss the importance of motility in the forms that possess it.

3. Identify or describe the members of the volvocine line (colonial series).

4. Identify or describe the filamentuous forms Oedogonium, Ulothrix, Spirogyra, and Cladophora; describe how Cladophora differs from the previous three.

5. Identify the desmids Closterium, Cosmarium, Scenedesmus, and Micrasterius.

6. Be able to identify and describe the structure and life cycle of either Caldophora or Ulva.

7. Explain the meaning and use of the following terms: isogamy, heterogamy, haplontic, diplontic, zoospore, coenocytic, and coenobium.

8. Make a statement regarding the relative advantages of isogamy and oogamy; explain.

9. Discuss alternation of generations as it relates to the life cycles of Ulva and Cladophora.

AUDIO SCRIPT

The green algae, as the Chlorophyta are commonly called, are the most abundant of the algal forms, comprising approximately 7,000 species distributed in fresh water, salt water, and terrestrial habitats. Their body form and size ranges from the unicellular Chlamydomonas, 25 microns in length, to the microscopic multicellular sea weed Ulva. They show greater internal organization than the Cyanophyta as seen in the electron micrograph on page 25 of Bold. The DNA and nucleolar RNA are packaged in the nuclear membrane, and the photosynthetic enzymes are in organized chloroplasts. Contained within the chloroplasts are PYRANOIDS, which appear to be the cite of starch synthesis and storage of the photosynthate. Another feature of the green algae is the variety in life cycles and reproduction, some of which will probably be repitituous of material covered in Biology 101. These variations are based on the chromosomal condition of the nucleus at the different stages of the life cycle, and the variations in the occurrance of meiosis in the different species. The green algae show many evolutionary trends, as seen in the handout sheet and also in the first kodachrome slide which you should compare. Notice that they appear to be in a direct line of evolution with the higher green plants, a viewpoint that is held by many morphologists.

There are several morphological types in the Chlorophyta; UNICELLULAR, COLONIAL, FILAMENTUOUS, MEMBRANOUS, and a form termed COENOBIAL, which we will define shortly. The unicellular and colonial forms may also be classified as MOTILE or NONMOTILE forms, depending on the presence or absence of flagellae. Let us examine a unicellular form first, the nonmotile Protococcus. Go to the supply table and prepare a slide of Protococcus by scraping some of the green material from the tree bark. This plant occurs both aquatically as a planktonic form, and as an epiphyte, growing in soil or on trees in humid terrestrial habitats. Now prepare the slide, observe it under high power, and return to the tape. BELL Follow the instructions in the lab manual for Protococcus and complete the drawing. One item that may be added to this sketch is the thick wall surrounding the cell or small colony, if the cells have divided and remained in contact. BELL

Related to Protococcus but occuring as a filamentuous form is Ulothrix, a fresh water type found attached to objects by means of a specialized end termed a HOLDFAST. Obtain some living material from the supply area and follow the directions in the lab manual. BELL Have you successfully answered the questions in the lab manual and completed the life cycle on page 11?...Asexual reproduction is achieved through the production and release of quadraflagellate zoospores in any vegetative cell of the filament, as seen in the left side of Plate II. If you are stumped by the term zoospore, refer to the glossary...... the term means a motile asexual cell produced by a nonmotile parent. Quadraflagellate means having four flagellae, and only careful adjustment of the light will make them visible. These zoospores will germinate within a few days in a suitable environment and develop into a filament, the basal cell becoming the holdfast. Sexual reproduction involves the fragmentation of the protoplast in a vegetative cell, forming 16, 32, or 64 biflagellated gametes. Thus there are no true GAMATANGIA (gamete forming organs), and the production of gametes or zoospores by a vegetative cell appears to be determined by the environmental conditions. The gametes are released when the cell wall breaks, and gametes from one filament may fuse with the gametes of another filament. Since the gametes are morphologically alike, this is referred to as ISOGAMY, and the mating of gametes from different filaments is termed HETEROTHALLISM. If the gametes mated with others of the same filament, we would have HOMOTHALLISM, which may occur in some species of Ulothrix. You may recall from Biology 101, the significance of cross fertilization.. to provide for genetic mixing. The resultant zygote produces a thick wall and may pass through a resting phase to survive harsh environmental conditions. Meiosis occurs in the zygote, producing zoospores which will develop into new filaments when the spore wall ruptures at germination. If we could measure the nuclear content of Ulothrix, we would find that the filament, zoospores, and gametes are HAPLOID, while the zygote is DIPLOID. Meiosis is said to be ZYGOTIC as it occurs in the zygote, and the plant is HAPLONTIC, spending the dominant part of its life cycle in the haploid condition. Such conditions are only of importance to the plant and not to morphology, but are interesting to consider from an evolutionary point of view, since the haplontic condition is generally considered primative to the diplontic condition.

Return to the supply table and obtain some fresh material of Oedogonium, another fresh water filamentuous form, and follow the instructions in the lab manual. There are also prepared slides of Oedogonium in its different forms, and zoospores for observation. BELL The vegetative cells are morphologically distinguishable from those of Ulothrix, the chloroplast being net-like instead of ring shaped, and oval female cells found regularly along the filaments. Again, asexual reproduction is by zoospores, though the flagellar number is quite large. Examine the prepared slide labeled zoospores. BELL The sexual structures are easily identified in living or preserved material. Male gametangia, ANTHERIDIA, are thinner than vegetative cells and liberate flagellated sperm, while the female gametangia or OOGONIA are large spherical cells each producing a single stationary egg. While Ulothrix had motile gametes, Oedogonium shows a different condition, in which gametes differ in size, HETEROGAMY, and in which the female is large and immotile, OOGAMY, a condition characteristic of many higher green plants. As in Ulothrix, the plant body and zoospores are haploid, and the zygote is diploid. Meiosis is zygotic, resulting in haploid zoospores which develop into new filaments. There are several species of Oedogonium, some homothallic and some heterothallic.

The previous forms were characterized by having immotile adults. Another algal line, the VOLVOCINE, has motile adults, and shows a well defined evolutionary line from unicellular to colonial form. At the base of this line is Chlamydomonas, a biflagellated unicellular form. Obtain some from the supply table and follow the instructions in the lab manual. BELL Chlamydomonas is isogamous, individuals of different strains acting as gametes and fusing together. If this material is available, follow the lab manual instructions for mating strains. BELL

Obtain material of Gonium or Eudorina, forms which consist of Chlamydomonas like individuals embedded in a matrix and acting as a small colony. Gonium consists of 4, 8, or 16 cells, depending on the species, forming a flat plate, while Eudorina has 16, 32, or 64 cells, less compactly arranged. Both types may give rise asexually to more colonies, or produce isogametes in sexual reproduction. Observe them and sketch the colony outline in the lab manual. BELL

The top of the Volvocine line is Volvox which, depending on the species, may have up to 50,000 Chlamydomonas-like cells embedded in a matrix and forming a spherical colony. New asexual colonies are pinched off inwardly, and parent colonies will be seen with one to several daughter colonies inside. Fragmentation of the parent colony results in the liberation of the new colonies. Observe some living Volvox under the microscope in a hanging drop so that the colony is not crushed. BELL The movement is coordinated so that the colony is moving in one direction at a time. Now place a cover slip on the preparation and observe it under high power. BELL Make the appropriate sketches in the lab manual. BELL Sexual reproduction is oogamous, but may not be present in the material that you have so you should refer to the text for diagrams and a discussion of this process. Answer the questions at the bottom of page 8 in the lab manual and refer to the text for the answers. BELL

One interesting point to mention in summary of the Volvocine line is the fact that each species develops to a specific number of cells in the adult stage (example Gonium pectorals has 16 cells). Such a colony with a constant number of cells is called a COENOBIUM. We shall see more examples of coenobial algae shortly.

From an aesthetic point of view, the most ornate of the Chlorophyta are a group commonly called the DESMIDS. They are largely unicellular with a few colonial members, quite common in fresh water ponds (such as the water fountain near the classroom building), and characteristically lack motility. Sexual reproduction is by CONJUGATION, a process which we will consider when we reach Spirogyra. Go to the supply table and prepare fresh mounts of the desmids Cosmarium and Closterium. Also observe the kodachrome tray for slides of desmids, then follow the lab manual instructions. BELL

A close relative of the desmids is the filamentuous form Spirogyra, which is characterized by a spiral-shaped chloroplast. Examine some fresh material from the supply table and follow the lab manual, part 3. Skip the part labeled optional. BELL Can you remember any other organisms covered in Biology 101 that showed conjugation?....The protozoan Paramecium and the bread mold Rhizopus are good examples.

What are the possible benefits of conjugation?....For one, we have genetic recombination followed by meiosis resulting in varied offspring. A second is the resistance of the ZYGOSPORE so that the species can survive harsh environmental conditions such as DESSICATION (drying of the pond).

Two more coenobial green algae are Scendesmus and Hydrodictyon. Obtain material from the supply table and follow the lab manual instructions. BELL Scenedesmus is a common fresh water form, and also is the cause of algal blooms in fish aquaria. There should be one nucleus in each cell, and the number of cells varies with the species. Hydrodictyon is commonly called "water net" as you can probably observe from its form. As you may have observed, young cells are uninucleate, a multinucleate condition developing with age. Hydrodictyon has an interesting life cycle with biflagellated reproductive cells, but rather than cover it here, refer to the text for a description.

A filamentuous form found as different species attached in fresh and salt water is Cladophera. Obtain some preserved material from the supply table and follow the lab manual, on page 16, part 4. BELL Like Hydrodictyon, the vegetative cells of Cladophora start as uninucleate and become multinucleate as they mature. The term COENOCYTIC is equivalent to multinucleate as used here. The plant is not coenobial, however, and new branches grow from the apical ends of parent filaments, giving the appearance of dichotomous branching. The chloroplast changes form with the age of the cell - it is continuous in young cells, and breaks up into irregular segments in older cells. Vegetative cells near the terminal end of a filament can mitotically cleave forming uninucleate quadraflagellate zoospores which will develop into new plant bodies. Cladophora and Ulva, a form to be studied next, show a life cycle characteristic of higher green plants, namely an alternation of generations or DIPLOHAPLONTIC cycle. This implies two plant forms, a diploid stage and a haploid stage, with meiosis occurring some time during the cycle. In the case of Cladophora, meiosis occurs in spore formation, ultimately giving rise to haploid plant bodies which morphologically resemble the diploid spore producing plant, a condition referred to as ISOMORPHOUS. The haploid plant develops biflagellate isogametes which fuse during sexual reproduction, and develop into diploid plants. The only clue to the type of generation is to observe the type of flagellated cells formed - biflagellate indicates haplophase, and quadraflagellate indicate diplophase. Finish the section on Cladophora, then obtain some Ulva from the supply table. BELL

The lab manual in section 5 is written for the genus Prosiola, so we'll have to make some modifications here. Ulva, called sea lettuce, is a common marine and brackish water alga which you may have seen in a trip to the beach, unless you were near an oil slick, in which case it would be a black algae. This is a membranous plant type, the blade being very broad but only two cells thick. Like Cladophora, Ulva is diplohaplontic, with isomorphous diploid and haploid plants. However, in some species, the gametes are heterogametes, the small male and large female being produced by different plants. The gamete fusion produces a zygote that develops into a diploid plant which will form quadraflagellate zoospores. Make a sketch in the lab manual of the Ulva plant body or THALLUS. BELL

In summary, the Chlorophyta are a group of plants diverse in their morphology and in their life cycles. One not mentioned but of great importance is Chlorella, a unicellular nonmotile form that has been extensively studied with regard to respiration and photosynthesis. It can be cultured in large quantities in the lab, and shows a high yield of crude protein in new cells, and fats and carbohydrates in older cells. This appears to be a cheap, ideal nutritional source, if one doesn't mind eating an algal steak. This organism has also been considered for use in space biology, as a producer of both oxygen and food, and a consumer of carbon dioxide and waste materials. There appear to be many unique uses for the green algae in the future. This completes our section on the Chlorophyta.

PLANT MORPHOLOGY

Section 3: Chrysophyta, Rhodophyta, and Phaeophyta

OBJECTIVES: After completing the work in this section, you should be able to:

1. Relate the occurrence of mass fish kills with specific types of algae.
2. Biologically define the term "sea weed".
3. Explain the economic importance of the diatoms.
4. Recognize Vaucheria and describe its morphology and reproduction.
5. Defend the argument that Euglena is a plant rather than an animal.
6. Outline the life cycle of Fucus; under which general type of life cycle does this fall?
7. Briefly outline the life cycle of Polysiphonia.
8. Define the following terms: carpospore, tetraspore, conceptacle, thallus, coenocytic.

AUDIO SCRIPT

The remaining algal groups contain numerous members and are ecologically diverse, but are usually deemphasized in a course of this nature. Their body forms and life cycles follow general patterns so only a few representatives of each group will be considered.

The division Chrysophyta includes three major groups of some 6,000 species; the yellow-green algae, the golden-brown algae, and the diatoms. The diatoms are abundant in both marine and fresh waters as bottom dwellers or plankton and are the most important economically of the Chrysophyta. They are important members of the aquatic food chain, and due to the nature of their cell walls, useful industrially. Glass, also called silocon dioxide, present in the cell walls, accumulates in bottom sediments as the organisms die and settle, forming deposits of DIATOMACEOUS EARTH, which is mined and used as a scouring agent and abrasive. The body may be bilaterally or radially symmetrical, and the cell wall or VALVES are usually sculptured. Follow the laboratory instructions, page 25 number 2 in the observation of the prepared slides of diatomaceous earth and the preserved diatoms on the supply table. BELL

The type yellow-green alga, *Vaucheria*, was long considered a member of the Chlorophyta until a careful study of its flagellae, food storage, and pigments showed it to be a yellow-green. Obtain some *Vaucheria* from the supply area and observe it under the microscope. BELL This dark green filamentuous form is commonly called "water felt" and found as mats in flowing or standing bodies of fresh water. A few species are marine, and some are found in moist soil. Mature filaments lack crosswalls, are multinucleate, and therefore COENOCYTIC. Can you name a green alga with a similar structure?....If you said *Cladophora* you are correct. Observe the chloroplasts, which are minute disc-shaped structures. These manufacture food which is stored as oil. Look for the prominant reproductive structures. Asexuallity is accomplished by large multiflagellate zoospores produced at the modified tip of a branch, the zoosporangium. Sexual reproduction is either homothallic or heterothallic (recall the definitions of these terms). Look in your text on page 96 for a diagram of this and try to find areas on your slide showing these structures. Then complete the section in the lab manual in part 3 page 25. BELL

The last members of the Chrysophyta are the golden-brown algae, which are uninucleate flagellated forms found in both fresh and marine waters. Some are free swimming, and many, such as *Dinobryon*, are colonial. Observe the kodachrome slide of *Dinobryon* in the slide projector and make a small sketch in the lab manual. BELL

Two small groups which display a mixture of plant and animal characteristics (enough to be considered animals by Protozoologists) are the divisions Euglenophyta and Pyrrophyta. Two members of the

Euglenophyta, Euglena and its colorless relative Astasia were studied in Biology 101, and are available for review if you have forgotten the details of their structure. BELL In spite of the presence of chlorophyll in many species, Euglena still relies on outside food sources, example bacteria, vitamin B_{12}, in its nutrition, and are therefore only partially autotrophic.

Nevertheless, the presence of chlorophylls a and b, and a starch-like storage product, PARAMYLUM, seem to make the Euglenophyta specialized members of the plant kingdom showing a regressive evolution in the development of colorless forms, as also seen in the fungi.

The Pyrrophyta, commonly called the dinoflagellates, are common fresh and marine flagellated forms with characteristic sculpturing of the cell wall. Observe the prepared slide and the kodachrome slides of the dinoflagellates, chiefly the genus Ceratium, and label the sketch in the lab manual. BELL Dinoflagellates demonstrate the natural ecological effects of algal blooms on fish life. Off the coasts of Florida and California, when environmental conditions are favorable (temperature, light, nutrients), certain species undergo massive increases in number and disrupt the normal ecology of the area, resulting in large fish kills. Such events have been termed RED TIDES due to the discoloration of the water, and appear to be a natural catastrophe similar to mans pollution of certain bodies of water, except that natural pollution usually corrects itself.

The two remaining algal divisions, the Phaeophyta and the Rhodophyta, are predominantly marine forms, developing complex body structures and reaching sizes up to several feet in length. Many are referred to as SEA WEEDS, and the brown alga Fucus is a common occurrence on the shores of New York in the summer time where great piles accumulate and decay in the hot sun, giving rise to a very characteristic odor...Fucus is the type genus that we will study, but others include the KELPS Laminaria, Microcystis, and Sargassum, the last being a form found in mass off the North Carolina coast. These giants of the sea are the ocean's versions of our own terrestrial forests. The brown color of the Phaeophyta is due to a pigment fucoxanthin, which masks the color of the chlorophylls. Excess photosynthetic material is stored as the carbohydrates LAMINARIN, MANNITOL, or oil droplets. Obtain from the supply table some preserved Fucus and the prepared slide, study them with the dissection and compound microscopes, and then return to the tape. BELL

An interesting adaptation in these forms is the air bladder, which acts as a floatation device, keeping the plant up in the lighted areas of the ocean. In the ocean, light disperses rapidly in the first several meters, and below a depth of 200 meters, it is essentially absent. This restricts plants to the upper waters, and they must therefore be either motile, light bodied, or have floatation devices. The reproductive structures, called RECEPTACLES, are located at the tips of the growing branches, and contain clusters of reproductive cells in cavities termed CONCEPTACLES. Observe the prepared slide for the sections of the green algae and other browns, Fucus does not have an alternation of generation; the adult plant is diploid, and meiosis occurs at gamete formation. Asexual reproduction is by fragmentation rather than by zoospores. Complete the sketches in the lab manual then return to the tape. BELL

The Rhodophyta, the red algae, are predominantly marine, with a few fresh water genera. A dominant red pigment, PHYCOERYTHRIN, masks the chlorophylls and acts as an accessory in photosynthesis. Excess food is stored as FLORIDEAN STARCH, which, like cyanophycan starch in the blue greens, is a specialized carbohydrate. The red algae also lack flagellated cells, another factor in common with the blue green algae. Structurally, they are usually delicate branching colonies, thin membranous sheets, or unicellular. Study the available herbarium preparations for a general picture of red algae structure. BELL They are economically useful as food in the Orient, and in the production of commercial materials such as AGAR, used in bacterial growth medium, and ALGIN, a filler used in some foods.

Obtain some Polysiphonia from the supply table, observe it with the dissection and compound microscopes, and follow the lab manual. BELL Polysiphonia is a delicate branching marine form with APICAL GROWTH, that is growth from the tip, and with a complex diplohaplontic life cycle. The sexes are separate, DIOECIOUS, male plants producing nonmotile SPERMATIA which are borne by water currents to the eggs of the female plant. The zygote becomes surrounded by sterile tissue and develops into a stage called the CARPOSPOROPHYTE. Diploid CARPOSPORES are liberated and develop into TETRASPOROPHYTE plants, also diploid. At maturity, the tetrasporophyte, which resembles the gametophyte, produces haploid TETRASPORES, which then develop into male and female gametophytes. Other red algae show the haplontic or diplontic types of life cycle. Examine the prepared slide showing the reproductive structures of Polysiphonia and complete the work in the lab manual. Complete the diagram on page 35 and refer to the text for the proper labels. Also complete the section on page 27. Emphasis will be placed only on the terms given in the tape.

Now observe the bioplastic mount of the four marine algae Acetabularia is a unicellular green, Ulva, a membranous green, and Fucus and Chondrus are complex brown and red. Then finish studying the kodachrome slides, concentrating on general body form. Do not memorize the specific names of those we have not discussed in the tape. Then return to the tape. BELL

This concludes our section on the algae, a group of some 20-25,000 species of fresh water, marine, and terrestrial plant-like organisms. We have not followed a close phylogenetic sequence.

There is still argument on the hierarchy in the lower plants, but generally in the algae, the Cyanophyta are the most primative, and the Chlorophyta in direct line with the higher green plants, the Metaphyta. A straight evolutionary line is one way of arranging the plant groups, but reality is probably a branching arrangement with some continuous line and some dead end branches. A useful reference which follows the phylogenetic approach is Plant Diversity: an Evolutionary Approach by Scagel, et. al. Take some time to scan this book for the different arrangement of material. We have spent our greatest coverage on the Cyanophyta and the Chlorophyta, not because they are better algae than the othesrs, but merely to use them as examples of diversity of body structure and life cycle within divisions. This is only personal bias, and some other instructor might have given equal treatment to the diatoms or the red algae. Now go on to the section on the introduction to the fungi.

PLANT MORPHOLOGY

Section 4: Introduction to the Fungi, Myxomycetes, Phycomycetes

OBJECTIVES: At the completion of this section, you will be able to:

1. Define and characterize the term fungus.

2. Compare nutrition in the fungi with that in the algae.

3. Compare modes of reproduction, using specific examples, of the fungi with the algae.

4. Identify the fruiting bodies of the slime molds Trichia, Dictydium, and Physarum.

5. Collect plasmodia or fruiting bodies of slime molds from local habitats.

6. Describe the general structure of the fruiting body of a slime mold.

7. Identify the sporangia of Rhizopus and outline the stages in conjugation.

8. Defend the argument that sex in Rhizopus is chemically controlled.

9. Outline the life cycle of Allomyces.

10. Culture one of the water molds, such as Allomyces, Saprolegnia, or Achlya and attempt to identify it.

11. Recognize a slide of Albugo and describe its mode of nutrition.

12. Define: zygospore, haustoria, mycelium, gamone, subterminal, aplanospore and rust.

AUDIO SCRIPT

Have you ever had a ripe case of ATHLETES FOOT or RINGWORM? How about finding nice patches of green mold on your bacon, bread, or cheese? A thick steak smothered in mushrooms? If so, then you are already familiar with our next group of plants, the fungi. The term fungus is descriptive rather than taxonomic, and includes a number of divisions of lower plants that lack chlorophyll. Since they cannot manufacture their own food, their nutrition is necessarily heterotrophic, being chiefly SAPROTROPHIC, that is living on decaying organic matter, and PARASITIC. Their size and complexity ranges from the unicellular yeasts to the macroscopic mushrooms, which, in spite of their large size, are still simple in their structure.

The group is larger than the algae, some 80,000 species, quite diverse in morphology, and ecologically important for reasons other than those used for the algae. Due to their nutritional requirements, the saprotrophic forms are decomposers of dead organisms, as were the bacteria, and the parasitic forms are the great scourges of agriculture. Various forms of fungus blight have had disasterous effects upon the human population - recall the Irish potato famine a century ago which caused the starvation of at least two million people and the migration of another two million. Closer to home we have a recent example of corn blight, which affected most of America's corn belt and may have economic effects on food production for the next few years. Two of America's great shade trees, the American elm and the chestnut have been faced with local extinctions due to destructive fungi. One reference book of interesting reading is The Advance of The Fungi, by Large, and is available in the lab. This is not obligate reading, but you may find this more interesting than the textbook.

The first group of fungal-like organisms, which were in the past considered part of the Protozoa, are the MYXOMYCETES of the division Myxomycota. These are commonly called the true slime molds, and are closely related to another small group, the ACRASIALES, or cellular slime molds. We do not have material of the cellular slime molds, but they have been a valuable experimental group for scientists such as J. T. Bonner. The vegetative stage of these forms takes on the shape of a motile feeding slug, composed of individual amoebae which swarm together due to some chemical attraction. Refer to the photographs in the text on page 124. BELL

The vegetative phase of the myxomycetes is called the plasmodium, and is a continuous coenocytic unit rather than a number of individuals as in the Acrasiales. Plasmodia can be found in the early spring growing and feeding on the under surfaces of rotting trees and leaves, and can be cultured in the lab. If any are available for you in the lab, observe them with the dissecting microscope. They can be raised on agar or on filter paper if they are fed oatmeal....BELL The plasmodium sinks into the substratum and absorbs nutrients as the host organic material decays. They show adaptation for drying environments by forming dormant resistant stages termed SCLEROTIA, which become active when moisture and heat is added again and can thus survive dry cold winter conditions.

When the environmental conditions are suitable, the plasmodium gives rise to fruiting bodies called SPORANGIA, which grow up from the surface of the plasmodium. These sporangia have characteristic shapes and size. Examine the sporangia of the available slime molds Physarum, Trichia, Dictydium, and any others. Observe the shape, coloration, and density of the sporangia under the dissection microscope. BELL

Sporangia vary in their microscopic structure, but generally consist of a stalk, or COLUMELLA, a woven thread-like network, the CAPILLITIUM, and, on these threads, the Spores. The spores are dispersed by wind currents and germinate forming flagellated stages or amoeboid forms which develop into new plasmodia. Examine the prepared slide of the slime mold and make the appropriate sketch in the lab manual. BELL An optional demonstration is the parasite of cabbage root, Plasmodiophora, which causes disarrangement of the host tissues as the spores fill the host's cells. Look for this in the prepared slide. BELL

If you have completed your study of the slime molds, let us progress on to the next group, the PHYCOMYCOTA. This is a diverse group which is not considered a single taxonomic unit by some authors. They consider instead six separate divisions, but we will study them as the phycomycetes, the algal-like lower fungi. We will study three representatives; the terrestrial bread mold, Rhizopus, a water mold, Allomyces, and a parasite, Albugo. All are characterized by lacking the specialized reproductive structures of the higher fungi, and lacking the plasmodium of the lower slime molds. The body structure is chiefly a MYCELIUM, a coenocytic network of threads; individual branches are termed HYPHAE. You are probably familiar with Rhizopus from Biology 101, or from finding it on old bread at home. It, and other air-borne forms, can be easily raised by leaving a slice of bread in a shallow dish of water exposed to the air for several days. A lustrous growth of different molds will develop, and Rhizopus will probably be one of them. Go to the supply table, and with a dissecting needle, scrape some material from the nutrient medium and mount it on a slide with a small amount of water. Observe it microscopically, following the lab manual. Turn on the tape again when you reach the part on reproduction. BELL Obtain the prepared slide of Rhizopus and study it with the microscope. Listen to the tape while you are studying the slide. BELL Sexual reproduction in Rhizopus involves the process of conjugation, something that you have already observed in the algae - recall the genus Spirogyra. This takes place between different strains of Rhizopus, simply called + and - strains. Hyphae of the two strains come in contact, and their tips become separated from the remainder of the hyphae, forming multinucleate swellings called GAMETANGIA. The gametangia fuse, and the resultant zygote develops a heavy black wall and becomes a resting ZYGOSPORE. The recognition of different strains is accomplished by specific sex hormones, termed GAMONES, which stimulate attraction in hyphae of mating strains and the formation of the sex organs. These hormones are released into the surrounding medium, forming a cloud of hormone. For a more detailed account of this complex process, refer to Bold, page 138.

The aquatic Phycomycetes grow as saprophytes or parasites on submerged animal or plant life. They can be grown in the lab by BAITING pond water with boiled hemp seeds, corn, wheat, or dead insects, and looking for a halo of mycelial growth after a few days. Several samples of pond water are available in the lab and have been baited with suitable materials. If you are interested in some optional work, collect some water from your own sources, use hemp seeds, and see if anything grows. Before attempting to identify the fungi in the pond samples, let us first look at a few sample aquatic phycomycetes. Allomyces is available at the supply table. Mount a few filaments on a slide and observe it with the compound microscope. Follow this section in the lab manual, page 38. BELL

Allomyces is a branched mycelial fungus, and careful observation of the hyphae will reveal the lack of complete septation in the filaments. These vegetative hyphae are multinucleate or coenocytic, and the terminal regions contain the reproductive structures. This genus exhibits alternation of generation (do you recall a few algae with this characteristic)? The sporophyte stage, asexual, may bear two types of sporangia: thin walled mitosporangia and thick walled meiosporangia. The mitosporangia are usually produced first, and their zoospores will exit through a pore in the sporangial wall and germinate into more sporophytes. The meiosporangia appear later in development, and possess a thick dark wall. They are resistant to dessication and harsh temperatures, and, as the term signifies, are the site of meiosis. Flagellated zoospores leave this sporangia and develop into the haploid gametophyte stage. In this species, the female gametangia is TERMINAL, and the male is adjacent to it or SUBTERMINAL. Look for sections on your slide that show these thin walled gametangia; also look for PAPILLAE or blobs on the surface which act as exits for the gametes. BELL

In some other species, the male gametangia is terminal, and may have a red color due to dissolved pigments. Can you see any of the gametes being liberated from the gametangia? They are heterogametes, the female being much larger than the male, and both are uniflagellate. The male is chemically attracted to the female, and the resultant zygote develops into the sporophyte stage. A summary of the life cycle is presented on page 133 of Bold. Study it and complete the lab drawings. BELL

Other water molds include Achlya and Saprolegnia, both of which are available as prepared slides. Get these slides from the supply table, study them, and compare them with the structure of Allomyces. BELL Both may be cultured in the same manner as Allomyces, though some species of Saprolegnia are parasitic on fish. They may be distinguished from Allomyces by the lack of partial septe, in their irregular branching, and their different reproductive organs. The zoosporangia are elongate terminal structures, and liberate biflagellate zoospores. These motile spores withdraw their flagellae after a short time and become nonmotile APLANOSPORES, which later germinate into motile zoospores. The second zoospore will encyst and develop into a new plant. In Achlya, the primary or first zoospores remain clustered around the mouth of the zoosporangium, while in Saprolegnia, they are dispersed.

Sexual reproduction involves the production of nonmotile gametes. The male antheridia and female cogonia, borne on lateral branches, come in contact with each other. Look for this in the prepared slide of Achlya. BELL As in Rhizopus, a complex chemical reaction stimulates the development and attraction of the gametangia, but in Achlya, some clones may be unisexual while others are bisexual and require a different clone with which to mate (this is heterothallism). Study the pictures in Bold on page 134, and any other texts available, on the structure of these water molds, and then try to identify some of the fungi in our pond water. Don't be disappointed if they don't look like any of the three we've studied; there are quite a number of water molds, some still to be identified and keyed, an extensive task for the taxonomist. BELL

The fungi that we have been studying so far are classified as saprophytes, obtaining their nutritional needs from dead or decaying organisms. Many species of the Phycomycetes are parasitic, living on plant or animal hosts and frequently resulting in serious damage to the host. Athletes foot never killed anyone, but a smut or rust can wipe out an entire agricultural crop in a local area. The term rust has many meanings, one of them signifying a fungal infection of plant material. The classical wheat rust will be considered later; right now, let us consider WHITE RUST, an infection of plants caused by species of the genus Albugo. Obtain from the supply table some infected leaves, and also the prepared slide of Albugo, and study these with both the dissecting and compound microscopes. Read the lab manual, page 38, and then return to the tape. BELL

The infection begins with a spore settling on the host and germinating mycelia spreading through the host tissues. Nutrition is obtained from the host by portions of the mycelium, termed HAUSTORIA, penetrating host cells. Portions of the mycelium push up to the outer part of the plant and form the sporangia, or SORI, which are the white patches on the plant surface. Wind and air currents cause the dispersal of the spores, produced by the sporangia in large numbers, and spores settling on a new host will cause infection if the surface is moist. Sexual reproduction involves the production of antheridia and oogonia, which, as in Achlya, are nonmotile. The zygote forms an oospore which develops slowly until the spring, at which time it liberates biflagellate zoospores capable of initiating infection. Now examine the prepared slide of Phytophthora infestans, the late blight of potato. This was the cause of the major upheaval in Ireland a century ago, when the chief food crop, the potato, was wiped out. Study the sections, looking for mycelia and sporangia. BELL

This completes our study of the lower fungi. After you have passed the tests on this section, go on to the program on the Ascomycetes.

PLANT MORPHOLOGY

Section 5: Ascomycota

OBJECTIVES: At the completion of this section, you will be able to:

1. Give the characteristics that distinguish the ascomycetes from the lower fungi.

2. Describe the general structure of the three fruiting bodies - apothecium, cleistothecium, perithecium, and give one example of an ascomycete for each.

3. List the economic uses of the yeasts.

4. Compare the sporangia of either Penicillium or Aspergillus with that of Rhizopus.

5. List the economic uses of Penicillium.

6. Describe the process of ascus formation.

7. Define or explain the following terms: ascocarp, conidia, sterigamta, hymenium.

8. Discuss the cause and transmission of dutch elm disease and chestnut blight.

9. Identify from living material, preserved material, slides, or kodachromes, those ascomycetes covered in this section.

AUDIO SCRIPT

The ascomycetes, division Ascomycota, are a group of fungi characterized by the presence of a specialized structure for sexual reproduction, the ASCOCARP. This distinguish them from both the phycomycetes, which lack such a specialization, and the basidiomycetes, whose structure is the basidium. The structure of the ascocarp is variable within the ascomycetes and we'll rely on this as our distinguishing features rather than the classification as presented in the text.

The simplest level of structure in the ascomycetes is seen in the yeasts, the example that we'll study being the genus Sacoharomyces. Obtain some living yeast culture from the supply table and prepare a slide. Follow the lab manual on page 45, make the required drawings, then return to the tape. BELL Yeasts are unicellular and commonly reproduce asexually by budding, which you probably observed. In sexual reproduction, determined by the environmental conditions, a cell will develop into a sac-like ascus and produce 4-8 spores, depending on the species. These spores then develop into vegetative cells. This cycle is diagramed and further explained in the text on pages 142-143. Certain aspects of the yeasts metabolism have been put to economic use. In respiration, as you should recall, carbon dioxide is produced, and this is exploited in the baking industry, as this gas causes the rising or leavening of bread and cakes. If aerobic respiration is blocked, then pyruvic acid is converted into ethyl alcohol (do you remember the product in animal respiration), and most of us are aware of the economic use of this product. Different strains of yeast are cultured for the production of a wide variety of wines, and if you are interested in some extra experimentation in this area, there are a number of references to aid you.

A large group of ascomycetes have a fleshy ASCOCARP, or fruiting body, in the shape of a cup, and are commonly called CUP FUNGI. These include edible varieties such as MORELS and TRUFFLES, which are considered delacacies in certain parts of Europe. The more common forms are Pyronema and Peziza; the former is discussed in the lab manual but we will substitute the latter in our work. The fruiting body in the cup fungi is called an APOTHECIUM, and differs from the flask-shaped PERITHECIUM and closed CLEISTOTHECIUM, which we will study later. Reproduction in these ascomycetes is usually asexual, with the production of numerous spores, termed CONIDIA. These germinate forming new mycelia, and the asexual cycle continues. The sexual cycle occurs in either spring or fall, when the mycelium forms female ASCOGONIA and male ANTHERIDIA. The antheridium enters the ascogonium, but the nuclei do not fuse immediately. They remain in close association within the cell, and this nuclear condition is called the DYKARYON (meaning 2 nuclei). A slender filament forms, each cell having the two nuclei, and the terminal portion folds over forming a hook-like structure, termed a CROZIER. The subterminal cell is the one which will develop into the ascus following nuclear fusion. For a diagramatic representation of this process, refer to Bold, page 152, and also to the text Introductory Mycology by Alexopoulos, page 228. Nuclear fusion results in the development of a sac-like ASCUS, in which four or eight ASCOSPORES develop from successive meiotic and mitotic divisions. In most ascomycetes, these asci occur as a fertile layer, the HYMENIUM, interspersed with sterile cells, called PARAPHYSES. Examine specimens of Peziza, a saprophyte found on decaying matter, and notice the cup-shaped apothecium. Then study the prepared slide of the ascocarp, refering to the description in the manual. There is also a photograph on page 152 of the text. Complete the drawings in the manual and return to the tape. BELL

While the cup fungi are saprophytic in their nutrition, a group of ascomycetes, called the POWDERY MILDEWS, are parasitic. Examine the specimens of grass infected with the genus Erysiphe graminis with the dissection microscope. Look for patches of powdery white growth. This appearance is due to the presence of upright hypae bearing conidia. BELL Now study the prepared slide of Erysiphe and follow the description in the lab manual on page 45. This fungus shows a second type of ascocarp, a CLEISTOTHECIUM, which is a closed structure. Follow the description of the cleistothecium from the section on Uncinula just below that of Erysiphe in the manual. A drawing is on page 149 of the text. BELL

After you have studied the structure of Erysiphe and made the appropriate drawings, we will study another parasitic form, Claviceps purourea, which affects wild grasses such as rye. It occurs on the plant as a hard dark body, called the SCLEROTIUM, replacing the tissues of the host, and occasionally resembling the host. Obtain a sclerotium from the supply table and study its texture; then study the prepared slide of a section of a fruiting head, called a STROMA, containing the third type of ascocarp, the flask-shaped PERITHECIUM. Follow the lab manual description on this study. BELL

Infection of plants by Claviceps occurs when insects pick up the sticky sweet conidia from one host and transport them to another host. The ascospores leave the perithecium through an opening, the OSTIOLE, as the asci expand due to internal pressures, and can further initiate infection. Claviceps purourea has been found to be a rich source of ERGOTAMINE, a powerful drug with several interesting effects. One of these is contraction of uterine muscles, and range farmers must take care that pregnant cows do not eat infected rye or abortion of the fetal calf is the usual result. Another effect is the development of hallucinations, such as those produced by LSD. Such an effect on a person or a population is termed ERGOTISM, and has been documented several times in history. More recently in France, an entire town was affected by bread baked from rye flour containing ergot. This bad trip is documented in a book titled The Day of St. Anthony's Fire and illustrated the drastic effects that ergotamine can have.

Even though the ascomycetes appear to be an obnoxious class of organisms, one particular group has been exceedingly beneficial to man. This group is referred to as the molds, and includes Penicillium, Aspergillus, and Neurospora. These are commonly found as saprophytes on rotting fruit and meat, can be cultured in the lab on agar plates, and can be distinguished by their color and colonies. The presence of the pesty blue mold Penicillium was noted for many years until an accident in the lab of Alexander Fleming in 1929 showed the pest to have medical value. One of Fleming's bacterial plates became contaminated with spores of the mold and caused lysis or death of the bacteria in the vacinity of the mold. Rather than discarding the contaminated culture, Fleming investigated the properties of the mold and subsequently isolated the active bacteriocidal ingredient, which he named penicillin.

Thus Penicillium became the first of the fungal-bacterial groups to contribute to the development of antibiotics, the most important group of medical compounds yet developed. The study of the molds and the fungal-like bacteria has since led to the development of several strains of penicillin, streptomycin, chloramphenicol, and the tetracyclines.

The uses of Penicillium are not restricted to medicine alone, but have been employed for ages in the manufacture of cheeses. The next time that you are shopping in your favorite grocery store or gourmet shop, purchase a lump of roquefort or camenbert cheese, and study its texture, color, and taste. The specific cheese is created through the action of the molds Penicillium roqueforti or P. camenberti on the milk curd as the cheese is aging. Thus the cheese is rotted, or to put it in a more acceptable way, it is ripened by the mold. The great variations in the different cheeses are due to the many strains or varieties of mold used in the cheese industry, giving us either hard and crumbly roquefort or soft and smooth roquefort. The blue molds have been a beneficial group.

Obtain from the supply area a bottle of preserved Penicillium and observe it under the dessecting microscope. Then study the prepared slide of Penicillium and Aspergillus, comparing their fruiting bodies (sporangia). Diagram the conidiophore or spore forming structure of Penicillium in the lab manual, then return to the tape. BELL (refer to the diagrams on page 144-145 of the text). The vegetative hyphae growing over the surface of the host send up stalks bearing the fruiting bodies, termed CONIDIOPHORES. These bear bottle-shaped cells, the STERIGMATA, upon which are produced the chains of conidia, the asexual spores. Aspergillus has a spherical fruiting body, while Penicillium is branched or brush-like. Aspergillus has been related to occasional poisoning of animals and man if it heavily infects food products.

Sexuality has been described in the molds, and the ascocarp is a cleistothecium (which other ascomycete that you have studied has this form). Obtain the prepared slide of the Aspergillus cleistithecium and compare this with that of Erysiphe which you have already studied. Then return to the tape. BELL

The remaining mold which I mentioned in the beginning of this section is Neurospora, which is pictured for you on page 147 of the text. If you observe in the diagram at the bottom of this page, the ascospores are borne in the perithecium in linear rows of eight spores each. This particular arrangement in spore production has been utilized by geneticists in the study of the hereditary traits in fungi. By carefully selecting ascospores, a trained geneticist can grow Neurospora and select for various traits, chiefly nutritional needs. Refer to a good genetics text, such as General Genetics by Srb, Owen, and Edger, for further information in this area.

This covers those ascomycetes in the lab manual and most of those in the text. Some mention should be given to two species of ascomycete that have wrecked havoc on two of America's finest shade trees, the chestnut and the American elm. Forty years after Endothia parasitica was introduced into the United States virtually 100% of the commercial chestnut trees were wiped out. The spores are carried from tree to tree on the feet of insects, birds, and squirrels, and invade the bark through breaks made by woodpeckers or squirrels. Millions of spores may be carried on the feet of a single bird. Dutch elm disease, caused by Ceratosomella ulmi, is transmitted by the elm bark beetle which bores into the bark of the tree carrying the spores of the fungus. Once established in a tree, the mycelium of the fungus is uncontrollable and the tree must be destroyed to prevent infection of neighboring trees. Both of these parasites were introduced from Europe, where native trees had developed a balanced resistance to the effects of the fungi, while American trees, having no resistance, are destroyed by the foreign parasite. If there are slides available of these two species, study them and compare them with material in the text on mycology by Alexopoulos. BELL

This completes the section on the ascomycetes. After you have completed the exam on this section, go on to the next section, basidiomycetes.

PLANT MORPHOLOGY

Section 6: Basidiomycota

MATERIALS: Audio Script
2 by 2 slides
Agaricus (fresh if available)
coral or pore fungi
Geaster (earth star)
Puccinia graminis - prepared materials of stages, slides of stages in life cycle
Ustilago zeae - whole specimen and prepared slide
Gymnosporangium - preserved gall and slide of basidia
Candidia albicans - type Neuteromycete, prepared slide
Lichens - bioplastic mount of three types, slide of cross section

OBJECTIVES: At the completion of this section of study, you will be able to:

1. Distinguish between a basidiomycete and an ascomycete using only reproductive structures.

2. Describe the development of a mushroom and identify the following regions of the fruiting body: stipe, annulus, pileus, lamellae, hymenium.

3. Compare homothallism with heterothallism in the mushrooms.

4. Define the term dikaryon and give examples of its occurrence in the Basidiomycetes.

5. Contrast the structure of Clavaria or Polyporus with that of Agaricus.

6. Briefly outline the life cycle of Puccinia, the wheat rust, and describe the location, formation, and any morphological characteristics of the following spores: urediniospore, teliospore, basidiospore, spermatium, aeciospore.

7. Compare the life cycle of Puccinia with that of the smut, Ustilago and cite at least two differences between them.

8. Describe the structure of a typical lichen; describe or identify three different morphological types of lichen.

9. Define the term fungi imperfecti and give one example of the group.

AUDIO SCRIPT

Hi there, music lovers! (Introductory music, The White Rabbit - deals with the use of hallucinogenic mushrooms) The theme of the preceding song was the effects of certain mushrooms that have hallucinogenic affects on the human mind. This weeks lab is on the group of fungi classified as the Division Basidiomycota, to which belongs the mind-expanding mushroom, as well as the common edible varieties. If the ascomycetes can be characterized by an ascocarp and ascospores, the basidiomycetes may be characterized by basidiocarps and basidiospores. The basidiocarp is the fruiting body bearing the basidia, reproductive structures which are homologous with the ascus but differ in forming their basidiospores externally rather than internally as in the ascus. This is a diverse group, ranging from the parasitic rusts and smuts, which do extensive economic damage to our agricultural crops, to the saprophytic and usually deliciously edible mushrooms. Since there is no typical basidiomycete, just as there was no typical ascomycete, let us use the common field mushroom as our starting point for this group.

Obtain a specimen of Agaricus, either living or preserved, whichever is available, from the supply table, and bring it back to your work area and return to the tape. BELL The body of the mushroom is the fruiting body or basidiocarp, bearing the basidia and basidiospores on the surfaces of the gills. It starts from germinating basidiospores, whose mycelia penetrate the substrate, such as the soil, and absorb their nutrients from decaying organic matter. Certain species are self compatable or homothallic and will develop sexually by themselves, while others are self incompatable or heterothallic, and require the hyphae of a compatable strain in order to complete their life cycle. Such heterothallic hyphae remain sterile unless they meet compatable hyphae.

In some species of basidiomycete, hyphae may break up into asexual reproductive units, termed OIDIA which form their own mycelium, and fuse with other oidial hyphae. Following mating, the DIKARYOTIC stage is formed (similar to that of the ascomycetes) and the mycelium is ready to develop into the basidiocarp, if the environmental conditions are favorable. This process starts as a button stage, a ball of interwoven hyphae, which grows up through the soil, forming the typical fruiting body. Now study the specimen and compare it to the description in the lab manual on page 51. Prepare the slide of the gill structure, and compare it to the prepared slide of Coprinis, another genus of mushroom, then make the necessary drawings in the lab manual and return to the tape. Also study the specimens of mushroom development on the supply table. BELL

In studying the slide of the gill structure, were you able to see the basidium, sterigmata, and spores?....In the development of the spores, the nucleus of the basidium undergoes meiosis, forming four nuclei, each of which migrates into a projection of the basidium, called a STERIGMA, and develops into a basidiospore. Thus you should have observed a club shaped basidium bearing four pointed projections, each bearing a single spore although there may be variations in the number of spores produced in different species. A single basidiocarp is capable of forming BILLIONS of spores in its lifetime, but only those that settle on a suitable substrate will develop.

As ecological units, the mjaority of the mushrooms are saprophytes and useful as decomposers in the food web. Economically, the field mushroom Agaricus campestris is raised as a delicacy, for those of us who appreciate a thick steak smothered in mushroom and butter sauce. One species produces PSILICYBIN, a hallucinogenic drug similar to LSD, while several other species of the genera Aminita and Russula contain toxins that can result in mild illness or death if eaten. Although there are morphological distinctions between edible and poisonous species, only a mushroom expert should eat one found growing wild. For more detailed information, refer to Krieger's book, The Mushroom Handbook.

Related to the mushrooms are the PORE FUNGI and the CORAL FUNGI, whose hymenial layers develop in pores or tubes rather than on open gills. Some,such as Polyporus, grow as flat projections off rotten logs and are commonly referred to as BRACKET or SHELF FUNGI. Study the preserved specimens of Polyporus and Clavaria, the latter a coral fungus, and make the appropriate sketches in your lab manual. Then study the prepared slide of Polyporus, looking for the hymenium, basidia, and spores. There is a photomicrograph in Bold on page 166 that you should refer to. Compare this structure with that observed in Agaricus. BELL

Some basidiomycetes, the PUFFBALLS, develop their fruiting bodies as entirely enclosed structures, and only the decay of the wall or mechanical disruption will cause the discharge of the spores. Examine the basidiocarps of Lycoperdon and Geaster, available from the supply table. Examine their surfaces with a dissecting microscope and look for the presence of small openings, OSTIOLES, which are present on some species. Little is known about the life cycles and cytology of this group. BELL

The next two groups of basidiomycetes that we will study, the rusts and smuts, are the most economically important members of this division due to their parasitic effects on many of mans agricultural crops. The life cycle of Puccinia graminis, commonly called wheat rust although it attacks oats, barley, and rye also, is the most complex of any we have thus far studied. This parasite alternates between the wheat stem and the leaves of the barberry plant, passing through several stages in each plant. In the wheat plant Puccinia starts as an asexual stage, termed the UREDINIUM, characterized as rust colored structures or streaks on the stem. Study the wheat stem labeled uredial stage under the dissection microscope, then study the slide labeled Puccinia uredia with the compound microscope. BELL

Did you notice any distinct characteristics of the spores being produced by the uredium?....The uredium gives rise, by mitosis, to the thin walled binucleate urediniospores, which are dispersed by air currents to the other wheat plants, which they infect. Infection is dependent on proper environmental conditions, such as moisture and high humidity. The damage to the host plant involves the mycelium of the parasite growing into the wheat tissues and absorbing nutrients from it, at the expense of the host. Since the infection occurs in a temperate climate, and cold winters normally occur, the parasite must be capable of surviving freezing temperatures. The uredinial stage is not resistant, but the mycelium produces another stage, the TELIA, which develops thick walled uninucliate TELIOSPORES, CAPABLE OF OVERWINTERING. The teliospores begin as binucleate cells, but at maturity the nuclei fuse, ending the dikaryotic phase. Study the wheat stem with the dark telia streaks, and then study the slide labeled Puccinia - telia. Make the appropriate drawings in the lab manual. BELL

When conditions are favorable again, the teliospores germinate, in the telium or in the ground if they have fallen. From the spore arises a thin hypha which develops into a basidium consisting of four individual cells, each of which produces a single spore. This differs from the basidium of the mushrooms, in which a single basidial cell forms four basidiospores. These spores are carried by air currents and will germinate only if they land upon the leaves or stem of a BARBERRY BUSH. Within a week of germinating, the parasite has developed a mycelium in the outer tissues, usually the upper regions, and begins forming flask shaped SPERMAGONIA (also termed PYCNIA). Examine the prepared slide of Puccinia labeled pycnia and look for the spermagonia and the small SPERMATIA released when the spermagonium ruptures the leaf surface. BELL

The Spermatia, discharged over the leaf surface in a sticky fluid medium, fuse with receptive hyphae which are usually located in the lower leaf surface. This fusion does not involve nuclear fusion, and the dikaryotic stage is produced; the nuclear condition remains dikaryotic until the next telial stage. The spermatialhypha union produces a cup-like structure on the lower leaf surface, termed the AECIA, which forms orange binucleate AECIOSPORES. These are the spores which are infective to the wheat plant; carried by air currents, they will germinate and develop into the uredinial stage on the host. It has been estimated that one barberry bush can yield 64 TRILLION aeciospores under suitable conditions. Study the prepared slide labeled Puccinia-aecia, observing the structure of the aecia and the aeciospores, and then make the appropriate drawings in the lab manual. Refer to page 160 in Bold for a summary of the life cycle. BELL

A second example of a rust is the ceder apple gall, Gymnosporangium, which produces enlarged fruiting bodies, the telial stage on juniper trees. Its aecial stages are found on apple trees, and the life cycle differs from that on Puccinia in lacking the uredinial stage. Study the preserved specimen and compare it to the observed fruiting bodies of Puccinia. BELL

The SMUTS are another group of plant parasites but differ considerably from the rusts in having a simpler life cycle involving only one plant host. Examine the prepared specimen of Ustilago zeae, the corn smut, and compare it with the diagram on page 161 of Bold. BELL....This species produces gall-like growths on corn ears and tassels. Like the rusts, smuts produce teliospores which begin as dikaryons and mature into uninucleate thick-walled spores. These spores are pushed through the plant epidermis as the fungus grows, and, when disseminated by air currents, can either germinate or overwinter, depending upon the availability of the host plant. Teliospores germinate as a filamentuous basidium which forms haploid basidiospores capable of initiating new infection. Study the prepared slide labeled corn smut and look for spore formation. Substitute this sketch in the lab manual for the one labeled Urocystis. BELL

A large group of fungi that has been set up in an artificial class, the Deuteromycota, are characterized by producing only asexual reproductive cells. The lack of any observable sexual reproduction has led to the common name of FUNGI IMPERFECTI. Many species grown in culture have formed sexual phases, usually asci, and have been reclassified as such. Our example is Candidia albicans, a deuteromycete that is occasionally parasitic in the human oral cavity, causing a condition termed THRUSH. Study the prepared slide of Candidia and make a sketch in an empty space in the lab manual. BELL Other members of this group, including the genus Trichophyton, are causes of various skin disorders, including ring worm, athletes foot, and jock rash.

The last group of lower plants to consider is also an artificial group, referred to commonly as the LICHENS. They are symbiotic composits of a fungus and an alga, with the fungus mycelium overgrowing the algal elements. The relationship is usually considered mutualistic in which both benefit, though there is some argument against this with regard to some species. Individual fungal and algal components have been cultured successfully, indicating that the relationship is not always obligate or totally necessary. There are three general morphological types of lichen: the crustose or encrusting form, foliose or leaflike, and the fruticose or branching form. Study the bioplastic mount and representative specimens of the three types of lichen and make habit sketches of each in the lab manual. Refer to the photographs and diagrams on pages 174-175 of Bold. BELL

Now study the slide of the lichen section and attempt to distinguish the fungal from the algal components. Refer to the diagram 14-7 on page 175 of Bold. Make a brief sketch of this in the lab manual. BELL....Ecologically, the lichens are considered pioneers in harsh habitats, such as bare rock surfaces or frozen arctic soil, and can be commonly found growing on the bark of trees. The next time you are near a tree, look for the variety of lichens on the surface. After you have completed your study of the Basidiomycetes, Deuteromycetes and Lichens, ask your instructor for the quiz on this material and go on to the next section on the Liverworts and Mosses. (MUSIC)

PLANT MORPHOLOGY

Section 7: Quizzes for Sections 1 through 6

Section 1: Bacteria and Cyanophyta NAME:____________

1. Define the following terms:

   prokaryotic

   trichome

   heterocyst

   akinete

   hormogonium

2. Give one example for each of the following blue-green algal types:

   unicellular

   colonial

   filamentous

3. Defend the present classification of the bacteria as Monera rather than as fungi:

4.a. Discuss the ecological importance of the bacteria; also list three forms which cause human illness.

  b. Discuss the ecological importance of the Cyanophyta.

Section 2: Chlorophyta NAME:________________

Part 1: Oral quiz on slides.

Part 2:

1. Show, by examples, the development of the Volvocine line of green algae from the unicellular to the colonial form.

2. Outline the life cycle of Ulva, showing the alternation of generation as it relates to meiosis and to the haploid and diploid stages.

3. Compare the genera <u>Cladophora</u> and <u>Spirogyra</u> on their structure and life cycle (include types of reproduction)

4. Define the following terms:

   zoospore

   coenobium'

   coenocytic

   isogamy

   haplontic

Section 3: Chrysophyta, Rhodophyta, and Phaeophyta NAME:______

1. Outline the life cycle of Fucus..

2. Describe the processes of reproduction in Vaucheria.

3. How does the life cycle of Polysiphonia differ from that of Fucus?

4. Define the following terms: (give an algal group in which each is found)

   thallus

   conceptacle

   carpospore

   diatom

Section 4: Fungi, Myxomycetes, and Phycomycetes NAME:_______

1. Compare nutrition in the fungi with that in the algae.

2. Describe the general structure (or diagram it) of the fruiting body of a slime mold.

3. Briefly discuss the process of sexual reproduction in Rhizopus.

4. Outline the life cycle of Allomyces..

5. Define the following terms:

haustoria

mycelium

aplanospore

Section 5: Ascomycota NAME:_______________

1. Describe or diagram the general structure of the three ascocarps:

   apothecium

   cleistothecium

   perithecium

2. List the economic uses of Penicillium, using specific examples.

3. Describe or diagram the process of ascus formation.

4. Discuss the cause and mode of transmission of both dutch elm disease and chestnut blight.

Section 6: Basidiomycota NAME:________________

1. Compare homothallism and heterothallism in the mushroom.

2. Compare the life cycle of Puccinia with that of the smut, Ustilago, and cite at least two differences between them.

3. Describe the structure of a typical lichen; describe or identify three different morphological types of lichen.

4. Define the term fungi imperfecti and give one example of the group.

PLANT MORPHOLOGY

Section 8: Bryophyta: Liverworts

OBJECTIVES: Without reference, be able to:

1. Define and/or recognize the definition of the following terms: rhizoid, antheridium, archegonium, thallus, capsule, stalk (sets), foot, elater, gemmae, gametophore.

2. Describe the liverworts and name three representative genera.

3. Draw and/or label a diagram of the life cycle of a liverwort. Be sure to indicate the events of fertilization and meiosis and the gametophyte and sporophyte phases of the life cycle.

4. Identify the structures listed above in number one on live material, preserved material, prepared slides or kodachromes (whichever is appropriate).

5. Given an unfamiliar liverwort, identify the typical liverwort structures found on it.

6. Recognize the following structures on Anthoceros (or colored pictures of same): foot, basal meristematic region, sporophytes, columella, spores, elaters, epidermis, photosynthetic tissue, and stomata.

7. Sketch a leafy liverwort such as Porella. Include amphigastria and the gemmae in your sketch.

AUDIO SCRIPT

Embryophyta - These are plants which have an embryo stage preceding the development of the new plant. The several groups of embryophytes have many characteristics in common. They certainly lack the diversity of the Thallophytes. Some of the characteristics which all the Embryophytes have in common are presence of chlorophyll A and B, Beta and usually alpha carotene and several xanthophylls such as zeozanthin and lutein. Most of the Embryophytes store starch, have a primary cell wall composed of cellulose and when flagellated cells are present the flagella are of the whip-lash variety. Many of these characteristics are hled in common with the green algae. As a matter of fact, the green algae are believed to be ancestral to the Embryophyta. In addition to the characteristics which are held in common with the green algae, the Embryophytes always show distinct alternation of generations and always have an incipient sporophyte which is multi-cellular and called an embryo. Asexual reproduction occurs in the embryophytes, but when it does it never involves asexual spores. The organs that produce the gametes are always multi-cellular. The male gametangium is called an antheridium. The female gametangium is called an archegonium. The other characteristics possessed by some of the groups of the Embryophytes will be discussed later in connection with the group that has them.

The first division is Bryophyta. The Bryophytes include the mosses and liverworts. The Bryophytes are small plants growing in very moist environments. They lack the vascular tissues of higher plants and are unable to conduct fluids over great distances so their size is always small. Fertilization is effected by swimming sperms and moisture must be always present for fertilization to take place. They show a distinct alternation of generations with the gametophyte generation being the dominant and the sporophyte the subordinate generation. The sporophyte never touches the ground, is always parasitic upon the gametophyte and is relatively shortlived. Since the Bryophytes have no vascular tissues, their vegetative parts are never correctly referred to as roots, stems or leaves. The stemlike organs, however, are properly referred to as caulidia. The leaflike organs are called phyllidia. You will notice in your lab manual that the author uses the terms "leaves" and "stems" and many other botanists do likewise. The correct terms often seem cumbersome and no short familiar terms are available, so roots, stems, and leaves it is. Bryophytes like all the Embryophytes have multicellular antheridia and archegonia. These antheridia and archegonia are borne on the gametophyte plants. Fertilization occurs and the zygote or fertilized egg grows into a sporophyte plant which remains attached to and parasitic upon the gametophyte. The sporophyte in turn produces haploid spores by the process of meiosis and each of the spores can develop into a new gametophyte plant so the life cycle is complete. In the Thallophyta you have seen a great many different kinds of life cycles. In the Embryophytes, however, there is only one kind, alternation of the generations with a definite gametophyte and a definite sporophyte stage. We will begin our look at the Bryophytes by beginning work on the liverworts. Turn to page 61 in your lab manual and to page 183 in your textbook. Take a few moments to read the introductory material in your textbook which describes the characteristics of the liverworts (signal). We have three liverworts for you to look at. These are Marchantia. The lab book suggests that we use Calopegia or Bezzania but we are substituting Porella for this part of the exercise. The third liverwort that you will be looking at is a kind of a specialized one called Anthoceros. This is sometimes called a horned liverwort and some authorities place it in a separate group. Take some preserved thalli of Marchantia, proceed with exercise No. 1 on page 61. Look at these, study them, attempt to answer the questions that are asked in that section. When you have done this return to the tape for some answers. (signal) Did you say that you were looking at the gametophyte generation? If you did, you are correct. Of what value is the airpore to Marchantia? If y our answer was that it allows for gas exchange, then you were correct. All of the prepared microscopes slides including the optional one are in your slide box. Be sure that you look at all of these things as well as comparing them with the pictures in your textbook. Preserve material contains the gametophores of Marchantia both male and female. Make sure that you can distinguish between these. In your slide set are slides showing cross sections through the male gametophore and through the female gametophore. Be sure you examine these and can tell the difference. There is also some prepared material of female gametophore with the sporophyte attached to it. Note that the sporophyte is of extremely small structure that remains attached to the gametophyte. Look carefully at the questions in the last paragraph of exercise 1. See if you can answer them. Continue and make the drawings suggested in the lab exercise on page 63 of your lab book. Enough space is provided for all of these drawings. When you have completed the drawings and labeled them correctly, return to the tape. (signal) Where does the sporophyte develop with respect to the archegonium? If you answered this that it grows right out of the archegonium and remains attached to it, you are correct. What is the function of the elaters? If you answered to coil and uncoil with moisture changes and help expel the spores after the capsule is open, you are correct. In what ways are spores and gemmae of Marchantia different? Your answer should be the spores are formed by the process of meiosis and the gemmae by the process of mitosis. How else may Marchantia reproduce? Your answer should be; in addition to the spores and gemmae, Marchantia can reproduce by fragmentation. Review the section No. 1. Look again at all the questions in it and when you are sure that you fully understand the material, proceed to Section 2. Obtain a small portion of the leafy liverwort Porella. This specimen in vegetative condition has many of the characteristics of those described in the lab manual on page 61 and 62. As you study the section of Porella, see if you can answer the questions on top of page 62 pertaining to it. Notice the leafy section over and look for the amphigastria and then return to the tape. (signal) Does the plant you are studying produce gemmae? You should have answered yes. These are produced on the upper edge of the philidia and they are cellular in size and different in shape from those of the Marchantia. When you have completely mastered the material in Section 2, move on to Section 3. In this section you will be working with Anthoceros, the horned liverwort. Obtain some preserved specimens of Anthoceros and proceed with the exercise on page 62, No. 3. The prepared slides shown in this section are found in your slide box. Using your textbook and the slides that are provided, plus the preserved material, complete Section 3 making the drawings as you are instructed there on page 63. Then label the drawings shown on page 65. When you have finished with this return to the tape. (signal) One noteworthy feature of the Anthoceros sporophyte is the presence of stomata in the epidermis. Stomata are a very common feature in the vascular plants but are rare in the Bryophyta. These, of course, function as the same as the air pores with the exception that they have guard cells which open and close and regulate the size of the stomata, thus allowing more or less air to enter or to leave. You will be provided with a diagram of life cycle of the liverwort. The study and comparison of life cycles is an important feature of plant morphology. Study this and make sure that you understand it completely. Be sure that you can indicate which is the haploid generation and which is the diploid generation. Be sure you know which cell marks the beginning of the sporophyte generation and which cell begins the gametophyte generation. Be sure you know where the events of fertilization and meiosis occur. When you have done this return to the tape. (signal) In summary then the liverworts are Bryophytes in which the gametophyte is flattened like a pancake. The antheridia and archegonia are superficial. In the sporophyte the capsule usually consists of both spores and elaters. You have just looked at three of about 5,000 species of liverworts. We hope that these three liverworts will have given you a chance to observe many of the major features of these plants and that the study of the life cycle has provided the basis to proceed to the next group. There are some 2 X 2 kodachrome slides available also. Be sure that you observe these before you finish the exercise. This ends the taped presentation on liverworts.

PLANT MORPHOLOGY

Section 9: Mosses

OBJECTIVES: Upon completion of this unit of work, the student should be able to describe plants and be able to recognize and identify the morphological features typical of the group. Without references, be able to:

1. Define and/or recognize the definitions of the following terms: Protonema, paraphyses, calyptra, operculum, peristome, and annulus.

2. Describe the mosses (Musci) and name three representative genera.

3. Draw and/or label a diagram of the life cycle of a moss. Be sure to indicate the events of fertilization and meiosis and the gametophyte and sporophyte phases.

4. Recognize from preserved or fresh material, prepared slides or colored slides the following structures of mosses: gametophyte, sporophyte, protonema, antheridia, archegonia, egg cell, foot, stalk, calyptra, capsule, operculum, peristome, paraphyses, and spore.

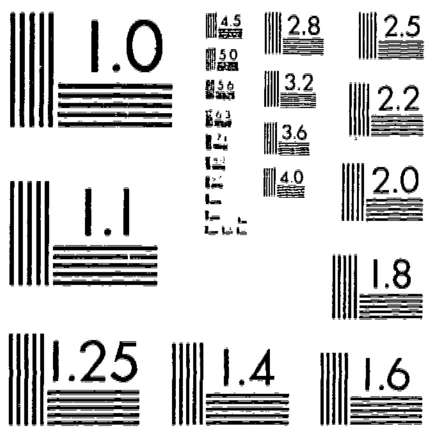
5. Given an unfamiliar moss plant, identify the moss structures which are found on it.

6. Recognize the large, water-holding cells in a cross section of the 'leaf' of Sphagnum.

AUDIO SCRIPT

The second group of bryophytes are the mosses. These are common low-growing plants in moist areas, bogs, woodlands and other places where there is sufficient moisture for the fertilization to occur. Instead of having flat thalli like the liverworts, the mosses have erect, much more leafy appearing, plant like structures. As in the liverworts, the gametophytes is the dominant generation and the sporophyte is the subordinate. Also as in the liverwort, the sporophyte is parasitic upon the gametophyte and is attached to it. The moss capsule is a more complex organ than the capsule of the liverwort. The capsule usually contains within it larger amounts of non-reproductive tissue. Another difference between the mosses and the liverworts is that mosses generally grow from a protonema. This is a small filamentous stage that develops from a spore that grows into the leafy plant which is, of course, the gametophyte. While the mosses never attain any great size, they are widely distributed and found in a wide variety of different kinds of habitats. There are presently over 14,000 different species described belonging to three orders making this a rather large and common group. Turn to page 67 in your lab manual and to page 225 and following in your textbook. In this exercise you will be asked to look at several different moss genera. The first exercise calls for you to use Funaria. Instead of Funaria in this section, you will look at Mnium. All other instructions in this section will apply to Mnium. The second section asks you to look at several other mosses. A third section asks you to look at samples of Sphagnum. We have all of these things for your use, as well as all of the prepared slides that you will need for this section. Begin now with section one substituting Mnium for Funaria and follow through answering the question. As you proceed you will perhaps have some difficulty making a good slide of the Antheridia. Do not be too concerned about this because there are prepared slides in the slide box which will show you as much or more detail than you could see if you made a good slide of your own. You should, however, be familiar with the area of the gametophyte plant which produces the Antheridia as well as the area of the gametophyte plant which produces the Archegonia. Proceed now with Section No. 1. When you have finished with this return to the tape. (signal) In Section 1 you are asked questions about the "leaves" of the moss plant. The "leaves" of the typical moss plant are one cell thick except for a slightly thickened midrib of rather long, thick-walled, cells that lack chlorophyll. Often there is no midrib and the cells are all alike. In some genera, such as Polytrichum, the hair cap moss, the leaf has a relatively broad central band which has many closely set thin longitudinal photosynthetic ridges, several cells high and one cell thick, arising from the upper surface. Notice as the sporophyte grows and develops, it has three very distinct parts. These are the foot, the stalk (or seta), and the capsule. The foot is a parasitic organ or perhaps rather an organ of absorption which is embedded in the female gametophyte tissue. The question on page 68 asks: if you see any evidence of algae-like characters in the mosses studied.

Does the protonema remind you of a filamentous alga? If it does, then you are no different from some scientists in the past who have classified moss protonema as some new kind of alga. Later in Section 1 on page 68 you are asked about the function of the peristome. The peristome usually consists of a couple of rows of teeth that project inward from the margin of the capsule, and sometimes close the opening of the capsule. When the weather is dry the teeth bend outward and allow the spores to escape. When the weather is wet these teeth bend inward and retain the spores within the capsule. The peristome and the operculum are not present in all genera of the mosses. Now review Section 1 and make sure you have all of this straight before we proceed to Section 2. (signal) We are now ready to proceed with Section 2 on page 68. Here you are asked to study prepared microscope slides showing a Polytrichum capsule. This slide is in your slide box. Continue with Section 2 and see if you can answer the questions in the section as you go. Make the drawing that it calls for on page 71. There is also included in your material and supplies a bottle which is marked "moss types". This includes the gametophytes with attached sporophyte with several different species of moss. You will have the opportunity to look at these things and compare them at this point. When you have finished with Section 2 and the optional exercise at the bottom of page 68, return to the tape. (signal) Notice that the capsule of Polytrichum is quite different from the capsule of Marchantia. First of all it is a rather complex structure compared to the simpler structure of Marchantia, and Polytrichum and contains no elaters which are of course, present in Marchantia. The reason for this is that it has some photosynthetic tissue in it and perhaps, to some degree, can produce its own food. Review Section 2 before proceeding to Section 3. (signal) Section 3 is about Sphagnum, which is moss quite different from those you have already looked at. Sphagnum is considered by many authors to belong to a different order of mosses. This group is usually called the peat mosses. Of course they are found in peat bogs, moist or wet places in cold and artic regions. Sphagnum is one of those mosses that does have some kind of commercial value. Occasionally it is packaged up and sold in garden stores and farm supply stores, as peat moss or Sphagnum moss. Proceed with Section 3 on page 69, when you have finished with that return to the tape. (signal) A common name for Sphagnum moss is bog moss or sometimes just peat moss. The leaves of Sphagnum moss are rather interesting because they have two kinds of cells in them. One type is chlorophyll bearing and the other type is large, dead, thick-walled and are called hyaline cells. These colorless of hyaline cells absorb water and release it very gradually under conditions when it is very dry. This water-retaining capacity of Spagnum is a feature that is used in gardening to hold moisture in the soil. Review Section 3 and be sure that you understand everything in that section. (signal) The structures of the mosses are similar in some respect to those of the liverworts. I think that it is easy to see a relationship between the two groups after having studied both of them in the detail that you have just done. The life cycle of the moss is similar to that of the liverwort. A life cycle diagram has been furnished for your use. It is correctly labeled and the diploid and haploid phases are in different colors



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(Diploid in black, Haploid in red). Beginning with the spore, which is the first cell of the gametophyte generation, the life cycle begins. This grows into a protonema, the protenema develops into the gametophyte state which produce antheridia and archegonia. The antheridia produce sperm, the archegonia eggs. The eggs and sperms fuse to form a fertilized egg or zygote. The zygote is the first cell of the sporophyte generation. This zygote develops into the sporophyte plant which produces foot, seta, and capsule and spores in the capsule. The spores are produced by the process of meiosis and become the first cell of the gametophyte generation. This shows very clearly an alternation of generations type of life cycle, and one that is quite typical of mosses, liverworts, and many of the higher plants. All of the higher plants show an alternation of generations but it is not nearly so obvious in the flowering plants. Be sure that you study the life cycle of the moss in detail and understand it fully. Know which cell constitutes the first cell of the sporophyte. Know which cell constitutes the first cell of the gametophyte. Know which part of the plant is the gametophyte generation and know which part of the life cycle is the sporophyte generation. Be able to fix the events of fertilization and meiosis. Practice by then attempting to draw a life cycle and label these things. When you have done this, return to the tape. (signal) In summary, the mosses seem to be a more highly developed group of bryophytes than the liverworts. The presence of a protonema is one characteristic that suggests this. The capsule is more fully developed. The presence of more highly developed antheridia and archegonia also suggests this. The capsule is more fully developed. The presence of more highly developed antheridia and archegonia also suggests this. In the mosses the antheridia and archegonia may be found on the same or on different gametophytes. The sperm are flagellated and swim to the archegonium where fertilization occurs. The zygote develops into an embryo which is ret ained within the archegonium for a short time. When the mature sporophyte develops, the basal portion remains embedded in the tissue of the gametophyte, where the sporophyte eventually develops a capsule or spore case which produces haploid spores, each of which is capable of developing into a mature gametophyte. The mosses are important ecologically as soil building plants. They are usually found in moist or wet environments and are quite shade tolerant, much more so than the higher plants. Their value as soil building plants is enhanced by their ability to reproduce rapidly by vegetative means and the tendency to form thick carpets with water holding capacity. This water holding capacity prevents soil drying and help prevent erosion. Some authorities feel that a carpet of moss can act as a natural mulch, a seed bed for the growth of seed plants.

The taped presentation is about to end. There is a kodachrome presentation on the mosses. Be sure you look at that. (signal)

PLANT MORPHOLOGY

Section 10: Ferns

OBJECTIVES: Without references, be able to:

1. Define and/or recognize the definition of the following terms: prothallus, sorus (sori), sporangium, annulus, indusium, and rhizome.

2. Describe the ferns and name three representative genera.

3. Draw and/or label a diagram of the life cycle of a fern. Be sure to indicate the events of meiosis and fertilization; and the gametophyte and sporophyte phases of the life cycle.

4. Identify the following structures on live material, preserved material, prepared slides or 2 x 2 colored slides (whichever is appropriate): circinate vernation, sori, indusium, annulus, spores, sporangium, prothallus, antheridia, archegonia, rhizoids, gametophyte with sporophyte attached.

5. Given an unfamiliar fern, identify the typical fern structures found on it.

6. Recognize and identify the structures and tissues of a Polypodium rhizome. These are epidermis, vascular bundles, pith, cortex, xylem, phloem, endodermis and pericycle.

7. Sketch a fern prothallus, including antheridia, archegonia, and rhizoids.

AUDIO SCRIPT

The preceding exercises have all been concerned with plants that do not have any vascular tissue. These are sometimes referred to as primitive plants. From now on all of the plants that we will discuss will be those that contain vascular or water conducting tissues. In exercise 10 we will consider the ferns. This is following the order that you will find it in the laboratory manual. And while this order is not phylogenetic because there are plants considered to be even more primitive vascular plants than the ferns, it seems somewhat logical to look at this large group and then consider the other more primitive vascular plants in exercise 11. Different authors disagree on the classification of the ferns. Some place the entire group as a division of the plant kingdom, while others make them a class of another division called Tracheophyta. Since we are not emphasizing the classification or taxonomy of the ferns (or any other group in this course) we will leave that to some future consideration and merely call them the ferns. Your textbook would tell you that the ferns are comprised of some 10,000 or more living species, as well as many fossil forms. They consist of such number and diversity that your textbook actually devotes three entire chapters to their consideration. (Chapters 21, 22, and 23). All this suggests that due to their great numbers and diversity that they are an extremely difficult group to make any kind of meaningful survey of. In spite of this difficulty we will ask you to make an attempt to learn some of the more important structures of the ferns, to survey some of the representative species of ferns, and finally to become familiar with the life cycle of the fern. This, hopefully, will be enough to survey this large and somewhat diverse group.

The ferns are one of several groups of non-seed-bearing vascular plants. All of these groups seem to have been of much greater importance in the past, but today have been largely replaced by the seed plants. The ferns reproduce by means of spores and have in their life cycle an independent gametophyte stage which requires that a certain amount of moisture to be present for fertilization to occur. This weak link makes reproduction much more of a matter of chance than it is with the seed plants. The presence of vascular tissues with the accompanying increase in efficiency in conducting water and other liquids makes it possible for these plants to attain much greater sizes than those in the ones previously studies. As a matter of fact, the ferns are all extremely complicated plants with true roots, stems, and leaves. Not only do the ferns have leaves, but the leaves are a type which are called megaphylls by botanists. The megaphylls contain in them many branches of vascular tissue which allows these to become large, broad, flattened structures much as we know of in all of the other higher plants. The ferns range all the way from extremely small, completely aquatic forms to some that are tree size and are referred to as tree ferns. These tree ferns are usually found in rain forests. Some in tropical rain forests while others are found in temperate rain forests. The life cycle consists of a distinct alternation of two separate generations.

Nowhere is this alternation of generations so pronounced, so distinct and so easy to observe as it is in the fern. More, however, will be said of this near the end of this exercise. Turn to page 75 in your laboratory manual and to page 326 in your textbook. Page 326 in the textbook is the beginning of Chapter 21 which, as said earlier, was one of the three chapters devoted to the ferns. This, and the pages following, form a basis for your text material. Exercise No. 1 on page 75 deals with the form of living ferns. This is designed to show you how the fern is divided into the parts; roots, stems, and leaves. Take some preserved specimens which are actually pressed into plastic covered mounts and study carefully this area in exercise No. 10, part 1. Try to answer the questions in part 1, and when you have finished with it return to the tape. (signal). If your answer to what sort of stem the fern has was a rhizome, then you were correct. Notice that the roots arise by growing directly from the stem. They are referred to as adventitous. Circinate vernation refers to the habit of the growing young blade of the leaf to unroll from the tip. These produce the characteristic growing young leaves of ferns which are frequently referred to as fiddle heads. Move on to exercise 10, part 2. In part 2 we will substitute the genus Polystichum for the genus Cyrtomium: Cyrtomium is a cultivated genus and many authorities feel that it should be classified in the genus Polystichum. That suggests that these two are very closely related so the substitution should present no difficulties. The prepared microscope slide is in your slidebox and is marked fern Polypodium. There is also a prepared slide in your slidebox entitled fern sporangia. This you can use for the third section of part 2, exercise 10. Study these structures, complete the drawings as suggested in your laboratory manual and then return to the tape. (signal) Did you notice that the indusium was attached by being an outgrowth of the fern leaflet itself? Did you answer that the sporangium was one cell layer thick? If you did, you were correct. One feature of the sporangium which is not mentioned in the laboratory manual is the special thickened layer of cells around one edge of the sporangium which is called the annulus. The annulus responds to changes in humidity and causes an uneven tension which allows the sporangium to rupture, break open and spores to be dispelled. Go on with part 3, exercise 10. Take the prepared slide marked Polypodium which is the one that will show you a sorus without an indusium. There are available twelve pressed species of ferns for you to use in this part. Using these pressed specimens and the little guide to the ferns which is also available for your use, complete part 3 and return to the tape. (signal) Go on with part 4, exercise 10. In your slide box there is a slide marked Polypodium, cross section of a rhizome. This is the one that you should use for this part of the exercise. Do the exercises described in your laboratory manual and use the textbook as a reference for this. Complete the diagram on page 83 and then return to the tape. (signal) Begin part 5, exercise 10. The gametophyte stage of the fern is called a prothallus. There are available in your slidebox, four slides showing various stages in the development of this prothallus or gametophyte. Use these for the study of part 5 and when you have completed this attempt to answer the questions in it, return to the tape. (signal) Did you notice that the very early stage of the fern prothallus is filamentous which makes it homologous with the moss protonema? If you have looked at these slides in serial order you will notice that the first one in the series shows the antheridia or male gametangia and the last one the archegonia or the female gametangia. There is a film loop on the antherozoids or sperm of the fern. Please look at that sometime during or immediately after this exercise. Continue with exercise 10 by doing part 6. There is in your slidebox a slide marked fern prothallium, sporophyte attached. Use this for this part. When you are finished with part 6 return to the tape. (signal) The last part of exercise 10, part 7 deals with the study of the life cycle of the fern. When you pick up your study sheet for this exercise you will be given a diagram of a life cycle carefully labeled. Use this and try to correlate the parts that you have just completed studying with those that ar pictured on this labeled diagram. As always in the study of the fe cycles, be sure that you are familiar with the occurrence of the events of meiosis and fertilization. Be sure that you know which plant part constitutes the gametophyte generation and which plant part constitutes the sporophyte generation. When you have become thoroughly familiar with this life cycle without looking at your notes, try to label the diagram in the laboratory guide. (signal)

In summary then, the ferns are a large group of plants with a distinct alternation of generations. The plant which most everyone recognizes as a fern is the dominant sporophyte generation with true stems and leaves. In addition to this the leaves are of a sort called megaphylls or large leaves. The life cycle is of a sort that is generally called homosporous, meaning that there is only one kind of spore produced. This single spore develops into a small, free-living photosynthetic, gametophyte plant called a prothallium or prothallus. On the prothallium are produced both anteridia and archegonia. Fertilization occurs when the sperm from the antheridia swim into the archegonia and unite with the egg. This zygote or fertilized egg develops into the sporophyte generation which is the large, conspicuous plant that most of us recognize as a fern. This sporophyte develops, on the undersurface of the leaves, sporangia which are in clusters which are called sori and each sporangium produces many spores. These spores result from the process of meiosis. Each spore is capable of developing into a gametophyte plant again, and thus the life cycle is completed. The taped exercise on the ferns is about to conclude. There are some kodachrome slides showing the various parts that you have been studying available for your use. Please take the time that you need to look at these and compare them with the drawings that you have made in your laboratory manual and with those that you have included in your notes.

PLANT MORPHOLOGY

Section 11: Club Mosses, Psilophytes and Horsetails

OBJECTIVES: Without references, be able to:

1. Define and/or recognize the definition of the following terms: Strobilus (pl. strobili), stele, tracheids, protostele, microspores, megaspores, microgametophyte, megagametophye, homospory, and heterospory.

2. Describe the Club Mosses and name two extant genera.

3. Describe the Psilophytes and name one extant genus.

4. Describe the Horsetails and name one extant genus.

5. Draw and/or label a diagram of the homosporous life cycle of Lycopodium. Be sure to indicate the events of meiosis and fertilization; and the gametophyte and the sporophyte phases.

6. Draw and/or label a diagram of the heterosporous life cycle of Selaginella. Be sure to indicate the events of meiosis and fertilization; and the gametophyte phases.

7. Identify the following structures on appropriate material or reproductions of the three groups of plants in this exercise; strobilus, rhizophores, microsporangia, megasporangia, microspore and megaspore.

8. Sketch and label a generalized diagram of a homosporous life cycle which could apply to Psilotum, Lycopodium or Equisetum.

9. Sketch and label a cross section of a stem with a protostele.

10. Recognize fossil forms studied as fossil plants of the correct group to which each belongs.

AUDIO SCRIPT

The three groups of plants discussed in Exercises 11 are often given division status each. Many times these are given the status of sub-divisions individually and in some cases only the status of classes. However classified, there are three different groups which were at one time considered as fern allies. The so-called fern allies were grouped together not necessarily because of their close relationships, but because they are all remenants of what were one time much larger groups. Much more is known of the fossil forms of all these because there are many more fossils of these than there are living forms. Because the three sections of Exercise 11 actually represent three separate and quite distinct kinds of plants. We will discuss each in order so that Exercise 11 will be somewhat unlike the preceding exercises. Also bear in mind that the three groups as arranged in your laboratory syllabus are not, most likely, in phylogenetic order. The phylogenetic order usually given for these three is the whisk ferns or Psilophytes first, the club mosses second, and the horsetails third. All three are generally believed to have preceded the ferns. The club mosses and relatives the quill worts are a small group of plants of some 1,000 or 1,200 species grouped together into only four genera. They are distinguished, however, by having a rather rich fossil record and many of the plants that lived in the carboniferous period or the coalforming age were members of this group. Some of them achieved tree-size. The club mosses like the ferns are vascular plants. They have conductive tissue in them. They have true roots, stems and leaves. But the leaves in the club mosses are not of the same sort one sees in ferns. These are of the type called microphylls or microphyllous leaves. The major difference between the microphyllous leaves and the megophyllous leaves of the fern is the number of veins. In microphyllous leaves, such as one sees in club mosses, there is one or rarely two veins in each while the ferns, as you recall, had a large number of branched veins such as you would expect to find in the higher plants. The conductive tissue in the stems is considered to be of a fairly primitive sort and is one of the facets that you will be asked to study in some more detail in the laboratory exercises. The roots, as those in the ferns, are clearly defined. All of the club mosses reproduce by means of spores. All have a distinct alternation generations with the sporophyte generation being the dominant and the gametophyte an inconspicious and subordinate generation. Special spore-bearing structures called the strobili or cones are generally present as separate reproductive structures in the club mosses. These strobili or cones are similar in appearance to a club, hence the name club moss. Turn to page 87 in your laboratory syllabus and to page 280 in your textbook. In Exercise 11 you will be asked to study two different genera of club mosses. These are Lycopodium and Selaginella. In part 1, exercise 11 you are asked to study several things about Lycopodium. We have preserved specimens of Lycopodium obscurum and Lycopodium lucidulum for you to compare and to study. A prepared slide called Lycopodium, longitudinal section of strobilus, is also available and will help you place the sporangia in regard to the leaves. There is also a slide marked Lycopodium, cross-section of mature stem. Complete part 1, exercise 11, label the drawing on page 91, and complete the other drawings requested on that same page. When you have completed this return to the tape. (signal) Notice that the leaves in Lycopodium have a kind of spiral or sometimes whorled arrangement. You can find two distinct kinds of leaves. Vegetative leaves and those that bear sporangia. The sporangia on your specimen, of course, are located in these cone-shaped structures, or stroboli. And each sporangium is on the upper surface of the leaves rather than on the lower surface as you find them in the ferns. Only some of the leaves, those that are specialized in the strobilus have sporangia. In Lycopodium lucidulum, the spore-bearing leaves or sporophylls are not collected into a aggregationl like they are in Lycopodium obscurum. Notice that each leaf has a single sporangium. Remember that the leaves are referred to in this case as sporophylls. Regarding the study of vascular cdumn or stele, the protostele is considered by botanists to be one of the most primitive types of vascular cylinder. The stele of many higher plants has pithinside of the xylem and phloem tissue. In the protostele, the pith is absent. The endodermis is well-developed in this plant. On page 285 of your textbook are some pictures of the gametophyte generation of Lycopodium. Look at these and become somewhat familiar with them, compare them mentally with the gametophyte of the fern. Moving on to part 2 of exercise 11 we will consider another kind of club moss. This is sometimes called little club moss and the botanical genus is Selaginella. Study the preserved specimen of Selaginella and complete the habit sketch requested on page 93. A prepared slide of Selaginella showing the longitudinal section of the strobilus with the megasporangia and microsporangia both visible is in your slide box. There are also slides of longitudinal sections of the strobilus of Selaginella showing the microspores and the megaspores. These together with the preserved material should enable you to complete the second paragraph of part 2. The prepared microslide of Selaginella sporelings is also available. The life cycle of Selaginella is different from that of both Lycopodium and the fern. Selaginella because it produces 2 kinds of spores is said to have a heterosporous alternation of generations. There is included in your material, diagrams of the life cycle of both Lycopodium and Selaginella. Germination of the spores of Selaginella occurs in a rather curious way. The development and growth of the micro-gametophyte occurs but the micro-gametophyte is retained within the sporangium wall and is much reduced. Frequently the female or megaspore is not expelled from the megasporangium, hence the megagametophyte is produced inside of the wall of the female sporangium. Once again in contrast with the life cycle observed in the fern and Lycopodium, two distinct kinds of spores are produced on the same plant. In the fern and in Lycopodium one gametophyte plant bore both the male and female gametangia. Part 3 of exercise 11 deals with the Psilophytes or the whisk ferns. These are covered in Chapter 18 of your textbook on page 268. The Psilophytes are considered to be the most primitive of all vascular plants. These plants have developed stems but no roots and the leaves are small microphyllous leaves. There are only two living genera and a handful of species of Psilophytes. But like the club mosses the Psilophytes are well represented in the fossil record. The living forms appear to be vestiges of what once must have been a much larger group of plants. As in the fern and the club mosses the Psilophytes have an alternation of generations. The dominate generation is the sporophyte and the subordinate is the gametophyte. Psilophytes have an independent gametophyte generation which is separate from and physiologically independent of the aporophyte maturity. Using preserved specimens mounted in plastic, complete part 3, exercise 11. When you have completed this return to the tape. (signal) On page 271 of your textbook are some photographs showing how the sporangia are born in Psilophytes. Continue on with exercise 11 beginning part 4; the horsetails or horsetail rushes as they are sometimes called. These are also called scouring rushes; are a small group of plants which have roots, stems and small leaves. They show a distinct alternation of generations with the sporophyte generation being dominant and the gametophyte generation being small and independent of the sporophyte. There is but a single living genus of horsetails, and this genus contains somewhere around 25 or so different species. So this, like the Psilophytes and the club mosses, seems to be a group of plants that is just a remanent of a much larger group. In part 4, exercise 11, we will examine two species of the one extant genus Equisetum. Turn to Chapter 20, page 310 in your textbook for the text reference for this section. Preserved specimens of Equisetum hyemale and Equisetum arvenae are available for your comparison. These two species are shown on page 311 of your textbook. The spores described in the second paragraph, part 4, exercise 11 will be available only during some seasons. Page 316 of the textbook describes this structure and in case the spores are not available, please use this as a poor substitute for the actual material. When you have finished with part 4, exercise 11 return to the tape. (signal)

Equisetum arvense is an unusual plant in that it has two kinds of stems. The stems are either sterile, which means simply that they are non reproductive and fertile which are the ones on which the strobili are found. Frequently the fertile or reproductive stalks of Equisetum are achlorophyllous or have no chlorophyll and tend to be white in color, while the ones that are the sterile stalks are the ones that manufacture food. In other species there is but one type of stalk, and on the end of the vegetative stalk the strobilis or reproductive structure is produced. Equisetum hyemale is of this sort. A spore has somewhat spoonlike appendages, (as your textbook calls them) called elaters. These are structure that tend to help in dispersal of the spores. They respond to slight changes in humidity by uncoiling. Part 5, exercise 11, is a consideration of the fossil record with the living forms of these three groups of plants. Your attention is called to the written material on fossils near the end of each of Chapter 18, 19, and 20. We have available some fossil Lepidodendron and some fossil Sigillaria for use in part 5. In your slide set is a slide of Lepidostrobus which is the fossil cone of Lepidodendron and Sigillaria. There is also available fossil Calamites. Study these and complete section 5 and then return to the tape. (signal)

A consideration of the life cycles of the Psilophytes and horsetails has been omitted until this point. In the printed material which you received at the beginning of this exercise you were given life cycle of Psilotum and the life cycle of Equisetum. You have already been directed to the life cycle of Lycopodium and of Selaginella. Study these four life cycles. You will notice that the Psilophytes, the horsetails and Lycopodium of the club mosses all are homosporous in their alternation of generations. While Selaginella shows a heterosporous alternation of generations. Homosporous alternation of generations whether it be found in mosses, ferns or horsetails, Psilophytes or in Lycopodium has the same pattern. One kind of spore which produces both the male and female gametophyte forms. While Selaginella has an unusual type which provides two kinds of spores each providing the single gametophyte. In summary the Psilophytes, the club mosses and the horsetails, or as they are sometimes called the fern allies. They all have the following things in common. They are all primitive plants with a much richer fossil record than is available in living forms. They all have michophyllous or little leaves, and they all have relatively primitive structures for reproductive purposes. These are non-seed plants and all show some sort of a gametophyte stage which is in most cases completely independent of the sporophyte. Since there are so few of these plants around, they can never constitute an extremely important part of any botany course, but they are extremely interesting because they furnish us a clue as to how life must have been on this planet at an earlier age. There are available kodachrome slide presentations showing many of the same forms of these plants that you find in your laboratory manual and in your textbook. The taped presentation on exercise 11 is about to end. (signal)

PLANT MORPHOLOGY

Section 12: Cycads, Gnetales and Ginkgo

OBJECTIVES: Without reference, be able to:

1. Define and/or recognize the definition of the following terms: stamen, carpel, integument, nucellus, endosperm, megasporophyll, microsporophyll.

2. Describe the Cycads and list two representative genera.

3. Construct and label a diagram of the life of a Cycad. Be sure to indicate development of micro and mega-spores and micro- and megagametes. Also indicate the events of fertilization and meiosis.

4. From living specimens, photographs, preserved specimens, colored slides (whichever is appropriate) recognize and identify the following structures: microstrobilus, megastrobilus, microsporophyll, microsporangium, megasporophyll, megasporangium, integument, nucellus, endosperm.

5. Describe Ephedra and state why it is sometimes considered a gymnosperm.

6. Describe Ginkgo and state why it is sometimes considered a gymnosperm.

7. From your comparison of Zamia and Selaginella write a paragraph either defending or attacking the statement: "The morphological structures of Zamia suggest that it has evolved from Selaginella or a plant very much like it."

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The remainder of this course will be devoted to several very important groups of plants. All of these groups have one thing in common. This is that they all reproduce by means of seeds. The seed is an extremely important botanical structure. Seeds, no matter what kind of plant they come from, have the following three parts, protective coat, some sort of stored food, and an immature plant called an embryo. It appears that these seeds are so efficient, reproductively that they are at least in part, a cause of the seed plants becoming the dominant plants on the earth. The seed plants may be further sub-divided into two groups on the basis of their reproductive structures. Traditionally one group is called gymnosperms. These are plants that have their reproductive structures in cones. The second group, the angiosperms, have their reproductive structures in flowers. In this, as in consideration of many other higher taxonomic levels, botanists are not in full agreement as to what constitutes division, sub-division or class, and since this course is not concerned with the taxonomy in these groups, we will omit that until some later course. A fair amount of time will be spent in the study of three groups of seed plants. The first of these groups is the Cycad group, the second, the conifer group and the third, the flowering plants. We will spend some time taking a brief look at two other seed plants. These are also cone bearing and they are undoubtedly only remant groups of what must have been larger groups of plants. Both of these groups are represented by at least one species in the United States, either introduced species or native. They are, Ginkgo and Ephedra. Your textbook covers the gymnosperms and angiosperms in several chapters. These are chapters 25 through chapters 31. We will now proceed with exercise 12 which deals with the Cycads as well as a little work on Ginkgo and Ephedra. The Cycads, Ginkgo and Ephedra were at one time all considered gymnosperms and all considered to be somewhat related. The author of your textbook, however, considers these three groups as most unrelated and considers each of them to be a division unto itself. He covers these in three separate chapters, chapters 25, 26 and 28. They all have several things in common, however. One, that they have seeds. Two that they have a structure which could be called a cone. Three, that they are all heterosporous or they produce two different kinds of spores. Turn to page 97 in your laboratory syllabus and page 388 in your textbook. The first part of exercise 12 deals with the plants called the Cycads. The Cycads were at one time considered to be gymnosperm plants. The term gymnosperm means naked seed. This means that the seed is not born inside of any kind of fruit but is exposed on the upper surface of modified leaf which forms a part of the cone. The Cycads are represented by a small extant group of genera but seem to have at one time been a very large group of plants on the earth. During the Mesozoic era when the dinosaurs lived, sometimes called the age of reptiles, these Cycads were probably the dominant plant type of the age. These like the other plants which we shall study in the near future are heterosporous, producing two kinds of spores, megaspores and microspores. These plants show a distinct alternation of generations. However, the gametophyte generation is borne and retained within the sporophyte tissue. This produces a situation in which the gametophyte generation is not nearly so obvious as it is in the ferns and some of the fern allies. Proceed with exercise 12, part 1, dealing with the Cycads. We have available for your study a living sample of Zamia. Zamia is one of the few Cycads which is native to North America and is found in southern Florida. Both the living Zamia plant and preserved cones of Zamia are available. As you proceed with exercise 12 try to complete the entire exercise. All the material that you need is available, for example, there are megasporophylls of Cycas, which is another cycad. We have a cross-section of megasporangium of Zamia with the heterosporous life cycle of Selaginella. It is important to do this because the origin of heterospory is an important evolutionary consideration in the development of seed plants. Carefully work through exercise 12, part 1, and when you have completed this part return to the tape. (signal) Were you able to answer all the questions? If you could not, perhaps some of the following comments will help you. Sometimes one of the Cycads, the one called Cycas is referred to as Sago palm. It has a vegetative leaf similar to that of a palm tree, at least at first glance, and this accounts for the misnomer. The palms are flowering plants, however, and not closely related. The comparison of Zamia and Selaginella is such an important consideration that we will defer that until your conference with your instructor. Please bring the completed chart on page 99 with you to that conference. Notice that the sporophylls of Cycas are more dissected than those of Zamia and in some ways this dissection makes them resemble the vegetative leaves of Cycas. The term megasporangium is sometimes used in place of the term ovule. The mature megasporangium and its contents is called the seed. The functional parts of the seed are the protective seed coat, stored food and the developing embryo. Notice how the Zamia archegonium is completely hidden. Did you answer that the jacket of the sporangium is several cells thick? Two distinct layers of tissue are not present. Pollen grains are present in the microsporangium and of course, the pollen grain develops from the microspore. Many more microspores are produced than the megaspores. When you have completed part 1, exercise 12, continue on with the next two sections. Part 2 deals with the Gnetales. The Gnetales are a small group of plants consisting of some three living genera. Many authorities do not feel that they are very closely related but that each of the three is a relic of some time when there was a much larger flora made up of these plants and their relations. You will be given the opportunity to examine one of these. This is the genus Ephedra and is one of our own native plants. The other two genera are not found in the United States. Proceed with part 2, exercise 12. The preserved specimen of Ephedra is available as are preserved cones, both male and female. When you have finished part 2, exercise 12, return to the tape. (signal) Some people feel that Ephedra is faintly reminescent of Equisetum because of its scale-like leaves and its jointed stems. Ephedra like Zamia is dioecious which means that the male and female reproductive parts are born on different plants. Notice that five two chambered microsporangia are present at the apex of the column. When you have completed part 2, exercise 12 and the drawing requested on page 103, return to the tape. (signal)

Part 3, exercise 12 deals with the third plant we will look at in this section. This plant is one of the most unusual plants in the world. It is called Ginkgo or the maidenhair tree and is sometimes referred to as a living fossil. The plant is not native to the United States but is grown here, now, as a cultivated plant. As a matter of fact the plant is known nowhere in the world in its wild state. Apparently domestication saved this plant from extinction. The Ginkgo, as the case of the cycads and many of the other plants that we have studied is a relic group represented by only one species. There are many more fossil forms known than this one single extant species. As with the Ephedra and Zamia and the gnetales and the cycads, Ginkgo was traditionally considered a gymnosperm because of naked seeds or seeds not contained inside of any kind of fruit. There is a preserved specimen of Ginkgo available for your study as well as preserved cones or strobili of Ginkgo. Continue with part 3, exercise 12. Chapter 26 of your textbook should help you with this section and when you have completed it return to the tape. (signal) Notice the long shoots and the spur shoots. Both of these bear leaves. The leaf of Ginkgo reminds some people of the maidenhair fern, hence the name of maidenhair tree. When you have completed part 3, exercise 12, and made the drawing requested on page 103, return to the tape. (signal) Zamia, Ephedra and Ginkgo all show distinct alternation of generations. All three of these plants are heterosporous. All produce two kinds of spores; microspores or male spores, and megaspores or female spores. There is included in your set of material, a bio-review sheet showing the life cycle of Zamia, and a bio-review sheet showing the life cycle of Ginkgo. You will notice some similarities between the two. Ephedra is missing from this group, and as a matter of fact you need only concentrate on Zamia. When you have completed your study on the life cycle of Zamia, return to the tape. (signal)

In summary, the three plants that you have just completed the study of, the Cycad, Zamia; the Ephedra; and Ginkgo are all considered by some authorities to be primitive gymnosperms. They are all seed bearing plants, and they bear their seeds not enclosed by any kind of fruit, but as the expression goes, naked. All are heterosporous, all show a distinct alternation of generations, and all grow to be rather large size plants. The gametophytes of these plants are enclosed by and protected by the sporophyte generation of the plant. Pollination occurs by means of wind so no water is necessary for fertilization. Of all the plants that we have studied thus far, these three are the first to have been thus free from water. There remains one further group of gymnosperms which we will study. There are, of course, the important conifers. These three, however, are only relic groups of what must have been a much larger group of plants. The conifers themselves are somewhat reduced in number from what they must have been at some earlier time and so all of the gymnosperms seem to be less adapted reproductively than the flowering plants which have largely replaced them. There are some slides available showing the various structures which you have seen. Please be sure that you examine them carefully. The tape presentation of this exercise 12, the primitive gymnosperms is about to conclude. (signal)

PLANT MORPHOLOGY

Section 13: Conifers

OBJECTIVES: Without references, be able to:

1. Define and/or recognize the definition of the following terms: pollen cone, seed cone, ovuliferous scale, ovule, megaspore mother cell, microspore mother cell, micropyle, micropylar arms, hypocotyl, cotyledon.

2. Describe the conifers and name three representative genera.

3. Given a key to the conifers, classify an unknown to genus level.

4. Construct and/or label a diagram showing life cycle of *Pinus*. Indicate the following structures or events: pollen cone, microsporophyll, microsporangium (pollen sac), misrospore mother cell, megaspore, megagametophyte, archegonium, egg, zygote, sporophyte generation, gametophyte generation, fertilization and meiosis.

5. Draw and label a diagram of a mature pine ovule with micropyle, integument, nucellus, megagametophyte, archegonium and egg.

6. Draw and label a diagram of a mature pine microgametophyte with prothallial cells, stalk cell, body cell, pollen tube and tube nucleus.

7. Draw and label a diagram of a mature pine seed with seed coat, storage tissue, hypocotyl and cotyledons.

8. From living specimens, photographs, prepared microscope slides, or colored slides (Whichever is appropriate); recognize the following objects or structures:pollen cone, seed cone, pine pollen grain, microsporophyll, microsporangium, megasporophyll, megasporangium, micropylar arms, micropyle, megagametophyte, archegonium, egg cell, seed coat, storage tissue (endosperm), hypocotyl, cotyledons, integument.

AUDIO SCRIPT

Part of the gymnosperms were considered in exercise 12. Exercise 13 concerns itself with a far larger group of gymnosperms which are the most familiar type, the group to which pines and their relatives belong. Included with the pines are the spruces, firs, hemlocks, and the douglas firs. Other members of this group include the cypresses, the true cedars, larch or tamerack, and many species from the southern hemisphere which are not known in our flora. The conifers were at one time a much more important group than they are today, and are known quite well from the fossil record. However, there are still enough of them around that they are considered an extremely important group economically. Probably they are worthy of much more consideration than some of the previous groups considered. The average individual refers to these as the evergreen trees, but as a matter of fact, there are a few of them that lose their leaves in the fall, just the same as the deciduous hardwood trees do. Almost everyone intuitively recognizes these plants because of their conspicuous cones and their needle-like leaves. Like the gymnosperms previously considered, these bear naked seeds on the upper surfaces of bracts which are a part of the cones. They are heterosporous. The sporophyte is the dominate generation with the gametophyte very subordinate and, as a matter of fact, usually concealed well within the sporophyte tissue. Fertilization by the wind rather than by water is the usual condition. To the average individual living in this area, pine is probably the most familiar of all of these plants. The conifers are decidedly terrestrial plants having been freed from the water or the necessity of water for fertilization by the condition of wind pollination which is so well known among them. From an economic standpoint, they are the source of a great deal of the timber produced, as well as many resins used in terpentine, and many other organic materials. Exercise 13, then, is concerned with the pine and many other organic materials. Exercise 13, then, is concerned with the pine and many of the plants closely related to it. The majority of the conifers are perennial plants and show a great deal of secondary growth. This means, of course, that they attain conditions of growth which are called trees in most cases. Many of the groups previously studied are also perennial in their condition of growth, but the conifers really exemplify this to the greatest degree. Chapter 27 in your textbook on page 424 is a text reference for the conifers. Turn to this page in your text and to page 105 in your laboratory syllabus. The first part of exercise 13 is an exercise designed to have you key out various members of the pines and their relatives. At least two or three kinds of pine are found on our campus, and some more are available at Rankin Lake Park, as well as many other conifers. Some of the conifers found at Rankin Lake Park are exotic species, some that are really not found in our flora. A collection of these conifers will be provided for you for your use in keying as prescribed in exercise 1 in the laboratory manual. As one looks over the key on page 105 the two genera that are well represented in our flora are

Pinus and Juniperus. Others such as Tsuga, Caemacyperus, and Taxodium are also found in North Carolina. Picae is found in the high mountains of the Carolinas, as is Abies, but both are more typical of Canada and the far north. Sequoia, Torryea, Taxus, Thuja, and Larix are also North American genera. Cedrus which is mentioned in the key is a European-West Asian genus which is frequently planted as an ornamental in our area. From the examples provided try to work out from the key the generic classifications. When you have completed this go on to exercise 13, part 2. (signal)

Part 2, exercise 13 asks you to examine some pine needles. You are provided with some pine needles with two-in-a-cluster and also with five-in-a-cluster. Whether two-in-a-cluster or five-in-a-cluster.the collective group forms a circular outline. Provided for you in your slide set is a prepared cross-section of pine needles from which you can complete exercise 13, part 2. Figure 27-2 on the top of page 426 in your textbook should help you with this section. When you have finished with part 2, exercise 13, return to the tape. (signal)

Part 3, exercise 13 asks you to look at pollen cones and seed cones of Pinus or Abies. We have Pinus for your use. Carefully read part three, work through it, and when you have finished with that, return to the tape. (signal)

The questions on part 3, exercise 13 asks how many megasporangia are found on each sporophyll. If your answer was two, you were correct. How many microsporangia are found on each sporophyll. The answer here is two also. When you have completed the drawings requested on page 111, proceed to exercise 13, part 4. Both cross and longitudinal sections of microsporophylls of Pinus are available for your study. The pollen grains are actually considered to be microgametophytes in which are contained two non-flagellated sperm nuclei as well as some other cells which are non-functional in the sense that they are not a part of the reproductive cycle. Page 431 in your textbook has a good diagram of the various cells contained in the microgametophyte or the pollen grain. Using this, as well as prepared slides, work through part 4, exercise 13 and when you have labeled these correctly, proceed to part 5, exercise 13. Prepared microscope slides of Pinus ovules are available for your study. Throughout the textbook from pages 429 on, one finds many diagrams pertaining to the megasporophyll, the ovule, and the internal parts such as the megagametophyte. A series of slides is available which will show you many of the successive stages in the development of the female gametophyte and of the egg. In part 5, exercise 13, your lab manual tells you that the megagametophyte or the female gametophyte plant in pine is a parasite on the sporophyte plant. It is retained within the sporophyte and, as a matter of fact, never becomes obvious during any stage of the life cycle. The microgametophyte, or the male gametophyte, of the pine is never more than five cells at its maximum development, while the female gametophyte is many more cells in number. Produced within the female gametophyte are archegonia, and, within each archegonium, a single egg. Make outline sketches as suggested in your lab manual on page 113 in your laboratory syllabus. When you have completed this return to the tape. (signal)

The mature ovule of pine, including the integments, nucellus, and finally the incipient embryo, is usually referred to as a seed. This is in line with the seed plants, the seeds of which all have an embryo, stored amounts of food, and a protective seed coat surrounding them. Move on to part 6, exercise 13. Pine seeds are available for your use, but you will have to soak them to produce the condition described in the laboratory manual. Continue on through part 6, exercise 13, attempt to answer the questions in it, and make the drawing requested on page 113, of a seed as found in pine. The nutritive tissue of the endosperm in a pine seed is a part of the old gametophyte tissue, therefore, is haploid in its chromosome composition. In the seed of a pine, therefore, one can observe three generations of pine plants. The seed coat is part of the adult sporophyte tissue, the endosperm which is the female gametophyte tissue, and the embryo which is the next generation of spororophyte tissue. When you have finished with part 6, exercise 13, return to the tape. (signal)

Pine is one of those plants which is said to be heterosporous. This means, of course, that it produces two kinds of spores, megaspores and microspores. The life cycle of pine is an extremely important part of this exercise. The laboratory syllabus, however, does not have anything concerning the life cycle of pines. There is provided for you a fairly complete life cycle which is completely labeled with the sporophyte generation and the gametophyte generation in different colors. Study carefully the life cycle diagram of pine. When you have completed this, return to the tape. (signal) The megastrobilis, or female cone, produces within it a megasporangium. Within this a megaspore mother undergoes meiosis producing four megaspores, one of which is functional. This megaspore develops into the megagametophyte, or the female gametophyte. This tiny female gametophyte plant is retained within the sporophyte tissue and produces within it archegonia, and each archegonium produces eggs. Elsewhere on the same tree, the microstrobili, or pollen cones, are producing microsporophylls and, on those, microsporangia. In these microsporangia are, produced by the process of meiosis, microspores. These microspores by the process of growth and development grow into microgametophytes which are called pollen grains. In each grain are contained two functional sperm. Fertilization occurs when one grain is carried to the ovule, or the female sporangium and one of the sperm of the pollen unites with the egg of the megagametophyte. The zygote, or fertilized egg, develops into the embryo of the seed. The embryo in the seed is capable of maturing and growing into a mature sporophyte plant or pine tree. With this, the cycle is completed. Study the life cycle diagram provided you. Become familiar with the gametophyte and sporophyte generations, as well as the events of meiosis and fertilization. When you are thoroughly familiar with the pine, return to the tape. (signal)

In summary then, the conifers are a large group of needle-leaf plants. Most of these are tree size in their habit. All show a heterosporous alternation of generation, with a very distinct and dominant sporophyte generation and a subordinate and hidden gametophyte generation. These plants, in general, are terrestrial in habit, water is not necessary for fertilization. In addition to the needle-like leaves, probably the most obvious characteristic of this group is the fact that they all bear cones. The botanical name for the cone, of course, is the strobilus, and these cones are in two forms, microstrobilus and megastrobilus, or male and female cones. They all belong to the class called gymnosperms, or plants with naked seeds. This, of course, does not mean that the seed is naked, but that it is not in a fruit like the other seed plants. Gymnosperms have seeds that are well adapted for reproductive purposes, consisting of a protective seed coat, a stored amount of food, and a new plant within. Of all the plants of the course which have been studied this far, this group is perhaps the most important economically. Much use is made of them for timber and other commercial uses. The tape portion of the section on conifers is about to conclude. There is a kodachrome presentation available dealing with the conifers. Please be sure to look at this before you conclude this exercise. This ends the tape of exercise 13, the conifers. (signal)

PLANT MORPHOLOGY

Section 14: Flowering Plants

OBJECTIVES: Without references, be able to:

1. Describe the basic differences seen in a comparison of leaves, stems and wood in lower and higher plants.

2. Construct and/or label a diagram of the gross morphology of a flower. Indicate the receptable, sepals, calyx, petals, stamens (anther and filament) and pistil (stigma, style, and ovary).

3. Construct an annotated diagram explaining pollination and fertilization in the flowering plants. Show details on the embryo sac, pollen tube and sperm nuclei, and formation of endosperm.

4. Given or shown a colored slide of a dissected flower, indicate the following structures: sepals, petals, stamens (anther and filament), pistil (stigma, style, and ovary), locule, ovule.

5. Construct and/or label a diagram showing the life cycle of an angiosperm. Indicate the following structures or events: flower, stamen, pollen sacs, microspore mother cell, microspore, pollen grain, microgametophyte, sperm cells, carpel, ovule, integuments, nucellus, megaspore mother cell, megaspore, embryo sac (megagametophyte), egg cell, polar nuclei, zygote, endosperm, seed, meiosis, fertilization, gametophyte generation, sporophyte generation.

6. Write a paragraph describing the evolutionary changes in the alternation of generation as seen in comparative studies of the life cycles of plants. Include examples, general trends, and probable reasons for gametophyte reduction and sporophyte expansion.

7. From living or preserved specimens, photographs, prepared microscope slides, or colored slides (whichever is appropriate); recognize the following objects or structures:

pollen sac	embryo sac	microspore
egg cell	pollen grain	polar nuclei
sperm nucleus	synergids	ovule
antipodals	integuments	micropyle

8. Compare a peanut with a pine nut in regard to the origin of the seed coat and fleshy storage tissue.

AUDIO SCRIPT

The flowering plants are surely the most dominant plants of our flora today. As you look out on the landscape, practically all the plants you would observe would be flowering plants of some sort or another. The remainder of these plants are gymnosperms, and the remainder of the vascular plants are made up of small numbers of very relic groups. A consideration of vegetative parts of flowering plants such as root, stems, leaves and the physiology of flowering plants are part of the study of general botany and will not be considered much in this course. However, since morphology is the study of the reproductive parts of plants, and their life cycles, these two sections of the flowering plants will be covered in great detail in this section. A consideration must be made as to what caused the flowering plants to become a dominant part of the flora. If reproduction is the most obvious feature of any living organism, then something about the reproductive facility of the flowering plants must have enabled them to become dominant in the flora. Exercise 14 will not only be concerned with the reproductive structures of flowering plants, but will be concerned also with the life cycles and a comparison of the reproductive facilities of the plants that have come before it. In this it is hoped that you would become familiar with the adaptive features of the flowering plants that made them the dominant plant form on the earth today. The flowering plants include some 300,000 species, approximately 12,000 genera of plants which have managed to cover the earth. The flower in the botanical sense of the word is much more than a flower in the sense that a horticulturalist or a florist might use it. It is a reproductive structure of specific parts and not necessarily showy or attractive in its appearance. The flowering plants as a group are either annual, biennual, or perennial; woody, or herbacious; they are either aquatic or terrestrial; as a matter of fact, they are in all conditions of life that we have studied to date. The one feature that they all have in common is the presence of a flower. Because the flower as botanically defined is so varied in its structure, it is difficult to describe.We will, therefore, in this exercise select a "typical" flower for consideration. The structure of a "typical" flower which would include the part of the sepals, petals, stamens, pistil familiar to you from a previous course. You should review these parts so that you are once again completely familiar with the various flora parts. Chapter 30 and 31 in your textbook, on pages 466 and 495 are text references to this section. Turn to page 466 in your textbook and 115 in your laboratory syllabus. The first part of the exercise deals with the evolution of alternation of generations. Pages 118 and 119 in your laboratory syllabus are a comparison of the life cycles of several plants studies to date. The comparison of the importance of the sporophyte generation and the gametophyte generation are listed here. You will notice that the sporophyte generation in Ulothrix is a single cell, the zygote; while in the conifers the last of the series, it is an extremely large, very complex kind of plant. This part of the exercise is designed to show that the sporophyte generation has become progressively larger and a more important part of the life cycle, while the gametophyte stage has become less important and finally almost insignificant as seen in the higher plants. This suggests that there is an advantage in diploidy, or the 2N condition, and a disadvantage in haploidy, or N condition. One might suspect that the diploid is adaptively advantageous, while the haploid is adaptively weak. Part 1, exercise 14 deals with the comparison of the life cycles. Complete part 1 and return to the tape. (signal)

Part 2, exercise 14 asks you to examine the macerated wood of pine and of a dicot. We will use _Aesculus_ or buckeye for the dicot. There are also slides of the stems of _Polytrichium_ and of _Pinus_ cut in cross sections. Notice the vascular tissues present in pine and not present in mosses. Study the leaves as directed in your laboratory syllabus. Finish part 2, exercise 14 and return to the tape. (signal) In all of the comparisons you will notice that there is an increase in complexity. Continue with part 3. Exercise 14, part 3 is a review of the gross morphology of a flower. The prepared slide of _Lilium_ also is a part of your review from Biology 102. Examine the microscope slide of cross-section of _Lilium_. Be sure you can identify the parts of a flower which are listed in this exercise on page 125 of the laboratory syllabus. Make a simple outline drawing showing the four major parts of the flower. Demonstration slides are available for your use showing the mature microspores, or pollen. Germinating pollen slides are available so that you can see the tube nucleus and sperm nuclei of the germinated pollen. Compare the microgametophyte of _Lilium_ and _Pinus_ and both of those with that of _Cycad_. How are they similar and how are they different. Prepared slides are available for your study through the remainder of part 3, exercise 14. Using the prepared slides and pages 469 following in your textbook complete part 3, exercise 14, and then return to the tape. (signal) Part 4, exercise 14, discussion is the fruit and how it differs from the seed. Dissect the peanut and compare it with the pinenut in the last exercise. Compare the outermost layer and the fleshy storage tissues as it suggests in the exercise. When you have completed this, return to the tape. (signal)

As in the gymnosperm the life cycle of the angiosperm is an extremely important consideration. A life cycle diagram has been provided you for the angiosperm. This is the life cycle of the lily which is somewhat atypical of the group, but many of the principles are found in the remainder of the angiosperms. As in the gymnosperms, this is a heterosporous life cycle. This means that there are distinct large spores, or megaspores, and smaller spores, microspores. Study this distinct alternation of generations, as well as the heterspory shown here. Begin in the flowering plant with the sporophyte generation or the sporophyte plant which is the mature plant. Consider the flower. Contained within the flower are stamen, or microsporophylls. These produce anthers or microsporangia and in the microsporangia, pollen grains or microspores. The microspores are produced from microspore mother cells by the process of meiosis, and in the course of their development become microgametophytes, or mature pollen grains. Each microgametophyte or mature pollen grain contains two functional sperm. The megasporangium which is born within the ovule produces one functional megaspore by the process of meiosis. This functional megaspore develops into the mature embryo sac, or megagametophyte. The megagametophyte consists of one functional one and seven other cells. One of the sperm from the pollen grain unites with the egg in the embryo sac to form the zygote, and this zygote develops into the embryo which is enclosed in the seed which will become the next sporophyte generation. An unusual condition in the flowering plants is that the other functional sperm in the pollen grain unites with two of the other cells in the embryo sac. These cells are called the polar nuclei. The one sperm and the two polar nuclei become the primary endosperm cell. This is a triploid cell which will develop into the endosperm which provides the food for the developing embryo. When the sperm and the egg unite, and the other sperm and the polar bodies unite, the process is called double fertilization. It is a condition common throughout the flowering plants. Study the life cycle carefully, including the part dealing with double fertilization. When you have mastered this, return to the tape. (signal)

In summary the flowering plants are a large group of plants, all of which bear specialized reproductive structures called flowers. Enclosed within the fruit on these flowers is a seed, a specialized reproductive structure. The mature complete flower consists of sepals, petals, stamens, and pistil. All of the flowering plants are heterosporous. All show a distinct alternation of generations. The microsporangia, are born on specialized structures called stamens. The megasporangia, are born on specialized structures called carpels. Fusion of the egg and the sperm produce a zygote which develops into an embryo. The embryo is ultimately enclosed in a seed which is a protective structure consisting of seed coat, stored food, and a new embryo. The seed which is an adaptive reproductive structure and the fruit which provides further reproductive advantages allowed the flowering plants or angiosperms to become dominant plants in the flora of today. The economic value of this group is a study in itself. Practically all of the food plants, the timber producing plants, the fiber producing plants, the oil producing plants, and many of the drug producing plants are included in this group. The tape on the flowering plants is about to end. Before you conclude, be sure you look at the kodachrome presentation dealing with this group. This ends the tape presentation on the flowering plants. (signal)

PLANT MORPHOLOGY

Section 15: Quizzes for Sections 8 through 14

Section 8: Liverworts NAME:_______________

1. Define the following terms:

   rhizoid

   thallus

   elater

   gemmae

   gametophore

2. Describe the liverworts and name two representative genera.

3. Draw and label a life cycle of a typical liverwort.

4. Compare and contrast *Anthoceros* and *Marchantia*.

Section 9: Mosses NAME:_________ ________

1. Define the following terms:

   protonema

   calyptra

   paraphyses

   operculum

   peristone

2. Describe the mosses and name two representative genera.

3. Draw and label a diagram of the life cycle of a typical moss.

4. Compare and contrast the life cycles of mosses and liverworts.

Section 10: Ferns NAME:___________

1. Define the following terms:

   sorus

   prothallus

   annulus

   indusium

   rhizome

2. Describe the ferns and name two genera.

3. Diagram and label a life cycle of a homosporous fern.

4. Sketch and label a fern prothallum.

Section 11: Club Mosses, Psilophytes, and Horsetails NAME:________

1. Define the following terms:

   strobilus

   stele

   tracheid

   heterospory

2. Describe the Club Mosses.

3. List one genus of psilophyte and one genus of horsetail.

4. Compare and contrast the life cycles of Lycopodium and Selaginella.

5. Sketch and label a cross section of a stem with a protostele.

Section 12: Cycads, Gnetales and Ginkgo NAME:________________

1. Define the following terms:

integument

nucellus

megasporophyll

carpel

2. Describe the cycads and name one genus.

3. Diagram and label the life cycle of a cycad.

4. Why are Ephedra and Ginkgo often considered to be gymnosperms?

5. Has Zamia evolved from Selaginella? Why?

Section 13: Conifers NAME:______________

1. Define the following terms:

   megaspore mother cell

   ovuliferous scale

   hypocotyl

   micropyle

2. Diagram and label a life-cycle of pine.

3. Sketch and label a mature pine ovule.

4. Sketch and label a mature pine microgametophyte.

5. Sketch and label a mature pine seed.

Section 14: Flowering Plants NAME: ________________

1. Compare and contrast the following:

   a. The stems of *Pinus* and *Polytrichum*

   b. The leaves of a moss and a seed plant

   c. Wood of *Pinus* and the wood of *Tilia*

2. Diagram and explain pollination and fertilization in flowering plants. Show detail of the mature grain and the embryo sac.

3. Diagram and label the life cycle of a flowering plant.

4. Describe the evolutionary changes in the alternation of generation as observed in a comparison of the life cycles of various groups of plants studied in this course.

5. Compare and contrast a peanut with a pine nut in the origin of the seed coat and fleshy storage tissue.