1. **General Characteristics and structures** – These organisms are all multicellular eukaryotes that are heterotrophs and acquire their nutrients by absorption. Foods are digested outside the organism by enzymes released by the fungi and then the nutrients are absorbed. Lacking chlorophyll, these organisms are entirely dependent upon organic matter. Most fungi derive their nutrients from dead organic compounds (saprobes or decomposers), but some draw their nourishment from living plant or animal material (parasites). They are made of tiny filaments called hyphae which have cell walls consisting of Chitin.

2. **Natural History** – Fungi belong to the Supergroup Unikonta because of DNA comparisons and posterior flagella. The first fungi organism appears in the fossil record about 460 million years ago during the Ordovician. It is believed that the first fungi was probably a flagellated ancestor that diverged from animals about 1 billion years ago according to molecular clock data. It is believed the microscope ancestors of terrestrial fungi did not fossilize well.

3. **Biogeography** – The distribution of fungi is worldwide; as a group, are found in almost every terrestrial and aquatic habitat. There are 100,000 described species and it is believe that there are as many as 1.5 million species of fungi.
Kingdom: Fungi
Division: Chytridiomycota

1. General Characteristics and structures – Coenocytic hyphae (no cross walls) or may be unicellular

2. Biogeography – They are ubiquitous in lakes and soil.

3. Unique Characteristics – These fungi have both protista and fungi characteristics.
   - Uniflagellated cells
     (Protist characteristic)
   - Cell Wall made of Chitin
   - Absorptive mode of eating
     (Fungi characteristic)
Kingdom: Fungi
Division: Zygomycota

1. General Characteristics and structures – This group includes the molds that grow on food such as Black Bread Mold. They have Coenocytic hyphae (no cell walls).

2. Biogeography - They are typically fast growing molds found on bread, peaches, strawberries and sweet potatoes.

3. Unique Characteristics - Observe the petri dish and slant of the living culture *Rhizopus* growing on agar. The white hairs are the haploid hyphae that make up the mycelium. The hyphae that travel horizontally are called stolons and the hyphae that are vertical are called rhizoids.

Example: *Rhizopus nigercans*
Kingdom: Fungi
Division: Zygomycota

Asexual Reproduction

The long hairs under the scope are the **hyphae** that make up the **mycelium**. The mycelium can form **sporangium**, containing the asexually produced **spores**. The special **hyphae** bearing the sporangia are called **sporangiophores**.
Kingdom: Fungi
Division: Zygomycota

Sexual Reproduction

Genetic recombination is by the process of conjugation which occurs when two strains grow close together. Each mycelium grows projections, called progametes. The cytoplasm of the two strains will fuse by a process called plasmogamy. At this point, the haploid nuclei pair off and the cell is said to be dikaryotic. The cell develops a rough, thick wall that can protect the nucleus from harsh conditions. This structure is called a zygospore which then can go through karyogamy to form a diploid cell.
Kingdom: Fungi
Division: Glomeromycetes

1. **General Characteristics and Structures** - Coenocytic hyphae with mutualistic relationships with plant roots.

2. **Biogeography** - These fungi are called arbuscular mycorrhizae. The tips of the hyphae enter the plant roots and branch into tiny treelike structures called arbuscules.

3. **Unique Characteristics** - This division was formerly included in the zygomycetes but genetic evidence supports these should belong to a separate clade. Although there are only 160 species, they have a symbiotic association with 90% of all plant.
Kingdom: Fungi
Division: Ascomycota

1. **General Characteristics and Structures** – These fungi are called Sac Fungi and include yeast, truffles, Dutch Elm disease and some mold. These fungi include Septate hypae (cross walls) and reproduce with Asci.

2. **Biogeography** - They are found in marine, freshwater and terrestrial habitats.

3. **Unique Characteristics** - The mushroom is this division is called an ascocarp.

Example: *Peziza*
Kingdom: Fungi
Division: Ascomycota

Sexual Reproduction:
The fruiting structure called an **ascocarp** is the result of sexual reproduction. The tips of the hyphae produce elongated sacs called **asci**. Within the **asci**, karyogamy occurs which produces a diploid nucleus. This nucleus divides by meiosis to create 4 haploid nuclei. The nuclei divide again by mitosis to form 8 haploid nuclei called **ascospores**. All the asci together are called the **hymenial layer**. Examine a prepared slide of *Peziza*, which shows a longitudinal cross section through the ascocarp.
Two examples of imperfect fungi are *Penicillium notatum*, which is used to make the antibiotic penicillin, and *Aspergillus niger*, which is used to flavor foods. Examine living cultures of *Penicillium notatum* and *Aspergillus niger*. Note the coloring and texture of each culture. They were once placed in the Division: Deuteromycota. These species are called imperfect fungi because they don’t have (or we haven’t found) a sexual stage. They are now considered to be in the division Ascomycetes because they reproduce asexually by means of conidia.
Kingdom: Fungi
Division: Ascomycetes

Ascomycetes reproduce asexually by conidia. Looking at prepared slides of the spore-bearing condidophores which house conidia. Spores of *Penicillium* appear blue-green and resemble a “kitchen fork”. Spores of *Aspergillus* appear black and resemble an “afro” hair style.
1. **General Characteristics and Structures** – The common name of these fungi are Cup fungi and they include mushrooms, toadstools, puffballs, smuts and rusts. They have Septate hyphae (cross walls) and Basidia.

2. **Biogeography** – These fungi are terrestrial and are important decomposers of wood and other plant material.

3. **Unique Characteristics** – The mushroom of these fungi are called basidiocarps made up of dikaryotic hyphae. They basidiocarp have a cap, gills, stipe and annulus.
Kingdom: Fungi  
Division: Basidiomycota

Sexual Reproduction:
The fruiting structure called a **basidiocarp** is the result of fusion of haploid hyphae. The fusion of haploid hyphae produce dikaryotic hyphae which make up the **basidiocarp**. The tips of the hyphae produce club shaped **basidia**. Within the **basidia**, karyogamy occurs which produces a diploid nucleus. This nucleus divides by meiosis to create 4 haploid nuclei. The 4 haploid nuclei move into appendages at the end of the hyphae called **basidiospores**.
1. **General Characteristics and structures** - Lichens are actually a symbiotic relationship usually between a fungi and an algae. The fungal component is usually an ascomycota, but may be a basidiomycota. The fungus supplies moisture and shelter from high light intensity for the algae. The algae components are generally single-celled forms of green algae or cyanobacteria. The algae furnish food for the fungus. Lichens come in various colors and structures.
Plant Classification

1. General Characteristics and structures – These organisms are all multicellular eukaryotes that are autotrophs and acquire their nutrients by photosynthesis. They have plastids which contain chlorophyll A, Chlorophyll B, and carotenoids and the cells have walls consisting of Cellulose.

2. Natural History – Plantae belong to the Supergroup Archaeoplastida whose members engulfed a cyanobacteria. The first plants appear in the fossil record about 500 million years ago during the Precambrian.

3. Biogeography – The distribution of plants is worldwide; as a group, are found in all but the harshest conditions. They accomplished this by producing a durable layer of a polymer called sporopollenin which prevents drying out. The nonvascular plants lack conductive tissue and are limited to a specific range of terrestrial habitats. These plants display two adaptations that first made the move onto land possible. They possess a waxy cuticle to reduce water loss and their gametes develop within gametangia for protection of the embryo.
Kingdom: Plantae
Division: Hepaticophyta

1. **General Characteristics and Structures** – These plants are **Nonvascular and Seedless**.

2. **Biogeography** – They are found in moist areas.

3. **Unique Characteristics** - Members of this division are small, **gametophytes** that are usually found in two different body types.
   1. **Thallose**: flattened dorsoventrally
   2. **Leafy**: resembling mosses
Liverwort Thallus

The thallus is divided into an upper and lower sector. The upper level contains chlorophyll-bearing cells and is used for photosynthesis. Along the upper surface, there are pores that open up to air chambers that surround the chlorophyll-bearing cells used for gas exchange. The lower surface is divided into larger storage cells. Attached to the lower surface are rhizoids (single celled) and scales (multicellular) used for attachment and water absorption.
Liverworts produce gametangia on separate gametophytic plants. The male gametangia (the antheridia) resemble umbrellas and produce sperm. The female (the archegonia) resemble the spokes of a bicycle wheel and produce eggs.
Antheridial and Archegonial Receptacles

The antheridium of a male liverwort contain sperm mother cells that produce sperm. The archegonium of a female liverwort contains a swollen area (venter) which holds the egg. The archegonium proceeds down into a neck with a canal that allows the sperm to get at the egg.
Liverwort
Sporophyte

The sporophyte generation is diploid (2n) and is dependent on the gametophyte generation. It is attached to the female gametophyte by a foot and a small stalk called a seta. The capsule contains spores and elaters. The elaters are used for dispersal. They change with a change in humidity and fling the spores away from the parent plant.
Asexual reproduction occurs when the thallus produces gemmae cups that contain gemmae. The gemmae are dispersed when it rains and water splashes the gemmae out of the cup. This insures that the conditions are right for the gemmae to germinate and produce new plants.
Kingdom: Plantae  
Division: Bryophyta

1. **General Characteristics and Structures** – Mosses are nonvascular and Seedless plants.

2. **Biogeography** - Members of this division are small, gametophytes that usually grow upright. In moist places, they may form a large mat of vegetation.

3. **Unique Characteristics** - Individual plants consist of a stem-like stalk with attached leaf-like structures that lack veins. Root-like rhizoids anchor the plant and absorb materials.
Protonema
(Germinating Spores)

The germinating structure is called a protonema. This structure is very similar to some filamentous green algae and is one piece of evidence that mosses might have evolved from some form of green algae. Be able to recognize this slide.
The protonema have buds that develop into the “leafy” moss. Examine the moss plants provided for you. Male plants can be identified by the flower-like cluster of “leaves” at the tip of the gametophyte. In the female plants, the “leaves” closely surround the tip of the gametophyte. Be able to recognize the difference between male and female plants.
Examine the prepared slide of a longitudinal cross section of a male gametophyte tip. The antheridia contain sperm that are surrounded by sterile jacket cells. The antheridia are found in between paraphyses which are believed to protect the antheridia.
The Archegonium

Examine the prepared slide of a longitudinal cross section of a female gametophyte tip. The archegonia has a swollen area called a venter which contains the egg. Above the venter is the neck of the archegonium. The archegonia are surrounded by paraphyses.
The Sporophyte Generation

The sporophyte generation of a moss develops in the archegonium of a female gametophyte. A capsule develops on a long stalk called a seta. The capsule contains spores held inside by a hard covering called the operculum. A soft covering called a calyptra is part of the gametophyte generation and is created when the sporophyte grows out of the top of the female gametophyte.
The Sporophyte Capsule

The *sporophyte generation* has photosynthetic tissue but is attached to the female gametophyte. It develops a *capsule* which is covered by a hard covering called an *operculum*. In the middle of the capsule is a structure called a *columella* that gives the capsule shape. Inside the capsule, *spores* are produced.
Plant Classification

1. **General Characteristics and structures** – These organisms are all multicellular eukaryotes that are autotrophs and acquire their nutrients by photosynthesis. They have plastids which contain chlorophyll A, Chlorophyll B, and carotenoids and the cells have walls consisting of Cellulose. Vascular plants first developed vascular tissue called xylem (for moving water) and phloem (for moving food).

2. **Natural History** – Vascular Plants first appear in the fossil record about 385 million years ago during the Devonian.

3. **Biogeography** – The distribution of plants is worldwide; as a group, are found in all but the harshest conditions. They accomplished this by producing a durable layer of a polymer called sporopollenin which prevents drying out. The nonvascular plants lack conductive tissue and are limited to a specific range of terrestrial habitats. These plants display two adaptations that first made the move onto land possible. They possess a waxy cuticle to reduce water loss and their gametes develop within gametangia for protection of the embryo.
Division: Lycophyta (Club Mosses)

1. General Characteristics and Structures - These sporophytes have true stems, roots, and leaves.

2. Biogeography – Many grow on tropical trees or on the floor of temperate forests.

3. Unique Characteristics - The stems are covered with small leaves with one vein called microphylls. They have modified leaves called sporophylls that bear sporangia.
Division: Pterophyta (Psilophyta)
Whisk Ferns

1. General Characteristics and Structures - These sporophytes are unique among vascular plants because they do not have true roots or leaves. They only have true stems.

2. Biogeography – They are found in the New World, Asia and the Pacific.

3. Unique Characteristics - The stems usually demonstrate dichotomous branching.
Division: Pterophyta (Sphenophyta) Horsetails

1. General Characteristics and Structures – These sporophytes are vascular plants that have true roots, stems and leaves.

2. Biogeography – They are found everywhere except Antartica.

3. Unique Characteristics – The leaves are microphylls (one vein) and lack chlorophyll at maturity. The stems have silica in their cell walls. Some stems have a specialized cone-like structure called a strobili.
1. **General Characteristics and Structures** – These *sporophytes* are vascular plants that have true roots, stems and leaves.

2. **Biogeography** – The majority of ferns inhabit warm, damp areas of the Earth. Growing profusely in tropical areas, ferns diminish in number with increasingly higher latitudes and decreasing supplies of moisture. Few are found in dry, cold places.

3. **Unique Characteristics** - The large leaves are called *megaphylls or fronds*. The fronds first appear tightly coiled and are called *fiddleheads*. This process is called *circinate vernation*. The specialized leaves with spores are called *sporophylls*. 
Characteristics of a Fern Frond

Ferns reproduce by producing spores. The fronds have small brown patches called sori. The sori are made up of clusters of sporangia which produce the spores. Many species have a protective covering called an indusium.
The sporangia have a conspicuous row of heavy-walled cells called an **annulus**. When the moisture in the cell changes, the **annulus catapults** spores out into the environment through the lip cells. The spores will develop into a **prothallus**. The spores develop into a gametophyte with both sexes. This is called **monoecious**.
The heart-shaped gametophyte generation of a fern is called a prothallus. Archegonia (which produce eggs) are usually found near the apical notch and antheridium (which produce sperm) are usually produced near the rhizoids (for absorption and anchorage). Eventually the sporophyte will grow out of the archegonia.
Fern Prothallus with a Sporophyte

On the prothallus, only one zygote will develop into a sporophyte. The simple structure consists of a small leaf, a root and a foot (the structure that attaches the sporophyte to the prothallus). The prothallus will eventually die off and the sporophyte generation will develop into a recognizable plant.