MICROBIOLOGY: Survey of Bacteria, Protists & Fungi

?? INTRODUCTION
Classify organisms according to the three-domain system
?? BACTERIA
Identify the three commonly recognized shapes of bacteria
Distinguish gram-negative from gram-positive bacteria
Recognize Gloeocapsa and Oscillatoria as cyanobacteria
?? PROTISTS
Differentiate between algae, protozoa, and slime-molds
Identify and give examples of green, brown and red algae
Describe the structure and importance of diatoms
Compare and contrast the characteristics of protozoans
?? FUNGI
Give examples of zygospore fungi, sac fungi and club fungi
Recognize *Penicillium* and *Aspergillus* as imperfect fungi
Describe the generalized life cycle of a fungus

INTRODUCTION

For study and comparison, organisms are classified into groups according to their evolutionary relationships. **Taxonomy** is the science of classification. Within the smallest group, the **species**, organisms share the same structure and usually can interbreed and produce fertile offspring. Closely related species are placed in the same **genus**. The genus and specific epithet together comprise the organism's **scientific name.** For example, *Homo sapiens* is the scientific name for human beings. (The genus name is capitalized, while the specific epithet is not. Both names are italicized OR underlined, but not both.) Closely related genera are placed in the same **family**, closely related families in the same **order**, and so on, with each category becoming larger and more inclusive up to the largest category – **domain.** The eight major categories of classification are shown below:

DOMAIN
Kingdom
Phylum
Class
Order
Family
Genus
Species

(Dear King Philip Came Over For Good Soup)

Modern biochemical analyses have shown that a common ancestor gave rise to three distinct lineages, which we call domains. Domain Bacteria and domain Archaea contain unicellular *prokaryotes*, which lack a membrane-bounded nucleus, whereas domain Eukarya contains *eukaryotes*, which have a true nucleus. The organization within domains Bacteria and Archaea is currently being debated, so there is no agreement on kingdoms within these domains. Domain Eukarya includes four kingdoms: Protista, Fungi, Plantae, and Animalia.

DOMAIN ARCHAEA	DOMAIN BACTERIA	DOMAIN EUKARYA
Extremophiles	Eubacteria	Kingdom Protista
Non-extreme archaebacteria	Cyanobacteria	Kingdom Fungi
Methanogens		Kingdom Plantae
		Kingdom Animalia

DOMAINS ARCHAEA & BACTERIA

All members of the Domains Archaea and Bacteria (formerly Kingdoms Archaebacteria & Eubacteria) are prokaryotic. Prokaryotes share the following features:

- Unicellular
- Lack organized nucleus and membrane-bounded organelles
- Usually less than 1 um in diameter
- Reproduction is primarily asexual via fission
- May be autotrophic, chemotrophic, saprophytic or heterotrophic

Because the archaebacteria are poorly understood, they will be eliminated from this microbiological survey.

I. BACTERIA

A. Classification

Bacteria are the smallest and most numerous organisms. Bacteria exhibit great diversity. They are responsible for many diseases and also play a major role in modern medicine and agriculture.

Most bacteria are found in three basic shapes: **bacillus** (rod-shaped), **coccus** (round or spherical), and **spirillum** (spiral or helical). Cocci may form clusters or chains, and rods may form long filaments. Some bacteria form endospores. An **endospore** contains a copy of the genetic material encased by heavy protective spore coats. Spores survive unfavorable conditions and germinate the form vegetative cells when conditions improve.

In addition to being differentiated by shape, bacteria can be separated according to how they react to a staining procedure called **Gram stain**, named in honor of a nineteenth-century microbiologist, Hans Gram. *Gram-positive* bacteria are purple after being stained by the Gram stain procedure, while *Gram-negative* bacteria appear pink. The Gram stain reaction is important to bacteriologists because it is one of the first steps in identifying an unknown bacterium. Furthermore, the Gram stain reaction indicates a bacterium's susceptibility or resistance to certain **antibiotics,** substances that inhibit the growth of bacteria.

B. Procedures

1. Bacterial Shapes

Study a "bacteria type" slide illustrating the three shapes of bacteria. You'll need to use the high dry and oil immersion objectives on your compound microscope. (Don't forget to use immersion oil with the 100X lens!) Draw and name the shapes of the bacteria you are observing below:

_____ _____ _____

Figure 1 Drawings of the three bacterial shapes (_____X)

2. Gram stain reaction of various bacteria

Examine the pre-stained slides indicated in the table below. Gram-positive bacteria are susceptible to penicillin, while Gram-negative bacteria are not. State the staining characteristics for the bacteria listed:

Bacterial species	**Gram reactions (+ or -)**
Bacillus megaterium	
Rhodospirillum rubrum	
Escherichia coli	
Staphylococcus epidermidis	

3. Culture common bacteria (per pair of students)

a. Obtain two sterile cotton swabs and one closed petri dish containing sterile nutrient agar.
b. Divide the plate into two sections by drawing a line down the center of the bottom of the plate. (Do not open the plate.)
c. Drag the tip of the cotton swab over a surface, such as the fish tank, door handle, your tooth, etc.
d. Open the petri plate and gently drag the exposed swab over half of the surface of the agar (as demonstrated by your TA).
e. Find another surface and repeat steps "c" and "d" on the second half of the plate using a new swab.
f. Close the lid and label the bottom edge of the dish with your initials and the surfaces that you swabbed.
g. Place the plate upside down in the drawer at your lab bench.
h. Examine the agar for bacterial growth in one week.

II. CYANOBACTERIA

Cyanobacteria, formerly called blue-green algae, are the photosynthetic members of the Domain Bacteria. Although cyanobacteria do not possess chloroplasts, they do have thylakoid membranes, where photosynthesis occurs.

Procedure: Examine cyanobacteria

Prepare a wet mount of the following organisms, or examine prepared slides, using the high dry and/or oil immersion objectives on your compound microscope. Draw what you see.

A. *Oscillatoria* - This is a filamentous cyanobacterium with individual cells that resemble a stack of pennies. *Oscillatoria* takes its name from the characteristic oscillations that you may be able to see if your sample is alive. Observe this living culture, are oscillations visible? _____

Oscillatoria (_____X)

B. *Gloeocapsa* - *Gloeocapsa* is surrounded by a thick, gelatinous sheath. How does *Gloeocapsa* differ in appearance from *Oscillatoria*? In what ways are they similar?

Gloeocapsa (_____X)

III. NITROGEN FIXATION BY BACTERIA

Atmospheric nitrogen is unavailable to plants. However, plants require nitrogen in relatively large quantities. Fortunately, certain bacteria and cyanobacteria are able to convert atmospheric nitrogen into usable form for plants. This process is called nitrogen fixation. Many of these "nitrogen-fixing" bacteria inhabit the roots of certain plants in "nodules", while others reside in the soil.

Demo – Root nodules

1. Observe the root nodules on display. The nodules containing nitrogen-fixing bacteria.
2. Examine the demonstration "root tubercle" slide. Can you locate the bacteria within the nodule?

Sketch the roots and label the nodules containing nitrogen-fixing bacteria:

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DOMAIN EUKARYA

All members of the Domain Eukarya (Kingdoms Protista, Fungi, Plantae & Animalia) are eukaryotic. Eukaryotes share the following features:

- ?? Uni- or multicellular
- ?? Possess an organized nucleus and membrane-bounded organelles
- ?? Eukaryotic cells are generally larger than prokaryotic cells
- ?? Eukaryotic cellular division requires the formation of a spindle apparatus
- ?? May be autotrophic, saprotrophic or heterotrophic

I. KINGDOM PROTISTA

Representatives of the Kingdom Protista include all eukaryotes that lack the distinguishing characteristics of fungi, plants and animals = algae, protozoans, slime molds, and water molds. Its members are primarily unicellular, with few multicellular forms. The complexity and diversity of protists make it difficult to classify them. The following classification is used to study the protists:

CLASSIFICATION: THE PROTISTS

Domain Eukarya

Kingdom Protista

Algae*	Phylum Chlorophyta = green algae
	Phylum Phaeophyta = brown algae
	Phylum Rhodophyta = red algae
	Phylum Euglenophyta = euglenoids
	Phylum Bacillariophyta = diatoms
	Phylum Dinoflagellata = dinoflagellates
Protozoans*	Phylum Rhizopoda = amoebas and allies
	Phylum Ciliophora = ciliates
	Phylum Zoomastigophora = zooflagellates
	Phylum Apicomplexa = sporozoans
Slime Molds*	Phylum Gymnomycota = slime molds
Water Molds*	Phylum Oomycota = water molds

*Categories not used in the classification of organisms, but added here for clarity.

A. ALGAE – "plant-like" protists

The algae make an enormous impact on the biosphere – both positively and negatively. Among their greatest contribution is the production of oxygen, because these are the photosynthetic protistans.

Pond scum, frog spittle, seaweed, the stuff that clogs your aquarium if it's not cleaned routinely, the debris on an ocean beach after a storm at sea, the nuisance organisms of a lake – these are the many images that pop into our mind when we first think about the organisms called algae. But many algae are also phytoplankton, the weakly swimming or floating algae that are at the base of the aquatic food chain.

1. Observation: Green Algae

The green algae (Phylum Chlorophyta) may be ancestral to the first plants because both of these groups possess chlorophylls a and b, both store reserve food as starch, and both have cell walls that contain cellulose.

You will examine a filamentous form (*Spirogyra)* and a colonial form *(Volvox).*

a. *Spirogyra*

Spirogyra is a filamentous alga that lives in fresh water and is often seen as a green scum on the surface of ponds and lakes. The most prominent feature of the cells is the spiral, ribbonlike chloroplast.

✍ Make a wet mount of live *Spirogyra* or observe a prepared slide. Draw what you see under the microscope:

Spirogyra (_____X)

b. *Volvox*

Volvox is a green algal colony. It is motile (capable of locomotion) because the thousands of cells that make up the colony have flagella. These cells are connected by delicate cytoplasmic extensions.

Volvox is capable of both asexual and sexual reproduction. Certain cells of the adult colony can divide to produce daughter colonies that reside for some time in the parental colony. A daughter colony escapes the parental colony by releasing an enzyme that dissolves away a portion of the matrix of the parental colony. During sexual reproduction, some colonies of *Volvox* have cells that produce sperm, and others have cells that produce eggs.

✍ Using a depression slide, make a wet mount of live *Volvox* or observe a prepared slide. Draw what you see under the microscope and label the daughter colonies, if any.

Volvox (_____X)

2. Observation: Brown Algae

The vast majority of the brown algae (Phylum Phaeophyta) are found in cold, marine environments. All members are multicellular, and most are macroscopic. Their color is due to the accessory pigment fucoxanthin, which is so abundant that it masks the green chlorophylls. Some species are used as food, while others are harvested for fertilizers. Of primary economic importance is **algin,** a cell wall component of brown algae that makes ice cream smooth, cosmetics soft, and paint uniform in consistency, among other uses.

Kelps are large (up to 100 m long), complex brown algae. They are common along the seashores in cold waters.

Fucus is a common brown alga of the coastal shore, especially abundant attached to rocks where the plants are periodically wetted by splashing waves and the tides.

✍ Examine the demonstration specimen of *Fucus*, noting the branching nature of the body.

3. Observation: Red Algae

Like most brown algae, the red algae (Phylum Rhodophyta) are multicellular, but they occur chiefly in warmer seawater, both in shallow waters and as deep as light penetrates. Some forms of red algae are filamentous, but more often, they are complexly branched with a feathery, flat, and expanded or ribbonlike appearance. Red algae are the source of **agar,** a substance extracted from their cell walls. Agar is the solidifying agent in media on which some microorganisms are cultured.

4. Observation: Diatoms

Diatoms possess a yellow-brown pigment in addition to chlorophyll. The diatom cell wall is in two sections, with the larger one fitting over the smaller as a lid fits over a box. Since the cell wall is impregnated with silica, diatoms are said to "live in glass houses". The glass cell walls of diatoms do not decompose, so they accumulate in thick layers that are subsequently mined as diatomaceous earth and used in filters and as a natural insecticide. Diatoms, being photosynthetic and extremely abundant, are important food sources for the small heterotrophs in both marine and freshwater environments.

✍ View a prepared slide of diatoms. Draw the shapes that you identify under the microscope.

Diatoms (_____X)

B. PROTOZOANS – "animal-like" protists

The term *protozoan* refers to unicellular heterotrophs that ingest food via formation of a food vacuole. Protozoans are classified according to their mode of locomotion and food capture.

1. Observation: Amoeboid protozoans

The best-known amoeboid protozoans (Phylum Sarcodina) are the amoebas, organisms that continually change shape by forming projections called *pseudopodia* (singular, *pseudopodium,* "false foot"). Organisms that locomote by forming pseudopodia are said to exhibit "amoeboid movement". Food capture is by way of phagocytosis – the organism surrounds and engulfs a food organism with its pseudopodia, forming a food vacuole. One notorious human pathogen is *Entamoeba histolytica*, the cause of amoebic dysentery.

✍ Examine the prepared slide of *Amoeba.* Draw what you observe under the microscope.

Amoeba (_____X)

2. Observation: Ciliated protozoans

Most members of the Phylum Ciliophora are covered with numerous short locomotory structures called *cilia.* The cilia beat in synchrony to move the organism. One of the larges ciliates is the predatory *Paramecium caudatum.* Beating cilia drive food particles into the oral groove of the *Paramecium.* Food is then transported to the gullet. The particles become enclosed by a food vacuole, where digestion will take place.

✍ Prepare a wet mount of *Paramecium caudatum* or examine a prepared slide. Draw what you observe under the microscope.

Paramecium caudatum (_____X)

3. Observation: Flagellated protozoans

Members of the Phylum Mastigophora have one or more flagella to provide motility. The group includes some fairly notorious human parasites that cause disease, including giardiasis (from drinking contaminated water), some sexually transmitted diseases (via *Trichomonas vaginalis),* and African sleeping sickness, caused by *Trypanosoma brucei.*

✍ Examine a prepared slide of human blood that contains the parasitic flagellate *Trypanosoma.* Also view the image under the Protist microslide viewer. Draw what you see.

Trypanosoma brucei (_____X)

4. Observation: Sporozoans

All members of the Phylum Apicomplexa are parasites, infecting a wide range of animals, including humans. *Plasmodium vivax* causes one type of malaria in humans.

P. vivax is transmitted to humans through the bite of an infected female *Anopheles* mosquito. The mosquito serves as a **vector**, a means of transmitting the organism from one host to another. Male mosquitoes cannot serve as vectors, because they lack the mouthparts for piercing skin and sucking blood. See Figure 25.9 on page 262 in Vodopich & Moore's Biology Laboratory Manual, 6th edition.

✍ Examine the image on the Protist microslide under the microslide viewer. Draw what you see.

Plasmodium vivax (_____X)

List two ways that you could distinguish between *P. vivax (*Phylum Apicomplexa) and *T. brucei (*Phylum Mastigophora) when observing a blood slide?

- o _____
- o _____

C. SLIME MOLD – "fungus-like" protists

The slime molds have both plantlike and animal-like characteristics. Because they engulf their food and lack a cell wall in their vegetative (nonreproductive) state, they are placed in the Kingdom Protista. However, when the reproduce, they produce spores with a rigid cell wall, similar to plants.

Demo: Observe the demonstration plate of *Physarum,* a plasmodial slime mold. (*Physarum* is the yellow substance growing on an oatmeal food source.)

D. WATER MOLD – "fungus-like" protists

Some of the most notorious and historically important plant pathogens known to humans are water molds. Included in this group is *Phytophthora infestans,* the fungus that causes the disease known as late blight of potato. This disease spread through the potato fields of Ireland between 1845 and 1847. Most of the potato plants died, and 1 million Irish working-class citizens who had depended on potatoes as their primary food source starved to death. Another 2 million emigrated, many to the United States.

Perhaps no other plant pathogen so poignantly illustrates the importance of environmental factors in causing disease. While *Phytophthora infestans* had been present previous to 1845 in the potato-growing fields of Ireland, it was not until the region experienced several consecutive years of wet and especially cool growing seasons that the late blight became a major problem.

II. KINGDOM FUNGI

Members of the kingdom fungi are primarily multicellular eukaryotes. Fungi are heterotrophic by absorption. Fungi are important decomposers, parasites, and foodstuffs.

Structure: A fungal body, called a **mycelium,** is composed of many strands, called **hyphae.** Sometimes, the nuclei within a hypha are separated by walls, and sometimes they are not.

Reproduction: Fungi produce windblown **spores** (small, haploid bodies with a protective covering) when they reproduce sexually or asexually. Following sexual union, a collection of specialized hyphae, called a **fruiting body,** is found in some groups. Spores are produced and released by the fruiting bodies.

Classification: Fungi are classified according to differences in their life cycle and the type of structure that produces spores during sexual reproduction.

DOMAIN EUKARYA
KINGDOM FUNGI
Phylum Zygomycota – zygospore fungi
Phylum Ascomycota – sac fungi
Phylum Basidiomycota – club fungi
Phylum Deuteromycota – imperfect fungi

Draw the generalized life cycle of a fungus (refer to Figure 26.2 on page 268 in Ex. 26 of the Vodopich & Moore Biology Lab Manual):

Generalized life cycle of a fungus

A. PHYLUM ZYGOMYCOTA: zygospore fungi

Representatives*:* Soil and dung molds, black bread molds (*Rhizopus)*
Commonly called "zygomycetes", all members of this phylum produce a thick-walled zygote called a **zygosporangium.** Most zygomycetes are saprobes. The common black bread mold, *Rhizopus*, is a representative zygomycete. Before the introduction of chemical preservatives into bread, *Rhizopus* was an almost certain invader, especially in high humidity.

Observation: *Rhizopus* demo plate

1. Observe the demo plate of *Rhizopus.* Note many hyphae (individual strands) that make up the mycelium.
2. Now note that the culture contains numerous black "dots". These are the **sporangia** (singular, *sporangium).* Sporangia are containers of **spores** by which *Rhizopus* reproduces asexually.

During sexual reproduction in *Rhizopus,* two different mycelia must grow in close proximity. (The difference in the mycelia is genetic rather than structural. Because they are impossible to distinguish, the mycelia are simply referred to as + and – mating types.) As the hyphae from each mating type grow close, gametangia are produced at their tips. Each gametangium contains many haploid nuclei of a single mating type. When the gametangia make contact, the wall between the two dissolves and the cytoplasms of each mix. The many haploid nuclei fuse. The resulting cell containing the diploid nuclei is called a **zygospore.** Eventually a thick wall forms around the zygospore forming the **zygosporangium.**

Observation: Prepared slide of *Rhizopus*

1. Obtain a prepared slide of *Rhizopus.* Examine it with the medium- and high-power objective of your compound microscope.
2. Find the stages of sexual reproduction in *Rhizopus,* including gametangia and zygosporangia.

✍ Draw what you see and label the structures.

Rhizopus (_____X)

B. PHYLUM ASCOMYCOTA: sac fungi

Representatives: Many small, wood-decaying fungi, yeasts (*Saccharomyces)*, molds (*Neurospora),* morels, cup fungi, truffles; plant parasites: powdery mildews, ergots

Members of the ascomycetes produce spores *(ascospores)* in a sac, the **ascus** (plural, *asci),* which develops as a result of sexual reproduction. Asexual reproduction takes place when the fungus produces asexual spores called **conidia** (singular, *conidium).* The phylum includes organisms of considerable importance, such as the yeasts crucial to the baking and brewing industries, as well as numerous plant pathogens. A few are highly prized as food, including morels and truffles. Truffles cost in excess of $400 per pound!

Yeasts differ from most other fungi because they are not composed of hyphae. Even though yeasts are unicellular, they form an ascus during sexual reproduction. Usually, however, yeasts reproduce asexually, either my mitosis and cell division or by **budding.**

Observation: *Saccharomyces* demo plate and prepared slide

Saccharomyces is a type of yeast commonly used in the brewing and baking industry.

1. Observe the demonstration plate on display. Note the absence of a mycelium and individual hyphae. Why is this? _____
2. Examine a prepared slide of yeast cells.

The cup fungi are commonly found on soil during cool early spring and fall weather. Their sexual spore-containing structures are cup shaped, hence their common name.

Actually, the structure we identify as the cup fungus is the fruiting body, produced as a result of sexual reproduction by the fungus. Most of the organism is present within the soil as an extensive mycelium. Specifically, the fruiting body is called an **ascocarp.**

Observation: *Peziza,* a cup fungus

1. Observe a preserved or dried specimen of a cup fungus.
2. Obtain a prepared slide of the ascocarp of *Peziza.* Examine the slide with the medium and high power objectives of your compound microscope.
3. Identify the elongate fingerlike **asci,** which contain dark-colored, spherical **ascospores.**

✍ Sketch an ascus and the ascospores.

Peziza (_____X)

C. PHYLUM BASIDIOMYCOTA: club fungi

Representatives: Mushrooms, stinkhorns, puffballs, bracket and shelf fungi, coral fungi; plant parasites: rusts, smuts

Members of this group of fungi are probably what first come to mind when we think of fungi, because this phylum contains those organisms called mushrooms. Actually the mushroom is only a portion of the fungus – it's the fruiting body, specifically a **basidiocarp,** containing the sexually produced haploid **basidiospores.** These basidiospores are produced by a club-shaped **basidium** for which the group is named. Much (if not most) of the fungal mycelium grows out of sight, within the substrate on which the basidiocarp is found.

Mushrooms called gill fungi have their sexual spores produced on sheets of hyphae that look like the gills of fish. Pore mushrooms have pores (tubes) instead of gills.

Observation: Mushrooms

1. Obtain an edible mushroom and identify as many of the following structures as possible, based on the description given:
   a. **Stalk:** The upright portion that supports the cap.
   b. **Annulus:** A membrane surrounding the stalk where the immature (button-shaped) mushroom was attached.
   c. **Cap:** The umbrella-shaped portion of the mushroom.
   d. **Gills:** On the underside of the cap, radiating lamellae on which the basidia are located.
   e. **Basidia:** On the gills, club-shaped structures where basidiospores are located.
   f. **Basidiospores:** Spores produced by basidia.
2. Sketch your mushroom and label all of the parts.

Mushroom

3. Return the mushroom to its original location in the room.
4. View a prepared slide of a cross section of *Coprinus.* Using the three dry microscope objectives, look for the gills, basidia, and basidiospores.
5. Sketch what you see below. Label the parts.

Coprinus (_____X)

Observation: Schizophyllum

A common plant pathogen, compare the structure of Schizophyllum, a basidiomycete, to that of the mushroom. How are they different? How are they similar?

D. PHYLUM DEUTEROMYCOTA: imperfect fungi (i.e., no known means of sexual reproduction)

Representatives: Athlete's foot, ringworm, candidiasis, *Penicillium, Aspergillus*

Deuteromycetes reproduce asexually by forming spores called conidia on upright hyphae known as conidiophores. They are "imperfect" in the sense that no sexual stage has yet been observed (leading to the use of *deutero,* meaning "second") and may not exist. Cell structure and biochemistry indicate that imperfect fungi are sac fungi (ascomycetes) that have lost the ability to reproduce sexually.

Imperfect fungi include the blue mold *Penicillium* species, which are famous for the production of the antibiotic penicillin, and the green mold *Aspergillus* species, which are used to manufacture products ranging from soy sauce to chewing gum. These molds grow on a variety of materials, such as fruits, cheese, leather, paper, cloth, etc. *Candida albicans* is a yeastlike imperfect fungus that causes vaginal infection in females.

Observation: *Penicillium* and *Aspergillus*

1. Observe the demonstration plate of *Penicillium.* Note, especially, the color of the organism.
2. Examine a prepared slide of *Penicillium.*
3. Examine a prepared slide of *Aspergillus.* Compare the conidiophores and conidia to that of *Penicillium.* How do they differ? Sketch the conidiophores and conidia of *Penicillium* and *Aspergillus* below:

Penicillium (____X) *Aspergillus* (____X)

E. MUTUALISTIC FUNGI: LICHENS

Fungi team up with plants or members of the Domain Bacteria or Kingdom Protista to produce some remarkable mutualistic relationships. The best way to envision such relationships is to think of them as good interpersonal relationships, in which both members benefit and are made richer than would be possible for each individual on its own.

Lichens are organisms made up of fungi and either green algae (Kingdom Protista) or cyanobacteria (Domain Bacteria). The algal or cyanobacterial cells photosynthesize, and the fungus absorbs a portion of the carbohydrates produced. The fungal mycelium provides a protective, moist shelter for the photosynthesizing cells. Hence, both partners benefit from the relationship.

Observation: Lichens

1. Examine the demonstration specimen of a **crustose lichen.** What is it growing on? _____ Describe the appearance of the crustose lichen:

2. Examine the demonstration specimen of a **foliose lichen.** What is it growing on? _____ Describe the appearance of the foliose lichen:

3. Examine the demonstration specimen of a **fruticose lichen.** What is it growing on? _____ Describe the appearance of the fruticose lichen:

4. Examine a cross section of a lichen using all three dry objectives of the compound microscope. This particular lichen is composed of fungal and green algae cells. Locate the **fungal mycelium** and then the **algal cells.** (Draw and label below:)

Lichen (____X)

It's likely that this slide has a cup-shaped fruiting body. To which fungal phylum does this fungus belong? _____

For more information regarding bacteria, protists or fungi, refer to Exercises 23, 24, 25 and 26 of Vodopich & Moore's Biology Lab Manual, 6th edition.

Information contained in this handout was adapted from the following sources:

Sylvia S. Mader, Laboratory Manual: Inquiry Into Life, 10th edition, McGraw-Hill Higher Education, 2003, pp.323-344.

Perry, Morton & Perry, Laboratory Manual for Starr and Taggart's "Biology: The Unity and Diversity of Life" and Starr's "Biology: Concepts and Applications", Wadsworth Group, Thomson Learning, 2002, pp.245-320.

Vodopich & Moore, Biology Laboratory Manual, 6th edition, McGraw-Hill Higher Education, 2002, pp.229-278.