Course Packet

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BIOL 1409
General Biology: The Diversity of Life

Course Notes & Lab Activities
for
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Biol 1409: Diversity of Life
Ziser - Course Packet

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Biol 1409: Diversity of Life
Semester Activities

Ziser, 2004

Lab Activities

The schedule for the lab activities is posted in the Course Syllabus. Changes will be announced ahead of time

Introduction & Use of Scopes

be able to identify and use the various parts of a compound microscope
be able to use a magnifying glass and dissecting scope
understand the difference between each of the above, the advantages and disadvantages of each and when each should be used
learn how to make a wet mount

Kingdoms of Life

look at a variety of water samples and learn how to visually distinguish between the major kingdoms of living organisms
be able to describe the appearance of members of each kingdom and how to tell them apart from each other
try to find and illustrate a couple of organisms from each kingdom

Characteristics of Life

select a specific living organism – your choice and then describe:

1. its environment
2. its unique characteristics
3. how that organism in particular illustrates each of the characteristics of life that we discussed in lecture;

Ecosystems of Texas (See take home assignments)

complete assignment on Texas ecosystems

Cells: The Basic Units of Life

observe and distinguish between procaryotic and eucaryotic cells
learn to identify the various organelles and structures associated with each in models and slides
learn the functions of some of these organelles and structures
identify and distinguish between selected tissues

Taxonomy and Classification

Learn the process of naming and classifying living organisms
Learn how to observe and describe sometimes minute details to be able to distinguish between different species
Learn to judge whether particular traits are important or unimportant in distinguishing between species
Construct a phylogenetic tree to show proposed evolutionary relationships

The Bacteria

learn how to collect, handle and grow bacteria
learn the characteristics used to identify bacterial species
learn to distinguish microscopic and colonial morphology
distinguish the cyanobacteria from nonphotosynthetic bacteria

The Protists (Algae, Protozoa, Slime Molds)

Learn to recognize members of the kingdom and to distinguish them from the bacteria
Identify and recognize selected organelles and structures
Distinguish between the three major kinds of protists

The Fungi (yeasts & molds)

Learn how to collect and culture and preserve fungi
Learn to distinguish between the various kinds fungal spores
Distinguish between the common varieties of yeasts and fungi

The Plants (mosses, ferns, conifers & flowering plants)

Identify and recognize the variety of cells, tissues and organs in typical plants
Survey the diversty of plants and the variety of form and function of the various organs
Understand the variations in life cycles of the different major groups of plants
The activities may also include some physiological experiments

The Animals (sponges, jellyfish, worms, parasites, arthropods, vertebrates)

Identify and recognize the variety of cells, tissues and organs found in the animal kingdom
Investigate some of the typical animal life forms and adaptations to a variety of habitats
Investigate some of the physiological processes common in most animals
Appreciate the great diversity and economic importance of animals
The activities may also include a few physiological experiments on animals

Biol 1409 Scavenger Hunt

Ziser 2004

You will be asked to find, collect, and identify some of a variety of organisms as we progress through our survey of the major kingdoms of life. There is a wide variety of items to choose from, you are not expected to bring in every item listed.

You must select two **items from each kingdom** listed. The items you bring in are due during the lab periods devoted to that kingdom, see your syllabus for more specific due dates. You will need to bring in a total of **10** different items suggested below, for **5 points each**; for a total of **50 points** toward your semester grade.

This Scavenger Hunt also offers several opportunities for extra credit; some are as noted for specific items, but you can also get 1 point extra credit for each **additional item** you bring in **after** you get your 50 points. These extra points will be counted toward the 25 additional extra credit points possible in the course.

To get credit for the items you bring in, you must adhere to the following requirements:

1. **you bring them in on the exact day indicated by the syllabus**
2. **you cannot *purchase* items *unless* it is specifically permitted in the list below**
3. **you will not get your credit unless you bring in *exactly* what is asked for; that means you need to make sure you know exactly what to collect - do some research, look it up, don't just guess and bring in something remotely like what is asked for and expect to get credit for it**
4. **you need to bring in the specimen relatively undamaged; eg don't take a mushroom or a bird's nest and shove it in your textbook for safe keeping**
5. **use common sense when collecting; eg. don't bring in anything that might endanger the class (eg live pathogens or parasites, venomous animals, poison ivy, etc), don't kill vertebrates just to collect for this project, don't steal nests that are "in use", don't violate laws and bans on hunting or collecting certain lifeforms, eg. we don't want any endangered species, etc; more specific details below**
6. **you will not get these items back; so don't bring in a family treasure – the idea is to make you actually get out into the *real* world (not the shell shop) and try to *find* this stuff yourself. Obvious "easy outs" will be penalized as cheating.**

Bacterial Kingdoms

1. bring in some bacteria
   any sample that you believe would have some natural, or symbiotic procaryotes, no pathogens
   make wet mounts, draw them; describe them

2. bring in a sample of commercially important bacteria
   you can purchase these; if you bring in a food product or drink it must actually have the bacteria in it, not just be manufactured using bacteria
   make wet mounts, draw them; describe them
   describe their role in making that product – be specific

3. bring in a sample of a plant with root nodules
   describe the symbiosis

4. bring in a sample of "green slime" from a pond, creek, stream, lake, etc
   make wet mounts and use keys to try to identify what specific kingdom they belong to determine whether the organism(s) you have collected are procaryotes or eucaryotes
   describe the process of photosynthesis

Protist Kingdom

1. bring in a natural or symbiotic algal specimen
   make wet mounts, sketch them and attempt to identify the algal group to which it belongs; eg diatoms, green, fire algae, etc

2. bring in a a commercially important alga (you can purchase this)
   describe how the alga is used to make the product

3. bring in a sample that contains some protozoan protists
   make wet mounts, sketch them and try to identify the protozoan group to which they belong

4. bring in a slime mold protist (EC)
   describe it and its life cycle

Fungus Kingdom

1. bring in an example of a fungus or yeast used to make a food, drink, or a commercial product
   the product must actually contain the fungus
   make a wet mount and draw and describe the fungus that you find
   describe how it is used to make the product

2. bring in an example of a fruiting body of a fungus
   use the key provided in lab to try to identify the major group to which it belongs
   EC make a spore print (see instructions in lab)

3. bring in an example of a lichen
   identify the growth form of the lichen as described in course packet
   use websites listed to try to identify the lichen
   describe how this specific lichen is an example of symbiosis and the kind of symbiosis it is

Plant Kingdom

1. bring in 2 plants, one that has a taproot and another that has a fibrous root
   EC press and properly dry and label the plant specimen as per information available in lab

2. bring in a moss gametophyte, and (EC) a moss sporophyte (look it up!)
   EC press and properly dry and label the plant specimen as per information available in lab

3. bring in a frond of a fern sporophyte with sori (look it up!)
   EC press and properly dry and label the plant specimen as per information available in lab

4. bring in some leaf trichomes (look it up!)
   be careful; none from poison ivy or bull nettle, etc
   look at them under the dissecting scope and draw them
   EC press and properly dry and label the plant specimen as per information available in lab

5. bring in a *modified* root, stem or leaf (look it up!)
   name the plant it comes from and what its new function is

6. bring in two plant ovaries, an immature one and a mature one (look it up!)
   EC if they are from the same species of plant

7. bring in a seed
   cut it open diagram and identify the endosperm and the plant embryo

8. bring in a fern "relative" but not an actual fern (ie not Phylum Pterophyta; look it up!)
   EC press and properly dry and label the plant specimen as per information available in lab

9. bring in **1** conifer leaf
   describe its adaptations to its environment

10. bring in two flowering herbs; one a monocot and the other a dicot (look it up!)
    EC press and properly dry and label the plant specimen as per information available in lab

11. bring in a dioecious (either male or female, only) flower
    EC press and properly dry and label the plant specimen as per information available in lab

12. bring in a sample of periderm (look it up!)
    but not from a live plant!

13. bring in a sample of xylem
    but not from a live plant
    describe its general function

14. bring in a male and a female pinecone

15. bring in six different kinds of pollen
    take pieces of clear scotch tape and touch each to the anther of six different kinds of flowers then tape it to a piece of dark colored paper or cardboard
    bring it in, look at it on the microscope and draw each kind of pollen

Animal Kingdom

1. bring in a live example of a "simple animal" such as hydras, sponges, flatworms, or (EC) roundworms

2. EC go "bear hunting" and bring some tardigrades in to lab
   describe their behavior

3. bring in a preserved animal ectoparasite (look it up!) or (EC) an endoparasite
   do not collect endoparasites from dead animals; and don't kill a live animal only for this purpose; the best way to get them is if you fish or hunt regularly
   preserve by placing in a small bottle of 70% rubbing alcohol
   identify the parasite as well as you can and describe how it lives

4. bring in a preserved animal that is a commensal or mutualist or ectoparasite of humans
   do not collect an endoparasite; preserve in 70% alcohol
   identify the parasite as well as you can and describe how it lives

5. bring in a preserved animal that is a pest in grains, pantries, flours, etc
   preserve in 70% alcohol
   identify the parasite as well as you can and describe how it lives

6. Bring in a fossil animal from the central Texas area
   identify it to phylum
   describe what kind of modern animal it is most closely related to

7. bring in a vertebrate skull
   don't kill an animal to do this; don't bring in a dead animal head still with soft tissue on it
   identify the animal

8. bring in any kind of feather except a flight feather (look it up)
   identify the bird and the kind of feather and its function

9. bring in an animal nest
   not one currently in use – an abandoned nest
   identify the animal that made it as accurately as possible

10. bring in an example of an immature animal; eg a larva, nymph, embryo, pupa, etc

not your kid brother or other vertebrate
preserve in 70% alcohol
identify its adult form

12. bring in an example of an endoskeleton and an example of an exoskeleton

13. make a plaster cast of animal tracks or burrows
identify the animal that made the tracks or burrows

Extra Credit Activities

You can earn up to a maximum of **25 extra points** by doing some of the activities listed below. Most will be worth up to a couple of points each, some of the more involved ones may be able to get you up to 5 extra points. Any extra points that you earn will be added to your final point total for the class.

Additional opportunities for extra will be announced throughout the semester, check the bulletin board regularly for details

Website Surveys

Visit ten websites, print its homepage and write an evaluations of each; what its got, what is useful, what is not useful for this class. You may even want to devise your own rating system for your evaluations. Be sure to provide the website address and title for each of your evaluations; each evaluation should be one side of a page long

Expose Lies

Any time you hear me make some broad generalization in class (eg. "All animals have this trait" or "No bacteria can do this" or some other similar kind of remark that you think isn't true, or you read in your textbook something that sounds suspicious, find evidence that the statement was incorrect. Provide your reference (a book or website) and exactly what I said and why it is incorrect. Each instance will get you one point. The more times you can prove that your instructor is an uninformed moron the more points you get for scientifically validating that hypothesis!

Seminars

Local colleges, universities, and nature centers frequently offer seminars and workshops throughout the semester. You can get extra credit by attending or participating and writing up a summary of the talk or presentation and submitting it along with a flier, ticket or other "proof of attendance" for the event. Check the bulletin board for postings

Self Guided Field trip to LBJ Wildflower Center or Zilker Gardens

Make a list of 10 flowering plant species (angiosperms) that are currently flowering
Make a list of 10 flowering plant species that are not currently in flower
Make a list of 5 nonflowering plants (eg. mosses, ferns, conifers) found there
Make a list of 10 different animals found there

Self Guided Field trip to Austin or San Antonio Zoo

Make a list of mammals in 5 different orders (see your text or website)
Select one animal and observe its behavior for at least 15 minutes and describe it: what is it doing, why is it doing it, what organ systems are involved, of what evolutionary advantage is it
Select a nonnative animal and describe what impact it might have if released into the central Texas environment

Self Guided Field Trip to Texas Memorial Museum (UT campus)

Make a list of 10 fossil animals or plants displayed in the museum that once lived in the Austin area
Make a list of the endangered species currently on display there
Name one example each of as many **classes** of animals as you can find on display there (see your text or a website for examples of animal classes)

Self Guided Field Trip to Texas Coast
(Port Aransas, Galveston, Corpus Christi, Padre Island, etc):

Describe the most important environmental factors affecting life on the coast and in coastal waters
Walk the beach and count the number of "shells" in a 100 ft stretch; note the total number AND the number of different kinds

Collect a few samples of DEAD shells (or photograph them), try to identify them and turn them in with your report

Describe, and if possible identify, 3 different kinds of plants growing in the back dunes of the beach

Make a list of the major species of birds and mammals that you *actually see* at the coast (not what you think is "supposed" to be there).

Self Guided Field Trip to New Braunfels Snake Farm

Make a list of 5 reptiles that are from the United States; and 5 reptiles that are not found in the US that are on display

List 3 species of Poisonous snakes on display and summarize information about each one

List ten different kinds of mammals on display.

Congress Avenue Bat Colony

What species of bat, common name and binomial name?

When did they start their flight, how long did it last

In what direction did they head when leaving the bridge?

Write a short paragraph on the biology of this species of bat, where it lives, what it eats, its range, etc

Cave Tour

Visit any of the caves in the area and write a paper that focuses on the biology and ecology of caves: eg what kinds of bacteria, animals, plants, fungi etc you find there, food chains, adaptations to cave environments, etc.

Biology Lab Safety Rules and Information

Health and safety are paramount values in science classrooms, laboratories and field activities. You are expected to learn, understand and comply with ACC safety procedures and agree to follow the ACC science safety policy. You are expected to conduct yourself professionally with respect and courtesy to all. Anyone who thoughtlessly or intentionally jeopardizes the health or safety of another individual will be immediately dismissed from the day's activity, may be withdrawn from the class, and/or barred from attending future activities. Specific safety training will take place before most activities. If you are late and miss this training, you will not be able to participate in the activity. You can read the complete ACC science safety policy at: *http://www2.austincc.edu/sci_safe/*.

Emergencies

ACC POLICE DISPATCH: 222 (from an ACC phone)
223-7999 (from a mobile or other phone)

Safety Equipment and Information:

Material Safety Data Sheets (MSDSs)

Information about chemicals used in this laboratory can be found in

Fire Extinguisher

To use a fire extinguisher, pull the pin in the handle and squeeze the handle while pointing the nozzle at the base of the flame.

Eyewash Station

If a chemical is splashed or rubbed into your eyes you must use an eyewash for at least 20 minutes with your eyelids held open.

First Aid Kit

Only minor cuts and burns can be treated in the lab. Serious injuries must be treated in a medical facility. Emergency Medical Services (EMS) will be called if you are injured and are unable to take yourself to a medical facility.

Insurance

You are automatically covered by an ACC Student Accident Insurance Policy if you have an accident during lab that was caused by the lab activity. Your instructor will provide you with the necessary forms.

Dress code and personal protective equipment

- While in a lab using sharp instruments or dangerous chemicals you must wear closed-toed shoes.
- In lab activities involving hazardous chemicals, you must wear long pants or skirts (below the knee) or a lab apron/coat (provided).
- You must wear goggles or safety glasses marked ANSI Z87.1 when directed to do so by the lab instructor or lab safety instructions.
- Wearing contact lenses in the lab is strongly discouraged. Students wearing contact lenses must wear safety goggles instead of safety glasses when appropriate.
- Gloves are provided and can be worn for any lab activity; Your instructor will inform you when gloves are required rather than optional.

Waste disposal

- You must precisely follow the waste disposal procedures. Never dispose of anything in lab without prior direction from the instructor.

Lab conduct

- **DO NOT**
  - horse around or perform unauthorized experiments.
  - eat, drink, or chew (tobacco or gum)
  - bring drinks or food (even in closed containers) into the lab.
- You shall follow all procedures in manuals, in handouts, and as given by the instructor.
- Report broken glass and chemical spills to your instructor immediately.
- You must clean up your individual work area/equipment and community work areas/equipment (e.g., sinks, balances).
- Only dispose of chemicals and waste as directed by the instructor.
- Wash hands prior to leaving lab.
- Always assume the chemicals used in lab are corrosive or irritating. Any time chemicals come in contact with your skin, wash the affected area immediately.

Disease

Blood-borne diseases, such as HIV and hepatitis, can be transmitted from person to person through contact with human blood. Follow the Universal Precautions whenever exposure to human body fluids is possible:

ÿ Consider all body fluids (saliva, blood, urine, feces, vomit) as potentially infected.
ÿ Do not touch or come into contact with anyone else's body fluids.

Course Specific Cautions (PIN Biol 1409)

Assuming reasonable care and caution required for any lab procedure, there are two situations that will require special precautions while working in this lab:

1. The Procaryote Kingdom (Collecting and Identifying Bacteria)

   Bacteria are opportunistic, that is, given the opportunity, they may be capable of causing an infection. You will be culturing bacteria and must handle bacterial colonies cautiously:

   Disposed of all contaminated materials in the biohazard bag or bleach bath as directed

   Wipe down the lab tables with disinfectant before and after your lab activities in which you use live bacterial cultures

   Wash your hands thoroughly after completing the lab exercise

   Additional safety precautions will be outlined in the lab

2. Working with preserved materials (protists, animals, fungi & plants)

   Some of these specimens will be preserved in either 70% alcohol or 10% formalin. both solutions are irritants, some may be allergic. Overall, the hazard levels are low as long as the vents are on, you are wearing protective gloves, and you rinse your specimens well before dissecting or handling them.

   Notify your instructor if you know you are allergic to these solutions

3. Your instructor will discuss additional precautions necessary for labs.

Laboratory Safety & Equipment

Familiarized yourself with the various supplies and equipmentin the labroom. Keep this sheet with you until you complete all the activities listed in this exercise.

Assume the blackboard is at the "front" of the room and the windows are on the "left" side

	Describe The Specific Location of Each
nitrile gloves	
safety glasses/goggles	
eyewash station	
sinks	
disinfectant spray bottles	
paper towels	
biohazard bag	
glass disposal boxes	
deionized water spigots	
fire extinguisher	
first aid kit	
hazardous materials spill kit	
vent switch	
emergency gas shutoff switch	

Making Observations
Biol 1409 Lab

All science begins with observations; it is the first step in any scientific investigation or experiment. The kinds of observations we make set the limits to what we can investigate; if we can't observe it, we can't study it. Virtually all of the information that you will learn in this course are the result of 1000's of years of observations made by millions of people. Many observations that biologists make are not direct observations; we use equipment such as microscopes that allow us to see beyond the limits of our eyes. Also, our observations are often biased in some way; we see what we expect to see, or think we "ought to see". For this reason, the same observations must be verified by many others before they are generally accepted as being valid. You will be asked to make numerous observations in this course. Your ability to do well in the lab will be directly related to how much effort you put into your observations.

To test your powers of observation perform the following activity:

1. Choose a living organism, outside the building, on the Pinnacle grounds and describe it as completely as you can:
   - be as specific and as accurate as you can
   - describe the organism, its physical features, its habitat, size, smell, color, etc
   - illustrations are an additional way to help describe the organism
   - be as complete as you can, don't leave anything out, no matter how insignificant you think it is
   - try to come up with 50 different observations about the organism you are describing

2. How does this organism show the major characteristics of life as described in lecture?

3. Now think of 10 questions about this organism and describe how you would go about answering each of them. You don't need to actually find answers, just describe how you could discover the answers to the questions that you pose.

4. Write up and turn in your description as instructed

Microscopy Lab

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A. The Compound Microscope

From information provided by instructor and the videotape, Familiarize yourself with the basic "anatomy" of the microscope and general functions of the following parts:

ocular (eyepiece), objectives, mechanical stage, revolving nosepiece, condenser, illuminator, iris diaphragm, light switch

From the introductory lecture and your lab activities:

-be able to define **magnification**
-be able to find and focus on prepared slides at all magnifications from scanning to high power
-be able to make "wet mounts" and find and focus at all magnifications
-understand the meanings of common abbreviations: cs, ls, sec, wm, etc
-know where to dispose of slides and cover slips

B. The Dissecting Microscope

Familiarize yourself with the basic "anatomy" of the dissecting scope and general functions of the following parts:

eyepiece, objective lens, magnification knob, stage, lamp switch, light adjusting knob, focusing knob

From the introductory lecture and your lab activities:

-be able to focus, adjust the magnification, and adjust the light on both types of scopes
-know when it is best to use this scope as opposed to the compound microscope

C. Magnifying Glass

-familiarize yourself with the use of a magnifying glass
-know when to use each of these methods of magnification and the advantages and disadvantages of each

The Kingdoms of Life

Biol 1409 Lab

1. Learn to recognize and identify representatives of each of the major kingdoms of life
2. What criteria can you use to distinguish them?
3. Are some easier than others?

Kingdoms of Life

<table>
<tr><td rowspan="6">Life</td><td rowspan="3">Single Celled or Colonial</td><td rowspan="3">Autotrophs & Heterotrophs</td><td>Archaebacteria</td><td rowspan="2">Procaryotes</td></tr>
<tr><td>Eubacteria</td></tr>
<tr><td>Protista</td><td rowspan="4">Eucaryotes</td></tr>
<tr><td rowspan="3">Multicellular</td><td>Autotrophs</td><td>Metaphyta (Plants)</td></tr>
<tr><td rowspan="2">Heterotrophs</td><td>Fungi</td></tr>
<tr><td>Metazoa (Animals)</td></tr>
</table>

General Characteristics

of the

Kingdoms of Life:

Bacteria (Archaebacteria and Eubacteria)

(cannot be easily distinguished from each other)
(tremendous physiological diversity)
procaryotic cells
cells very small, no nucleus, little or no internal structure
may be single or grouped in clusters or chains
have cell wall which gives them three basic shapes: cocci (spheres), bacilli (rods) or spirals
some may have blue green pigment for photosynthesis

Protists (protozoa and algae)

eucaryotic cells: generally much larger cells with nucleus and other structures visible inside cells
cells are typically larger than the cells of the other eucaryotic (multicellular) kingdoms
many different sizes and shapes of cells
some with rigid cell walls, some very geometric shapes; others without cell walls and very flexible
single cells, colonies, or filaments or chains of cells
some greenish or brownish and photosynthetic
most motile with flagella, cilia or amoeboid movement

Fungi (mushrooms, yeasts and molds)

eucaryotic cells: have rigid cell walls and cells are fairly large, most long and thin retangular or filamentous shaped
most are multicellular (except for yeasts)

nonmotile, most seem to grow from the ground or rotting organic matter like plants (but they are not photosynthetic)
no true tissues or real organs, just clumps of cells slightly specialized to absorb food and produce spores
the most visible part of most fungi is the fruiting body which produces the spores; it takes the form of a mushroom, bracket fungus, morrel, toadstool or just appears as a fuzzy blue, green, red, black or brown growth on living or dead organic matter
under a microscope they appear as a dense mat of interconnected, uncolored fibers (= mycelium) which grow into their food and form the fruiting bodies

Plants (mosses, ferns, grasses, flowering plants)

eucaryotic cells
most are large, multicellular with distinct tissues and organs; major organs are roots, stems, leaves, flowers and fruits
they are nonmotile, usually anchored in the ground but some attach to other plants
have fairly thick, rigid cell walls giving most cells a square or rectangular outline
almost all are green since cells carry out photosynthesis

Animals (sponges, jellyfish, worms, clams, insects, us)

eucaryotic cells
multicellular but not all are large, many are microscopic and not much larger than some protists
cells do not have rigid walls and are often very small (you may only see individual cells under high power)
most (but not all) are motile and very active; often seen feeding
most (but not all) have distinct organs organized into organ systems such as a digestive tract, heart and blood vessels, brain and nerve cords, respiratory system, mouthparts, etc

The Classification of Living Organisms

Ziser, 2004

Kingdom: Archaebacteria*

[*Higher taxonomic categories, eg. phyla, classes, etc., have not yet been worked out for bacteria]

Methanogens
Halophiles
Thermoacidophiles

Kingdom: Eubacteria*

Cyanobacteria
Spirochaetes
Green-Sulphur Bacteria
Pseudomonads
Enterobacteraceae
Rickettsias
Chlamydias
Actinomycetes
Lactobacilli
Micrococci
Bacilli
Bacilli
Mycoplasmas

Kingdom Protista (Algae, Protozoa, Slime Molds)

Phylum Pyrrhophyta (dinoflagellates)
Phylum Chrysophyta (diatoms)
Phylum Euglenophyta (euglenoids)
Phylum Chlorophyta (green algae)
Phylum Rhodophyta (red algae)
Phylum Phaeophyta (brown algae)
Phylum Sarcodina (amoebas)
Phylum Mastigophora (flagellates)
Phylum Ciliophora (ciliates)
Phylum Apicomplexa
Phylum Microspora
Phylum Myxomycota (plasmodial slime molds)
Phylum Acrasiomycota (cellular slime molds)
Phylum Oomycota (water molds)

Kingdom Fungi (yeasts and molds)

Phylum Chytridiomycota
Phylum Zygomycota (zygomycetes)
Phylum Ascomycota (ascomycetes, sac fungi)
Phylum Basidiomycota (basidiomycetes, club fungi)
Phylum Deuteromycota (deuteromycetes, *fungi imperfecti*)

Kingdom Plantae (Plants)

Phylum: Bryophyta (mosses)
Phylum: Hepaticophyta (liverworts)
Phylum: Anthocerotophyta (hornworts)
Phylum: Pterophyta (ferns)
Phylum: Psilotophyta (whisk ferns)
Phylum: Sphenophyta (horsetails)
Phylum: Lycophyta (club mosses)
Phylum: Coniferophyta (gymnosperms)
Phylum: Cycadophyta (cycads)
Phylum: Ginkgophyta (ginkgoes)
Phylum: Gnetophyta (gnetophytes)
Phylum: Anthophyta (angiosperms; flowering plants)
Class: Dicotyledons (dicots)
Class: Monocotyledons (monocots)

Kingdom Metazoa (Animals)

- Phylum: Placozoa
- Phylum: Porifera [Sponges]
- Phylum: Mesozoa
- Phylum: Cnidaria [Jellyfish & Corals]
- Phylum: Ctenophora [Comb Jellys]
- Phylum: Platyhelminthes [Flatworms]
- Phylum: Nemertea [Ribbonworms]
- Phylum: Gnathostomulida
- Phylum: Nematoda [Roundworms]
- Phylum: Rotifera
- Phylum: Gastrotricha
- Phylum: Kinorhyncha
- Phylum: Loricifera
- Phylum: Priapulida
- Phylum: Nematomorpha [Horsehair Worms]
- Phylum: Acanthocephala [Spiny-Headed Worms]
- Phylum: Entoprocta
- Phylum: Mollusca [Molluscs]
- Phylum: Annelida [Segmented Worms]
- Phylum: Arthropoda [Arthropods]
  - Subphylum: Trilobita
  - Subphylum: Chelicerata
    - Class: Merostomata (horshoe crabs)
    - Class: Pycnogonida (sea spiders)
    - Class: Arachnida (spiders, scorpions, mites, ticks)
  - Subphylum: Crustacea
    - Class: Branchiopoda (tadpole shrimp, water fleas, brine shrimp, fairy shrimp)
    - Class: Maxillipoda (seed shrimp, copepods, fish lice, barnacles)
    - Class: Malacostraca (shrimp, crabs, lobsters, crayfish, pill bugs, amphipods,)
    - Class: Remipedia
    - Class: Cephalocarida
    - Class: Pentastomida (tongue worms)
  - Subphylum: Uniramia
    - Class: Chilopoda (centipedes)
    - Class: Diplopoda (millipedes)
    - Class: Pauropoda
    - Class: Symphyla
    - Class: Insecta
      - Order: Protura
      - Order: Diplura
      - Order: Collembola (springtails, snowfleas)
      - Order: Thysanura (silverfish, bristletails)
      - Order: Ephemeroptera (mayflies)
      - Order: Odonata (dragonflies, damselflies)
      - Order: Orthoptera (locusts, grasshoppers, walking sticks, praying mantis)
      - Order: Dermaptera (earwigs)
      - Order: Plecoptera (stoneflies)
      - Order: Isoptera (termites)
      - Order: Embioptera (webspinners)
      - Order: Psocoptera (book lice, bark lice)
      - Order: Zoraptera
      - Order: Mallophata (biting lice
      - Order: Anoplura (sucking lice)
      - Order: Thysanoptera (thrips)
      - Order: Hemiptera (true bugs; squash bugs, chinch bugs, stink bugs)
      - Order: Homoptera (cicadas, aphids, scale insects, leafhoppers)
      - Order: Neuroptera (dobsonflies, at lios, lacewings)
      - Order: Coleoptera (beetles, fireflies, weevils)
      - Order: Strepsiptera
      - Order: Mecoptera (scorpionflies)
      - Order: Lepidoptera (butterflies, skippers, moths)
      - Order: Diptera (true flies; fruit flies, house flies, mosquitoes, crane flies)
      - Order: Trichoptera (caddisflies)
      - Order: Siphonaptera (fleas)
      - Order: Hymenoptera (ants, bees, wasps, hornets)
- Phylum: Sipuncula [Peanut Worms]
- Phylum: Echiura [Spoonworms]
- Phylum: Pogonophora [Beard Worms]
- Phylum: Onycophora [Velvet Worms]
- Phylum: Tardigrada [Water Bears]
- Phylum: Phoronida
- Phylum: Brachiopoda [Lampshells]
- Phylum: Ectoprocta [Bryozoa]

Phylum: Echinodermata [Echinoderms]
Phylum: Chaetognatha [Arrowworms]
Phylum: Hemichordata [Acornworms]
Phylum: Chordata [Chordates]
Subphylum: Urochordata
Subphylum: Cephalochordata
Subphylum: Vertebrata

vertebrates

Class: Agnatha
Class: Chondrichthyes
Class: Osteichthyes
Class: Amphibia
Class: Reptilia
Class: Aves
Class: Mammalia
Order: Marsupialia (opossums)
Order: Insectivora (shrews and moles)
Order: Chiroptera (bats)
Order: Edentata (armadillos)
Order: Lagomorpha (rabbits and hares
Order: Rodentia (rats, mice, squirrels, gophers, beavers)
Order: Cetacea (whales and dolphins)
Order: Carnivora (dogs, bears, raccoons, skunks, cats)
Order: Pinnipedia (sea lions, walruses)
Order: Sirenia (manatees, sea cows)
Order: Artiodactyla (deer, bison, cows, pigs, goats)
Order: Perissodactyla (horses, donkeys)
Order: Primates (lemurs, monkeys, gorillas, baboons, humans)
Suborder: Prosimii (lemurs, bush babies, tarsiers, lorises)
Suborder: Anthropoidea
Superfamily: Ceboidea (new world monkeys)
Superfamily: Cercopithecoidea (old world monkeys)
Superfamily: Hominoidea
Family: Hylobatidae (gibbons)
Family: Pongidae (apes, chimpanzees, gorillas)
Family: Hominidae
Genus: Australopithecus
Genus: Homo
Species: *Homo habilis*
Species: *Homo erectus*
Species: *Homo sapiens* (humans)
Subspecies: *Homo sapiens neanderthalis*
Subspecies: *Homo sapiens sapiens* (modern humans)

Taxonomy and Classification

Biol 1409 Lab

Ziser, 2002

This exercise is based on the discussion of taxonomy and classification discussed in your text section 18.5

Taxonomy and **classification** involves describing and naming new organisms and determining their evolutionary relationships to species that have already been described. While some species can have 100's of **common names** throughout the world each has only a single **scientific name**. The "**species**" is the basic unit of biological classification. Organisms are considered to be the same species if they can successfully interbreed and produce offspring under natural conditions. It is the only "real" unit, all other levels (eg. **phylum**, **class**, **genus**, etc) are artificial and often change as our knowledge of a group increases. There are many ways to classify objects; eg, color, size, shape, external similarity, etc. The trick is to try to determine which characteristics are the best to describe a particular species and to distinguish it from other similar organisms. Whenever a new species is discovered a representative sample is collected and used as the "type specimen" for that species; it is described in detail and becomes part of a permanent museum collection. The scientific name of a species is a "**binomial name**" which includes two parts: the **genus** and the **species epithet**; while the genus is also part of the **hierarchical classification scheme** first proposed by **Linnaeus**, *both are required as the single unique name of a particular species*. The scientific name is usually a latinized pair of words that describe some characteristic of the organism or that honors the name of someone important to the person who names the species. The genus is always capitalized and both are underlinded or italicized.

Systematics is the process which attempts to determine evolutionary relationships (ie. geneology) of a species. This is done by looking for anatomical, physiological or biochemical similarities between species; fossil comparisons, studying embryological development and ecological characteristics of a species. Some of the criteria that are used in taxonomy and systematics include determining whether a particular trait is **primitive** or **advanced**; **generalized** or **specialized**, or **homologous** or **analogous**. Look up the definitions of these terms in your text.

Probably one of the most critical aspects of this exercise is the ability to make careful observation and logical deductions from those observations. In this exercise you will describe the characteristics of a set of shells, give them a scientific name, and then try to construct an evolutionary tree to show possible interrelationships between the different species.

A bivalve is an animal that lives within the shell it secretes. When the animal dies the soft parts rot away leaving only the hard shells. The attached illustrations provide some of the terminology you might want to use as you describe your shells (you do not need to learn or memorize these terms, they are only offered to allow you to more easily describe your different shells.

In this exercise each pair of you will be given a bag with a variety of bivalve shells. Some of the shells are from the same species some are from other species of bivalve. Your goal will be to meticulously describe each kind of shell and to propose its interrelationships with other shells in the set. The following information will be useful in your work:

- these are bivalves with a left and a right shell; some shells in the bag may be left, others right: whether a shell is a mirror image of another similar one is NOT a valid trait to use to separate and identify a "species"
- remember, these shells are only part of the animal, not the whole animal; what you will attempt to do here is more akin to what paleontologists do to describe fossils than with how biologists generally try to describe species
- all shells are numbered, consider all shells with the same number to be the same species
- shells with different numbers are *probably*, but not necessarily, different species – you decide
- all bivalves grow, therefore a difference in size alone is not always a criterion for distinguishing between two or more different species
- for this exercise you can assume that all the different 'species' of shells are related in one way or another, how close the relationship actually is depends on your own judgement

- some characteristics are the result of shell damage, eg. holes made by oyster drills or sponges, wear and tear from wave action, bleaching by sunlight, and would not make good criteria on which to compare different species. You will need to decide which shell features are the most important for characterizing a species
- You will also need to determine which characteristics are the most primitive and which are the most advanced in order to try to determine evolutionary relationships

Procedure:

1. **Remove** the shells from the bag and **sort** them by number
2. Attempt to **describe** each different set of shells based on the information and illustrations provided
3. Attempt to **determine the evolutionary relationships** between the shells (ie. those that you decide are more similar are more closely related to each other and those that you believe are more distantly related are less closely related)
4. **Name** each species of shell using the binomial system (if you believe two are very closely related you might want to put them in the same genus, etc.
5. Once you have established the interrelationships, **construct an "evolutionary tree"** of the different shell species that you have and using the binomial "species" names that you gave each of them. Feel free to illustrate your evolutionary tree if you want to
6. **Describe the rationale** you used in constructing the tree (why did you think some were more closely related than others, why did you think some were more advanced than others, etc)

Name:_____

Due Date:_____

'Species' Names & Descriptions:

#	Binomial Name	Species Description
1		
2		
3		
4		
5		
6		
7		
8		
9		

Latin Word Roots

In constructing binomial names it is best to use latin terms or latinized versions of other words. Below is a list of relevant terms you may wish to select from in 'naming' your species:

animal	zoi
arc	arcus
armor	opl
bag	ascid, balanti
beautiful	bell
bluish gray	caesi
bored through	toreus
box	thec
brilliant white	cand
brittle	cladar
brown	brume
case	thec
chamber	camer, thalam
circle	circ
color	chrom
common	phortic
concealed	crypt
convex	cyrt
cover	apercul
cup	amby, cali
curved	cyrt
dusky	pheo
flattened	applanat, deplanat
found in water	hyphydr
foreign	allotr
fragile	cladar
furrow	anula
glassy	hyalo
gray	glanc, pheo
grooved	glypho
hard	duri
heavy	bar, baro
hidden	crypt
high	alti
hinge	thair
hollow	kyst
indistinct	asem
irregular	anomal
keeled	carinat
a kind of mollusc	naupli
a kind of shellfish	otio
large	grandi, mega
lid	opercul
little	paur
little animal	zodi
little pouch	peridi
lobed	lobut
lump	chondrill
mother of pearl	nacr
mussel	mytil
narrow	angusti
obscure	asem
ocean nymph	bero
oval	paramec
pouch	balanti
rainbow	iri
ridge	lir
ring	annu, circ
rough	asper, scabios, scyph
round	gongyl, strongyl
scaly	scabios
sea	pont
seashore	aigial, littor
sedentary	sessil
shell	conch, kelyph, ostrac
shield	cetr
short	brev
small	paur
smooth	aphel, glabr, lito
sphere	sphaer
spiny	acantho
strange	allotr
streaked	plagat
striped	vittat
tall	alti
thick	hadr
thin	arai, attenuat
tooth	gomphi
toothed	dentat
uneven	anomal
water nymph	naia
weak	arai, attenual
wear off	detrit
wedge	cune
white	leuco
projecting teeth	chauliod
wrapper	arill
wrinkled	syphar
yellow	flav

Cells – The Basic Units of Life

Biol 1409 Lab

Ziser, 2002

All living matter is composed of **cells**. Many organisms consist of only a single cell and are referred to as **unicellular**, others are made up of many, sometimes trillions, of cells and are referred to as **multicellular**. All cells arise from other cells. The metabolism of living organisms, all their biochemical activities, takes place within cells and as a result of cellular activity.

All cells are surrounded by a **cell membrane** which encloses the **cytoplasm** (protoplasm) and various other internal structures. The cell membrane restricts passage of materials in and out of the cell and helps to protect the cells structural and functional integrity.

There are two major kinds of cells found in living things. The bacterial kingdoms (the archaebacteria and eubacteria) are composed of **procaryotic cells**. All other kingdoms (protists, fungi, plants and animals) are composed of **eucaryotic cells**.

Procaryotes

Procaryotic cells are smaller and structurally simpler cells than eucaryotic cells. They have a **cell membrane** and often a rigid **cell wall** surrounding the cell membrane and giving the bacterium its basic shape. Some bacteria also secrete a thick **capsule** (atlas p28; fig 3.19), a jelly-like layer that they use to attach to surfaces and to protect the organism from harsh conditions. There are no internal 'organelles' although there may by various "inclusions"; ie. crystals of various moleucles, droplets of fats and oils, etc. Some bacteria produce a resistant structure called a **spore** which is inside some cells. and some procaryotic cells have one or more **bacterial flagella** (atlas: p 27; fig 3.12)[Fig 3.11] for movement.

Eucaryotes

Eucaryotic cells are usually much larger and structurally more complex compared to bacterial cells (Atlas p2; Table 1.1; p3; fig 1.3; p6, fig 1.16)[Table 1.1, Fig1.3, Fig 1.18]. They also have a **cell membrane** and **cytoplasm**. But only fungi, plant and some algal protist cells have a **cell wall**, animal and protozoan protists do not have a rigid cell wall and their cells are therefore more flexible and their shape more variable. Internally, floating in the cytoplasm are various **organelles** (small organs), each with a specific function similar to some of the organs found in large complex organisms. For example, one or more nuclei (singular: **nucleus**) are found in almost all eucaryotic cells and are often the largest organelle present. The nucleus contains the genetic material, the **chromosomes**, which are made of **DNA** and control all metabolism. Cells that carry out **photosynthesis** (in algae and plants) contain green organelles called **chloroplasts** which contain all the enzymes necessary for photosynthesis. Eucaryotic cells also contain **mitochondria** which contain most of the enzymes for extracting energy from organic foods, a chemical process called **respiration**. Plant cells often have large **vacuoles** which store water, starch or other food. Cells that move usually have small whip-like extensions called **cilia** or **flagella**.

In addition to the structures mentioned above eucaryotic cells contain quite a few other organelles and internal and external structures as shown in the illustrations in your atlas. Many of the organelles in eucaryotic cells are so small that they are invisible wihout special stains or greater magnification but you can see at least some of these structures in the lab today.

In most multicellular eucaryotes, particularly the plants and animals, cells are grouped into **tissues**. Tissues are groups of similar cells which perform a specific function in the animal or plant. After looking at cells you will observe a few of the different kinds of tissues found in plants and animals.

Lab Activities:

[Most of these slides will need to be viewed at a magnification of 400x]

Remember: do not use the 100X lens

1. Examine the slide labeled **Bacteria Types, wm**:
   Note the small size of the cells even at high (400X) magnification .

Note the three major shapes of bacterial cells produced by the presence of a rigid cell wall
Can you see any internal structures inside any of the cells?

2. Examine the slide labeled **Bacterial Capsules wm:**
   These cells have been stained so that the capsule appears as a thick 'clear' area around each cell
   What is the function of a capsule?

3. Examine the models of plant and animal cells
   Identify the cellular organelles mentioned at the beginning of this exercise.
   How do these two different kinds of eucaryotic cells differ?
   How are they similar?

4. Now examine the slide labeled ***Amoeba proteus*, wm**:
   Amoeba is a protozoan protist; note the lack of a rigid cell wall. The organism is surrounded only by a thin flexible cell membrane
   Note the large nucleus in roughly the center of the organism.
   Can you see or identify any other structures inside the cell? Compare what you see to the illustration in your atlas (p31; fig 4.10) [Fig 4.1, Fig 4.19].

5. Examine the slide labeled ***Spirogyra* wm**:
   Spirogyra is a multicellular (filamentous) algal protist common in ponds and ditches. Compare what you see on your slide to the illustrations in your atlas (p37, Fig 4.37) [Fig 4.61]. The organism on your slide has been stained so appears blue rather than green as illustrated in your atlas.
   Notice the rectangular shape of the cells which is produced by the rigid **cell wall** surrounding the **cell membrane**.
   Observe the unusually shaped spiral or spring shaped **chloroplast** which is used for photosynthesis.
   Can you see the **nucleus** inside the cell?
   Can you find any other structures or organelles such as the ones labeled in your atlas?

6. Examine the slide labeled **Onion mitosis root tip *Allium*, ls**:
   Many of these cells are in the process of dividing, when this happens you can actually see the **chromosomes** (made of **DNA** and proteins) within the cells. (Atlas p17, fig 2.2) [Fig 2.5]
   Most of the cells are roughly square in outline due to the presence of a **cell wall**. Just inside the cell wall is the **cell membrane** but you probably won't be able to see it as a distinct structure.
   Also most cells have a distinct **nucleus** in the center. The darker dot inside each nucleus is called a **nucleolus** and contains another nucleic acid called RNA.
   In some cells, instead of a nucleus you can see small 'sausage shaped' structures. These are **chromosomes** that have replicated as the cell begins the process of division.
   Why can you see so many cells dividing here but not on the other slides you have looked at?

7. Make a wet mount of an Elodea leaf from the finger bowl on the side table:
   Elodea is a plant and its cells are also surrounded by a thick **cell wall**, can you find it?
   This time you are looking at living cells so they should appear pretty much like the illustration in your atlas (p3; fig 1.5) [Fig 1.5].
   Locate the small oval green **chloroplasts**, each cell has several, note that the chloroplasts are the only structures in the cell that are green, yet they are what give all plants their green color.
   Are the chloroplasts moving? Sometimes the movement exhibited by living organisms is internal rather than external as it is in most animals. this internal cellular circulation is called cyclosis.
   Notice also that all the chloroplasts are pushed to the sides of the cell. If you look closely (and use your imagination a little) you will see the most of the interior of the cell is occupied by a large colorless **vacuole** which contains water and some organic molecules.
   If you hunt a little harder you should also be able to find the **nucleus** in at least some cells.

8. Make a wet mount of some of your own cheek cells following the instructions given:
   Cheek cells are thin, pancake shaped cells that line your mouth [Fig 1.29]. Since these are animal cells you will not see a cell wall, a **cell membrane** forms the main boundary around each cell.

You can also see a large **nucleus** in the center of the cell and a **nucleolus** inside it.
Can you see any other organelles inside these cells, if so can you identify them?
As you look around on your slide you should also be able to see several kinds of bacterial cells. What are their shapes. Compare their size to that of the cheek cells.

All members of the bacterial kingdoms consist of individual procaryotic cells. Members of the eucaryotic kingdoms can be unicellular or multicellular. In the most complex multicellular forms, the plants and animals; groups of cells have become specialized to perform specific functions such as support, movement, communication, etc. These groups of specialized cells are called **tissues**. Now that you have familiarized yourself with individual procaryotic and eucaryotic cells lets look at a couple different kinds of **tissues**.

9. Examine the slide labeled **Typical Monocot and Dicot Leaf epidermis, wm**
   Almost all multicellular organism have some kind of specialized tissue covering the outer surface of the organism. This tissue can serve a variety of functions depending on the organism including protection, support, gas exchange, absorption, secretion, among others.
   Since this is a plant tissue you will see a cell wall surrounding the cell which are roughly rectangular in shape. (Atlas p92, fig 6.118) [Fig 6.195, Fig 6.196].
   What organelles can you find?
   Notice that not all cells are alike. Observe pairs of 'bean-shaped' cells called guard cells; these cells form pores in the epidermis to allow carbon dioxide to enter the plant and oxygen and water vapor to escape. Do the guard cells have chloroplasts? Do they have any other organelles?

10. Examine the slide labeled **mammal areolar tissue spread**:
   This is an animal tissue that is used as a kind of glue (it is also called "loose connective tissue"). It is filled with scattered cells and various kinds of fibers in a jelly like secretion which holds everything together.
   Compare your slide to the illustration in your atlas (p12, fig 1.42) [Fig 1.44]. Can you distinguish between the cells and the various fibers in this tissue.
   What organelles can you identify?

11. Examine the slide labeled **blood, frog:**
   Blood is the only liquid tissue that moves or curculates in an animal. It is composed of several kinds of cells floating freely in a liquid plasma of water and organic and inorganic molecules. Blood tissue becomes more complex in more complex animals. It also takes on more functions as it becomes more complex including carrying oxygen and nutrients to cells, removing wastes, carrying hormones, working as part of the immune system to protect the body, etc.
   Do the blood cells have a cell wall?
   What organelles can you identify?

12. Finally, examine the slide labeled **mammal adipose tissue, sec**:
   Adipose tissue is an animal tissue used to store fats or oils(lipids). It is the tissue that many of us would like to have a lot less of in our bodies than we actually do! Compare your slide to the illustrations in lab and the figure in your atlas (p11, fig 1.34) [Fig 1.43].
   When you first look at the slide the tissue appears somewhat like a honeycomb – a bunch of empty chambers. If you look closely on high (400x) power you should be able to see a nucleus pressed against the cell membrane.
   The center of the cell is filled with a large oil droplet or fat vacuole where fat is stored.

Reproduction, Development & Life Cycles
Biol 1409

-Ziser, 2004

Most living organisms reproduce both **sexually** and **asexually**. Asexual reproduction produces genetically identical copies (ie. clones) while sexual reproduction produces genetically unique offspring. There are advantages and disadvantages to both types of reproduction that will be discussed in lecture. Even in organisms which rely mainly on sexual reproduction for procreation (such as vertebrates or flowering plants) asexual reproduction appears in the form of growth, wound healing, tissue repair and replacement, or as more complex processes such as budding, regeneration, and vegetative propagation.

In this exercise you will study examples of various kinds of sexual and asexual reproduction and begin to learn the terminology associated with them. You might want to make sketches of some of the slides or illustrations to help you remember what they look like.

A. Reproduction

Some Terms Related to Asexual Reproduction

Fission: Is the simplest kind of reproduction in which one organism divides in half and essentially breaks into two separate organisms.

Slide: *Paramecium* fission (Atlas: p17,34) [Fig 4.31]

Fragmentation: When an individual organism spontaneously breaks apart into several separate pieces which regenerate into complete individuals

Budding: A very common type of asexual reproduction is budding. The process is similar to fission but the division is unequal – the bud starts as a small outgrowth of the parent organism. The bud may eventually detach from the parent and become an individual organism or remain attached to produce a colony. In plants more complex buds grow into branches, leaves and reproductive structures such as flowers and cones.

Slides: *Hydra* with bud (Atlas: p102) [Fig 7.10]
Preserved: flower and winter buds (Atlas Fig 6.99, 6.100) [Fig 6.166, 6.167]

Asexual Spores: Asexual reproduction by spores usually involves a reproductive structure called a sporangium. Since the sporangium is constructed differently in different organisms it goes by many names. All sporangia, however, are basically a sac-like structure which contains a few to many reproductive spores. Asexual spores are all genetically identical. Look at the materials below and identify the sporangium and the asexual spores each contains.

Slides: *Rhizopus* sporangia (Atlas: p46,47) [Fig 5.4, 5.5]
Preserved Materials: fern frond with sori (Atlas: p71,72) [Fig 6.81,6.84]

Vegetative propagation: Most plants can reproduce vegetatively by making cuttings or naturally by runners, rhizomes, suckers, etc.

Regeneration: Members of every multicellular phylum are capable of some form of regeneration. This process is used to replace missing or damaged parts rather than to actually reproduce the entire organism. Some organisms have great powers of regeneration while others can only regenerate simple cells and tissues. Humans for example regenerate all their bone tissue about every 7 years and all their blood cells about every 4 months. In other animals, such as lizards, when a body part is broken off accidentally or by a predator the animal is able to regrow the entire missing part. Starfish can regenerate new "arms" when one is broken off and sometimes a single arm can regenerate an entire starfish.

Preserved Material: regenerating starfish

Polyembryony: In some parasitic animals the embryo is able to clone copies of itself. This allows a single egg to produce 1000's of potential individuals and enhances chances that at least a few will be able to find a new host to complete their life cycle.

Some Terms Related to Sexual Reproduction

Usually, sexual reproduction involves the union of two different kinds of sex cells or gametes. In some cases, sexual reproduction does not involve whole cells but only the exchange of some or all of the genes on a chromosome between two organisms.

Conjugation: A '+' and '-' strain (we can't really call them male and female) of a species exchange equal amounts of genetic material or pieces of a chromosome. This process gives each individual new and different genes than it had before conjugation.

Slides: *Paramecium bursaria* conjugation wm [Fig 4.32]

Sexual Spores: Fungi can also produce sexual spores. Sometimes these sexual spores are produced inside large 'fruiting bodies.' Some of these fruiting bodies are the familiar mushrooms, toadstools, and truffles. Visually, these sexual spores are indistinguishable from the asexual fungal spores discussed earlier but this time each individual spore contains a unique combination of DNA. Observe the slides and dried examples of mushrooms and truffles below and note the spores.

Slide: *Rhizopus* conjugation, wm [Fig 5.7, 5.8]

Preserved or Live Materials: misc. mushrooms, brackets, truffles, etc

In most cases, sexual reproduction involves the union of male and female gametes. Most variations in sexual reproduction depend on the actual form of the male and female gametes, how the gametes are produced or whether the developing egg has actually been fertilized or not before it begins development.

Heterogamy: When the 'male' and 'female' sex cells differ the reproductive process is called heterogamy. This is the most common type of sexual reproduction in plants and animals.

Slides: sperm cells: Human sperm smear
egg cells: Mammal ovary Graafian Follicle (Atlas = oocyte on Fig 8.109)

Pollen: In higher plants, the sperm cell is part of a microscopic pollen grain and the egg is part of a cluster of cells called the ovule. The pollen grain cannot swim on its own like sperm cells do, instead it makes its way to the ovum by means of wind, water or animal dispersal.

Slide: mixed pollen grains (Atlas: p96) [p131]

Monoecious Organisms or Hermaphrodites: Only plants and animals produce true reproductive organs. Monoecious organisms are those containing both male and female reproductive organs. Most flowering plants are monoecious; the flower contains both anthers that produce the pollen grains and the pistil that contains the ovule. Many animals, especially those that are sessile (nonmotile) or parasitic, are hermaphroditic. Use the illustrations in your atlas to identify the male and female organs in the examples below

Slide: *Clonorchis sinensis* wm (Atlas: p109) [Fig 7.53]
Model: flower structure (Atlas: Fig 6.85, 6.119) [Fig 6.218]
Illustrations: misc. hermaphroditic organisms:
snail (Atlas 7.54) [Fig 7.68]
earthworm (Atlas 7.68,7.72) [7.86]

Dioecious Organisms: These are organisms that produce either male or female reproductive organs and gametes but never both at the same time. Some plants and many animals, including humans, are dioecious

Protandry: is the ability in some dioecious animals to actually change their sex based on environmental cues such as changes in temperature.

Illustrations: misc. invertebrates, amphibians and fish

Sexual Dimorphism: in many dioecious plants and animals (including humans) the males and females are not identical, but differ in appearance. This is called sexual dimorphism. For example, in most invertebrates the male is usually smaller than the female while in higher animals the female is often the smaller of the pair. In addition to size, dimorphism may also result in differences in structures and color between genders. In birds the male is usually more brightly colored. What would be the advantages and disadvantages of such differences?

Slide: *Schistosoma* male and female
Preserved Materials: misc. birds and mammals
male and female pine cones
Ascaris male and female (atlas 7.42-7.46) [Fig 7.95, 7.97]
Illustrations: misc.

Parthenogenesis (Virgin Birth): With the exception of one suspected supernatural intervention in the human species this process only regularly occurs in nonhuman animals. In these cases the unfertilized egg is able to develop even though it has not been fertilized by a sperm. Most rotifers, and some social insects such as bees and ants regularly reproduce this way. Some higher animals such as fish and frogs can also sometimes reproduce in this way.

Preserved Material: misc. social insects (bees, ants)
Illustrations: misc. insects and other inverts

B. Development and Embryology

All living organisms exhibit some form of growth and development. In Procaryotes such changes are hardly noticeable and relatively simple and straight forward. Eucaryotes, however, and especially multicellular eucaryotes (Fungi, Plants, and Animals), typically show more variations in their developmental processes than do bacteria. The sequence of discrete, recognizable stages that these organism pass through as they develop from the formation of a **zygote** (the fertilized egg) to the sexually mature adult are referred to as its **developmental cycle**.

Most plants and animals go through various recognizable immature stages as development progresses. In vascular plants a **seed** (essentially an embryonic plant in arrested development), then a **seedling** develop eventually leading to the mature form (see atlas 6.84 & 6.147). In the animal kingdom, also, various developmental stages occur before maturity is reached. Such terms as **embryo, larva**, **pupa**, **fetus, metamorphosis**, **nymph**, etc are used to describe these immature stages. Sometimes, the immature stage survives longer than does the adult; some mayfly nymphs take a year to develop while the adult lives for only an hour or two. In some organisms, the number and duration of the immature stages may even vary from one population of the same species to another and depends on various environmental cues.

Embryos: Embryos are immature stages of plants and animals that are not able to feed and move independently. Observe the example of a plant embryo inside a seed, several embryonic stages of starfish and some illustrations of human embryos below.

slides: *Pinus* mature embryo median ls
chick embryo, 33hr [Fig 2.16]
illustrations: human embryonic development

Larvae: Larvae are an immature stage found in animals which move and feed independently and often have no resemblance to the adult of the species. Many groups of animals have characteristic larval stages. A few examples are illustrated below:

slides: cercaria wm/redia & cercaria wm (atlas 7.34, 7.37) [Fig 7.54]
mussel glochidia
nauplius barnacle wm
preserved: caterpillars, maggots, grubs, etc (atlas 7.91, 7.93) [Fig 7.128, 7.130]
tadpoles (atlas 2.11)

Cercaria are the free living immature stage of some parasitic flatworms. They swim from one host to another, often burrowing through the skin to infect the new host and complete the life cycle

Glochidia are larvae of freshwater clams that are parasitic on the gills of fish until they mature and fall to the sediment and begin life as freeliving clams. Note the large 'teeth' that they use to attach to their hosts.

Nauplii are the larval stage of many crustaceans such as shrimp, crabs, barnacles, etc. they are an important part of the plankton of oceans and lakes. Note the appendages used for swimming.

Caterpillars, maggots and tadpoles are examples of larvae that look and feed quite differently than the adults that they become (butterflies, flies, and frogs, resp.)

Nymphs: Nymphs are immature stages of animals that at least somewhat resemble the adult of the species and that live and feed independently

preserved: mayfly, dragonfly, stonefly nymphs (atlas 7.91) [Fig 7.128]

Fetus: In addition to embryonic development, vertebrates (higher animals) produce an immature stage that does resemble the adult but that is completely dependent on the mother for nutrition and protection.

preserved: misc vertebrate fetuses: human, shark, horse, etc
illustrations: human fetal development

C. Life Cycles

Life cycles vary tremendously among the kingdoms. Even some protists have rather elaborate life cycles. The life cycles of most eucaryotes typically include both **asexual** and **sexual** reproduction. Higher animals are an exception in that they only produce offspring by sexual reproduction. Many organisms reproduce sexually at one time of the year or under a certain set of conditions and sexually at other times of the year or under a different set of conditions thus producing a complex life cycle where asexual and sexual types of reproduction alternate. In some life cycles that involve an **alternation of generations** the form of the organism produced asexually varies considerably in size, shape and ecology from another form of the same species produced by sexual reproduction. The complete life cycle of such an organism includes both body forms to complete its cycle.

Ferns are good examples of plants that show alternation of generations. A tiny heartlike structure called the prothallium is the sexual stage of the fern. It produces egg and sperm. Upon fertilization the egg developes into the large, more familiar, fern plant. These large ferns reproduce asexually by spores.

slide: fern prothallium (atlas 6.51) [Fig 6.75]
preserved: fern fronds with sori [Fig 6.81]

Jellyfish are good examples of animals that show alternation of generations. A tiny, hydra-like polyp, rarely seen, asexually produces tiny jellyfish (medusae, ephyra) that grow into the large, more familiar jellyfish. The jellyfish produces egg or sperm. On fertilization the zygote once again becomes the tiny polyp stage [atlas 7.19-7.24]

slide: *Aurelia* scyphistoma wm [Fig 7.24]
Aurelia strobila wm [Fig 7.25]
Aurelia ephyra wm [Fig 7.26]
preserved: jellyfish (moonjelly, *Aurelia*) [Fig 7.27, 7.28]

Name:_____
Due date:_____

Ecosystems of Texas

Biol 1409

Ziser, 2004

Ecologically, Texas can be subdivided into ten distinct regions or ecosystems: Some of the major ones are: The **High Plains**, **Piney Woods**, **Cross Timbers**, **Praries**, **Edward's Plateau**, **Chihuahuan Desert** and the **Tamaulipan Province**. Each of these are characterized by a specific kind of soil type, rainfall, temperature range, and water availability among other distinctive characteristics. These physical, geological and chemical features result in distinctive plant communities for each region as well as characteristic animals and other organisms.

In this exercise you will use the internet and/or the library to familiarize yourself with the general features of each ecosystem as well as some of the kinds of living organisms that are **characteristic** of each. Some of this information will be relatively easy to find, other types of information may be more difficult (but not impossible) to come by. You will have until Monday, July 15, to complete this report

I. Abiotic Factors

Complete the table below by describing the most distinctive and important ***abiotic*** characteristics of each of the Texas vegetative regions (some references will use different names for these regions but you should be able to figure them out by looking at a Texas map of the regions):

Some Natural Region of Texas	Major Abiotic Characteristics
High Plains	
Piney Woods	
Cross Timbers	
Blackland Prairie	
Edward's Plateau	
Trans Pecos	
South Texas Plains	

II. Biotic Components

Now find one or two examples of living organisms that are found in each of the categories listed in the attached table for the central Texas ecoregions. Write their common or scientific name in the table. The organisms you list must be, as much as possible distinctive and characteristic for the region; in other words, try to find things that are only found in one region and not in the others.

	Cross Timbers	Blackland Prairie	Edward's Plateau
Bacteria			
Fungus			
Protozoan Protist			
Algal Protist			
Herb or Flower			
Tree or Shrub			
Insect			
Other Invertebrate			
Fish			
Amphibian or Reptile			
Bird			
Mammal			

III. Summary of Texas' Natural Regions

Finally, write a short summary of ***how the regions differ*** from each other in such things as climate, diversity of habitats, diversity of plant and animal life and similarity. Stress the differences rather than the similarities of each.

The Bacteria

Collecting & Identifying Bacteria

Biol 1409 Lab

Ziser, 2004

Bacteria are ubiquitous in the environment. They play a major role in biogeochemical cycling and are of major economic and medical interest because of the diseases they can cause in plants, animals and humans. Individual bacteria are sometimes difficult to see even with a microscope. Anatomically, the size and shape of individual cells shows little diversity, even the two *Kingdoms* of procaryotes are difficult to distinguish from each other under the microscope. But biochemically, bacterial species show a greater diversity than members of any of the other kingdoms of life. Because of their small size and the difficulty in distinguishing between the 1000's of bacterial species, their study requires us to try to culture them in the laboratory in order to determine their biochemical characteristics.

Many bacteria can be grown on artificial media that contains the essential nutrients they need for their metabolism. Bacteria are generally collected using various types of **enrichment** and **selective** culture media. Enrichment media act like fertilizers to encourage their rapid growth. Selective media contain **inhibitors** which prevent some species from growing while allowing others to thrive. But not all bacteria will grow on artificial culture media. Therefore, any environmental collection generally does not include *all* the bacteria that might be present. Only those that grow on such media can be cultured and identified. Once an environmental sample has been collected the next step is to make a **pure culture** of individual bacterial species. A pure culture is one that contains only a single bacterial species. This is done by special streaking techniques that separate out individual cells on an agar plate. Each colony that develops on such plates grows from individual cells and is therefore a pure culture of a single species of bacteria.

Once a **pure culture** is achieved, individual species of bacteria can be identified using **colony culture characteristics**, **bacterial morphology** (the size, shape and arrangement of individual bacterial cells), and **biochemical characteristics**. Slides are made and special stains are used to elucidate the size and shape and any unique structures (flagella, capsules, spores) produced by the species; Colonies of pure cultures are described in terms of their **colonial morphology**. This involves an analysis of their size, shape, color and other macroscopic features. Wet mounts are made from pure cultures and stained to determine the **microscopic morphology** of individual groups of cells and their staining characteristics. Probably the most important stain in microbiology is the Gram stain in which differences between the cell walls of bacteria cause some to stain red (**Gram negative**) and another group to stain blue (**Gram positive**). Finally specialized **differential** media are used to determine some of the metabolic pathways used by the microorganism. Such media contain one or more specific nutrients and some kinds of physical or chemical **indicator** to determine whether the nutrient is being utilized or which end products are being formed. The indicator causes a change in color or some other easily observed property when a specific nutrient is utilized.

We will not attempt to make pure cultures or to identify each species of bacteria. This process could take a week or more for a single species of bacteria. In this exercise you will collect mixtures of bacteria and grow them on several types of media to see some of the kinds of colonial forms and a few of the biochemical reactions that the colonies produce. You will also make a slide and stain your bacteria to observe their shapes, groupings and relative sizes.

You will also be looking at a variety of prepared slides and fresh material to get an idea of the diversity of bacteria and to learn a little about their importance to us. While you don't have to recognize anthrax or syphilis on sight you should be able to describe the basic shapes of cells or give some examples of the pathogens that you look at or the economic importance of other organisms that you view. You might want to make some sketches of what you look at to help you remember it.

Lab Objectives:

- Be able to recognize these organisms as procaryotes (ie. bacteria)
- Be able to distinguish cyanobacteria (blue green bacteria) from other types of bacteria
- Be able to name and describe a few examples of bacterial diseases
- Be able to list some of the "economically important uses" of bacteria by humans

- Be able to distinguish between the three basic shapes of bacterial cells and the common groupings of cells
- Be able to describe how bacteria are cultured and the kinds of media and characteristics used to identify them

Culture Media:

Nutrient Broth Tube
Nutrient broth is an enrichment medium with the same composition as nutrient agar but without the solidifying agent

Thioglycollate Broth Tube
This culture medium contains special chemicals that remove oxygen from the broth and an indicator to show if and where oxygen is present. Generally aerobic bacteria grow at the surface, anaerobic bacteria grow toward the bottom, and facultative (can anaerobic or aerobic respiration) grow throughout the broth.

Nutrient Agar (NA) and Tryptic Soy Agar Plates(TSA)
Nutrient agar and tryptic soy agar are general enrichment media on which a wide variety of bacteria can grow

Mannitol Salt Agar Plate(MSA)
This is a selective medium, the salt in this agar prevents the growth of bacteria that are particularly sensitive to high concentrations of salt. It is also differential in that mannitol is a nutrient that is able to be used by some bacteria as a food source. The agar also contains a chemical indicator, phenol red, which turns yellow if the mannitol is being metabolized by the colony of microorganisms.

MacConkeys Agar Plate(MAC)
This agar also contains a relatively high concentration of salt and other inhibitors which prevent the growth of some bacteria while allowing others to grow. The medium also contains lactose, a sugar used by many species of bacteria as an energy source. The agar contains the indicator neutral red which turns the colonies pink or purple if the lactose is being utilized by a colony.

Procedure:

This lab exercise will be spread over two lab periods. In the first period you will collect your initial cultures . In the second lab you will prepare and stain slides of your samples and determine some of their biochemical characteristics. You will use any additional time in both labs to look at preserved slides and other materials that illustrate the diversity of bacteria.

CAUTION: Bacteria are opportunistic, that is, given the opportunity, they may be capable of causing an infection. Follow safety procedures as outlined by your instructor when handling living bacterial cultures.

Lab 1

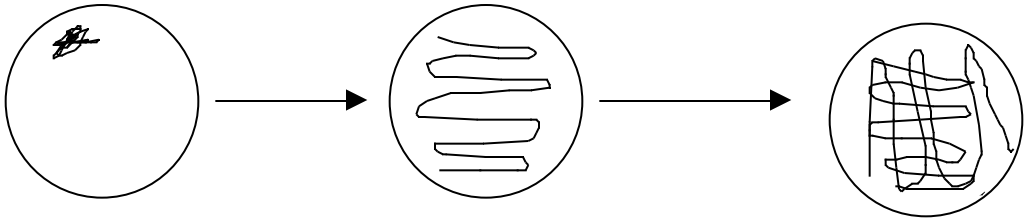
A. Collecting Bacterial Samples

1. Take one of each of the three types of agar plates and "expose it" to likely sources of bacteria or use the sterile swab to brush some of the sample onto the plate. This should be easy since bacteria are literally everywhere. Your instructor will offer some suggestions. Only open the lid long enough to deposit your sample then cover the agar plate immediately. Try to get samples as suggested below:
   - NA/TSA any kind of sample will do
   - MSA take a sample from yourself, or things commonly touched by humans
   - MAC Take samples from soil or areas where birds or other animals congregate

2. Take the tubes of nutrient broth and thioglocyllate broth and 2 sterile swabs outside of the building.

Use the swab to collect a **small amount** of soil and drop it into each tube.

3. Return to the lab and for each plate, take a sterile swab and spread the sample by dragging the swab in a "zig-zag" motion across the plate, turn the plate 90º and repeat the process – this should disperse the bacteria you have collected across the entire plate and make it more likely that you will get at least some individual colonies. As you finish with each plate, discard the swab in the biohazard bag.



4. Use a sharpie to label your plates and tube with your name or initials and the type of sample you collected.
   Then tape your three plates together with masking tape and place them, ***upsidedown,*** on the tray at the instructor's table
   Place the tube of nutrient broth in the test tube rack on the same tray

5. The instructor will incubate them for a couple of days. In the next lab you will describe the colonies and observe microscopic characteristics

6. Dispose of all used swabs and tongue depressors in the biohazard bag provided

B. Bacterial Shapes and cell arrangements:

slides: Bacteria types, wm
Gram positive coccus
Rhodospirillum rubrum
bacterial capsules

1. Review the slide of the three types of bacteria and be able to distinguish between the three major shapes of bacteria. Also note any characteristic arrangements or groupings of these cells and the other bacteria you will look at in the lab. Use the illustrations provided in lab to describe these arrangements.

2. Review the slide of bacterial capsules. Some bacteria are able to secrete a thick jellylike layer around each cell for either protection or the help them attach to a substrate.

C. Bacterial Pathogens

Most of our knowledge of and experience with bacteria are in the form of human pathogens. Observe the slides listed below as examples of human pathogens:

slide: ***Bacillus anthracis*:** the bacterial agent responsible for anthrax.
slide: ***Mycobacterium tuberculosis*:** the bacterium responsible for causing tuberculosis
slide: ***Treponema pallidum*:** the agent responsible for syphilis

D. Economically Important (nondestructive) Bacteria

1. *Rhizobium* is an example of a mutualistic bacterial species. These species are able to utilize the gasseous nitrogen (N_2) as a nutrient to manufacture proteins and other essential organic molecules that few other organisms are able to metabolize nitrogen in this form. The bacterium infects the roots of certain plants including string beans, peas, alfalfa, clover and other legumes and form root nodules. The symbiotic bacteria receive organic foods from the plant in exchange for nitrogen in a form the plant can use. This allows the plant to grow in poorer soils or with less fertilizer than that needed by most other plant species

slide: ***Rhizobium meliloti***

display: note root nodules on the bluebonnet plant on display in the lab

2. yogurt

Yogurt is a milk product produced by fermenting the milk with a species of Lactobacillus. This process produces acids which helps to give yogurt its unique flavor.

slide: **Yogurt smear**

E. Cyanobacteria (=Blue-green bacteria)

Blue-green bacteria are some of the oldest forms of life to appear in the fossil record. They were some of the first organisms to do photosynthesis and were largely responsible for generating free oxygen in earth's early atmosphere. Today, cyanobacteria are important autotrophs in soils and aquatic ecosystems where they sometimes form dense "blooms". Many of the blue green bacteria form long filaments of cells.

live: cyanobacterial mixed culture
Anabaena sp.

slide: ***Oscillatoria*, wm** (atlas fig 3.6, p26) [Fig 3.20,3.21]

slide: ***Nostoc*** (atlas, fig3.2, p25) [Fig 3.19]

Lab 2

A. Identification of Bacteria (second lab period):

Three major types of identification techniques will be presented:

microscopic morphology
colonial morphology
biochemical testing

1. Make a wet mount of a drop from the nutrient broth tube by placing a drop directly on a slide, covering with a cover slip and viewing under the microscope

2. Use the available illustrations to describe as many of the different kinds of colonies on each of your agar plates as you can detect and record your results in the table provided on your data sheet

3. Record whether any of the colonies on the MSA plate are utilizing the mannitol. Also, record whether any of the colonies on the MacConkeys plate are utilizing the lactose. Describe your results on the data sheet.

4. Make a wet mount of the most interesting colonies from each plate. Remember to use aseptic techniques; keep lids on plates, do not lay lids on tabletop, etc:
   a. place a drop of water on a slide
   b. use a toothpick to scoop up some of a colony and stir it into the drop of water
   c. place slide on a *warm* hot plate or in the incubator to allow the water to evaporate
   d. when the slide is completely dry remove it from the hot plate
   e. dip the slide in a staining jar of methylene blue and leave for 30 seconds
   f. remove from the staining jar and place the slide in deionized water for another 30 seconds
   g. remove the slide and place between folds of a paper towel and blot dry. Do not rub the slide to dry it since this will wipe off your bacterial smear

5. View the slides under the microscope and draw and describe the microscopic morphology using the illustrations provided.

6. When you are finished working with your bacterial cultures discard the plates in the autoclave bag, place the tube of broth back in the test tube rack, and spray down your work area with disinfectant.

Name:_____
Date Due:_____

Summary of Colony Characteristics
Lab Data Sheet

1. Estimate the number and kinds of different colonies growing on each of your agar plates:

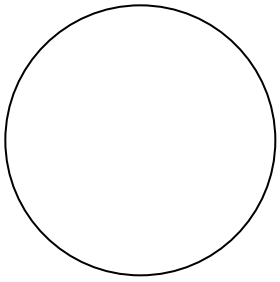
Source of Sample	plate	Est # of colonies	Est kinds of colonies	
	NA/TSA			
	MSA			can any colonies metabolize mannitol? _____
	MAC			can any colonies metabolize lactose? _____

2. Measure and describe up to 5 different kinds of **colonies** that you find on each of the plates that you incubated (use descriptive terms from the handout provided:

plate/ source	color	diameter (mm)	form	elevation	margin
NA/ TSA source:					
MSA source:					
MAC source:					

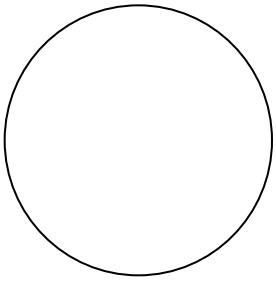
Microscopic Morphology

Draw some examples of bacterial **cells** in each of your plate cultures in the circles below. Beneath the circles, indicate the total magnification that you used to view the cells



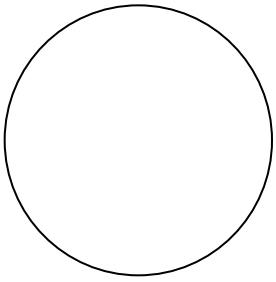
Magnification:_____

from NA colony



Magnification:_____

from MSA colony



Magnification:_____

from MAC colony

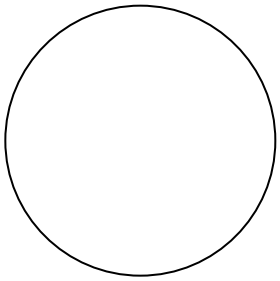
Now, **describe** the **microscopic morphology** (shape and arrangement of individual bacterial cells) that you drew above. Use terms from the handout provided

NA Plate:

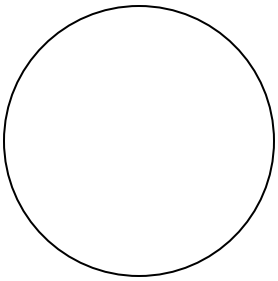
MSA Plate:

MAC Plate:

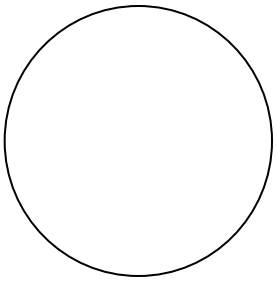
Draw some examples of the different kinds of bacteria that you found in the **nutrient broth** & **thioglycollate broth**. Beneath the circles indicate the total magnification that you used to view the bacteria.



Magnification:_____



Magnification:_____



Magnification:_____

Could you see any of the bacterial cells actually moving? **Describe** any kinds of movements that they were making.

Use the spaces below to illustrate any additional bacteria that you looked at from **your cultures** and **prepared slides**. Label drawings and indicate the magnification used to view & draw each:

Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**

The Protists
(Algae, Protozoa, Slime Molds)
Bio 1409 Lab

Ziser, 2004

Most protists are **unicellular eucaryotes** having a variety of organelles including a **nucleus**. Photosynthetic forms contain **chloroplasts**. These organisms are abundant in most aquatic habitats where they form an important part of the **plankton**. Other protists are found in soil and other non-aquatic environments. The "kingdom" Protista includes a diverse assemblage of simple, single celled or **colonial** eucaryotes. They are roughly subdivided into three major groupings: the plant-like **algae**; the animal-like **protozoa**, and the **slime molds** and fungus –like protists. You will be examining representative slides and some live and preserved specimens of each major 'subphylum' of protist.

I. The Algae: plant-like protists

Most algae are aquatic, either freshwater or marine and comprise an important part of the **phytoplankton**, but some are also found in soil, on tree trunks, bare rock and in ice and snow . The algal protists all carry out **photosynthesis**, and most have a **cell wall**, often of **cellulose**. However most species of algae are **unicellular** or simple colonial forms. A few form large **seaweeds** 100's of feet long, but even these **do not have true tissues** or organs as do true plants. In addition, the algae have a much more diverse array of **photosynthetic pigments** which gives some of the groups their names. They also have cell walls composed of a wider variety of materials than do plants, also, unlike plant cells, Many common algae form filaments of cells joined end on end. Other unicellular algae are motile with flagella or gliding movement.

Algae occur as single-celled or small colonial forms and as larger seaweeds. There are three major groups of mainly single celled algae. There are two major groups of seaweeds. One algal group consists of both single celled forms and larger "seaweeds". The algae can be further subdivided into **phyla** based on the characteristics of their cell walls and the types of photosynthetic pigments that they use:

The fire algae (dinoflagellates or pyrrhophyta)
: the cell wall consists of cellulose plates fused into a rigid armor producing a distinctive shape often with several spinelike processes; sometimes produce toxic 'red tides'

The diatoms (glass algae or chrysophyta)
: the most abundant group of algae, the highly symmetrical and often intricately sculptured shells are impregnated with silica;

The euglenas (euglenophyta)
: members of this group lack a cell wall and have flagella and are therefore more protozoan like but they do carry out photosynthesis; often in very eutrophic waters

The red algae (rhodophyta)
: a group of seaweeds most common in warmer tropical waters; include the coralline algae

The brown algae (phaeophyta)
: mostly marine group of cooler rocky shores; some approach plants in structural complexity having specialized structures for anchoring, buoyancy, photosynthesis and reproduction

The green algae (Chlorophyta)
: by far, the most diverse group from single celled forms to colonial to large multicellular seaweeds

II. The Protozoa: animal-like protists

The protozoa inhabit a diverse array of habitats including freshwaters, saltwaters and soil. The protozoan protists exist as single celled or as colonial forms, they **lack a cell wall** but some secrete a shell-like covering of silica, calcium carbonate or a flexible pellicle. Many protozoa have complex and **specialized organelles** within their cells that perform a variety of functions but the protozoa are heterotrophs and therefore do not have chloroplasts. The protozoa are classified mainly according to how or if they move: using either **cilia, flagella, amoeboid motion, or being nonmotile**. Many have formed **symbioses** with other species. Some of the parasitic forms have rather elaborate life cycles and are of special concern. The major groups (phyla) of protozoa are:

The amoebas
: protozoa that move using amoeboid motion in which they creep along extending 'false-feet' or pseudopodia

The flagellates
: protozoans that move using one or more long whiplike flagellum

The ciliates

protozoa that move using numerous short cilia as paddles. Some are on stalks which attach to the substrate and use their cilia to create water currents for feeding

The apicomplexans

all are parasitic with complex life cycles involving several stages, both sexual and asexual reproduction, and often more than one host. they are nonmotile protozoans

III. The Slime Molds and Water Molds: fungus-like protists

This small group of organisms includes some of the most interesting, but hard to observe, protists. Some grow fungus-like fruiting bodies and reproduce by spores but also spend part of their life cycle as protozoan like single celled organisms. Other member form more traditional fungus-like hyphae and fruiting bodies.

«««««« »»»»»»

Lab Objectives:

- recognize both living and preserved members of the kingdom
- recognize and classify protists into their major "subphyla"(eg. algae, protozoa, or slime molds) from various samples of pond, lake and river water samples
- categorize both living and preserved members into these three major groupings
- recognize and identify organelles and structures as indicated and describe the function of each
- describe the way members of the three different groups move
-describe and distinguish between some of the different kinds of protozoa, algae and slime molds.

Lab Activities:

You **do not** need to be able to distinguish the various phyla of the protists in lab, but you should be able to recognize whether the specimen you are viewing is an **alga**, a **protozoan** or a **slime mold**. You should also try to locate and identify the various **organelles** and structures listed below. The prepared slides and live specimens are listed under the group to which they belong.

When viewing the live specimens make a wet mount first and look at each. Then, if necessary, make another slide using the "detain" if you need to slow an organism down to see it better

These tables are only given to help you organize the slides and live specimens you will be viewing. You do not need to individually identify species or even phyla of protists.

1. Observe the living specimens
2. Compare the living organisms to prepared slides of the same organism; how are they similar? how do they differ?
3. Note their means of locomotion, how they move, how fast they move
4. Did you observe any feeding activity in the live protozoa?
5. How many different kinds of organelles could you find in the live algae and protozoa? In the prepared slides?
6. You might want to make a table that describes each major group and add illustrations of representative organisms for each

I. Algae

A. The fire algae

organism	live	slide	atlas
dinoflagellates		x	
Peridinium		x	4.7 [4.17]

1. Recognize various examples of the group
2. Note the 'armor plating' of cellulose plates
3. Try to find the flagella

B. The diatoms

organism	live	slide	atlas
mixed fw diatoms		x	[p34]
marine diatoms		x	[p34]
Synedra	x		

1. Recognize various examples of the group
2. Note the intricate geometric patterns on the glass 'shells' of the organism

C. The euglenas and the unicellular and colonial green algae

organism	live	slide	atlas
Euglena	x	x	4.16-19 [Fig 4.25]
Volvox	x	x	4.25-28 [Fig 4.41,4.42,4.43]
Oedogonium	x	x	4.32-35 [Fig 4.54]
Spirogyra	x	x	4.37-38 [Fig 4.61]
Chlamydomonas	x		4.23 [Fig 4.35]
Ulothrix		x	4.30-31 [Fig 4.48,4.49]
Chlorella	x		
Closterium	x		4.40 [Fig 4.70]

1. Recognize various examples of the group
2. Identify the following structures in *Euglena*:: **flagellum, nucleus, chloroplast, absence of cell wall**
3. Identify the following structures in *Volvox*: this is a **colonial form, cells of colony, flagella, daughter colonies**
4. Compare these algae to the examples of blue-green bacteria available: *Anabaena* and *Oscillatoria*

D. The seaweeds

organism	slide	preserved	atlas
limeweed, *Corallina*		x	
Irish moss, *Chondrus*		x	
Laminaria		x	4.45 [Fig 4.83]
giant kelp, *Macrocystis*		x	[Fig 4.82]
rockweed, *Fucus*	x		4.50-54 [Fig 4.89]
Gracilaria		x	
Sea lettuce, *Ulva*		x	4.42 [Fig 4.74]
Nemalion		x	
gulfweed, *Sargassum*			4.45-49 [Fig 4.86]

1. Recognize various examples of the group
2. find the following structures in the appropriate specimens: **blade, stipe, holdfast, air bladder** (see atlas p4.45)

II. Protozoa

A. The flagellates

organism	live	slide	atlas
termite flagellates	x		
Trypanosoma		x	4.15 [Fig 4.24]

1. Recognize preserved and living representatives of this group
2. Locate and identify the flagellum

B. The amoebas

organism	live	slide	atlas
Amoeba	x	x	4.9-10 [Fig 4.19]
radiolarians		x	
foraminiferans		x	

1. Recognize preserved and living representatives of this group
2. Identify the following structures in *Amoeba*: **nucleus, food vacuoles, pseudopodia, ectoplasm, endoplasm**
3. Observe and be able to describe the movement in living specimens
4. Distinguish between radiolarians and foraminiferans

C. The ciliates

organism	live	slide	atlas
Paramecium	x	x	4.19-.20 [Fig 4.29]
Stentor	x	x	[Fig 4.34]
Spirostomum	x		
Paramecium fission		x	4.22 [Fig 4.31]
Paramecium conjugation		x	[Fig 4.32]

1. Recognize preserved and living representatives of this group
2. Identify the following structures in *Paramecium*:: **macronucleus, micronucleus, pellicle, cilia, oral groove, contractile vacuoles**
3. If possible observe feeding behavior of *Paramecium* and *Didinium*
4. If possible observe the "startle response" in *Vorticella*
5. Distinguish between the two major types of reproduction in *Paramecium*: asexual reproduction = **fission**, and sexual reproduction = **conjugation**

D. The non-motile parasitic protozoa

organism	live	slide	atlas
Plasmodium		x	[Fig 4.107-4.113]

1. Recognize various stages (but you don't need to name each stage) in the life cycle of *Plasmodium*, the malaria parasite

III. Slime Molds and Fungus Like Protists

1. Recognize various examples of the group from illustrations in lab and in text and any live specimens that might be available

«««««« »»»»»»

<u>Review Questions:</u> Answer these questions on a separate sheet and attach it to your Protist Data Sheet

1. In what ways do protozoa differ from animals
2. In what ways do algae differ from plants
3. In what ways do slime molds differ from fungi?
4. How do photosynthetic bacteria differ from the algae?
5. Make a table of all 3 groups of protist; describe the major characterisitcs of each and use some sketches to illustrate how they differ from each other.
6. List the best ways that YOU can figure out to distinguish between the three major kinds of protists and how to distinguish the algal protists from the blue green bacteria.

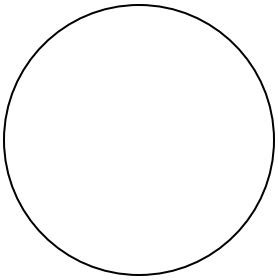
Name:_____
Due Date:_____

The Protists

Data Sheet

Make some illustrations of examples of the each of the three major groups of protists. Then describe how each group differs and how you can recognize and distinguish each from the other kinds of protists under a microscope or hand lens.

I. The Algae



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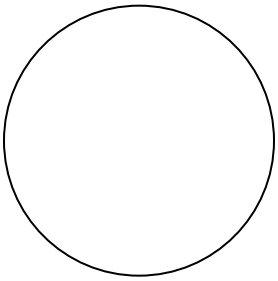

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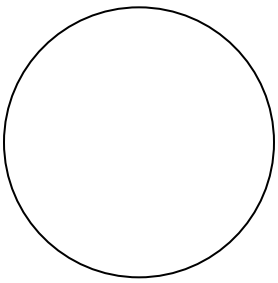

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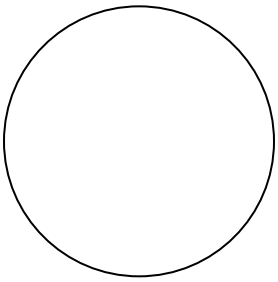
Descriptions of Algae (including seaweeds)

II. The Protozoa



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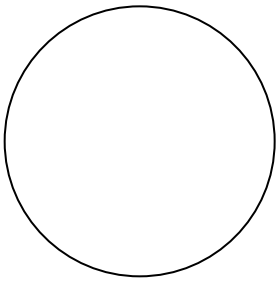

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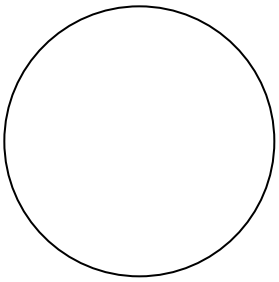

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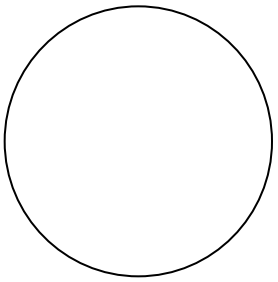

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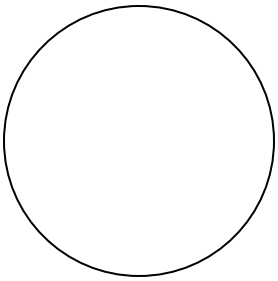

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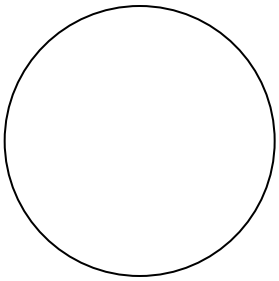

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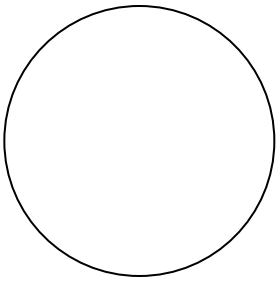

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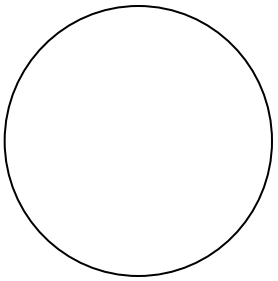

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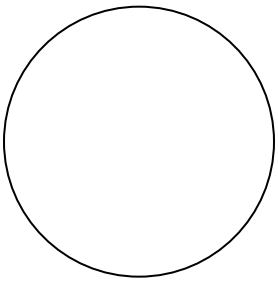
Name:_____

Description of Protozoa:

III. The Slime Molds



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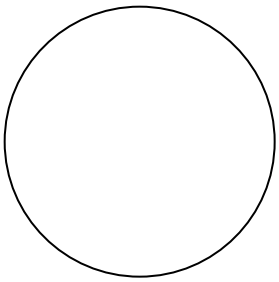

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Description of Slime Molds:

The Fungi
The Simplest Multicellular Eucaryotes
Biol 1409

Ziser, 2004

The fungi belong to one of the three **multicellular eucaryotic** kingdoms of life and in terms of their structure, are the simplest of the three. The kingdom includes **yeasts** and **molds**. Their **nonmotile** nature (except for one small group) and the fact that many grow from the ground and seem to have rootlike and stemlike structures causes many to think of them as plants. However they are not autotrophs, they do not carry out photosynthesis; they are actually more animal-like in their eating habits, since they are **heterotrophs**. While there are some predatory and parasitic forms, most feed on decaying organic matter. Most of us are familiar with members of the kingdom in the form of mushrooms, bracket fungi, various molds and mildews, and the common "ringworm" and yeast infections of humans.

Most fungi are near the "tissue-level" of organization being comprised of several types of cells but only very simple structures, such as **fruiting bodies**, that somewhat resemble organs, mainly used for reproduction. Some fruiting bodies are microscopic in size, others are the more familiar mushrooms and toadstools. In most, the major part of the fungus body consists of cobweb like strands of cells called **hyphae** that permeate the soil or rotting log or other organic matter on which they feed. A group of hyphae from a single individual are referred to as the **mycelium**. Fungi reproduce by both **sexual** and **asexual spores** and most have a relatively complex life cycle that involves the alternation of sexual and asexual stages.

In this exercise you will:

- Collect and culture fungi from spores using a culture medium called Sabaraud's Agar which is selective for fungi.
- Collect some larger fruiting bodies locally and identify the group to which each belongs
- Use the cultures that you grow to study the basic anatomy of the organisms
- Learn the names of some of the sexual and asexual spores and the structures in which they are produced
- Learn to recognize the general characteristics of some of the major types of the more familiar fungi and symbiotic fungal associations

I. Familiar Fungi: Mushrooms and Relatives

1. Study the fresh or preserve mushrooms, these are the 'fruiting bodies' of fungi. Identify the **cap** (pileus), **ring** (annulus), **gills**, **stalk** (stipe), and **cup** (volva) if present.

2. The Diversity of Fungi:
   View any additional slides, fresh specimens or preserved fungi available.
   Be able to identify some of the common types of fungi including:

Molds – includes Penicillium, a mold common on citrus fruits and the original source of the first antibiotic

Mildews – grow on moist walls, leather, and a variety of plants where spores appear as a white powder

Morels and Truffles – are considred by some to be among the tastiest of the edible fungi. The fruiting body of morels grows above ground while that of truffles grows below ground.

Mushrooms and toadstools – numerous edible as well as toxic and hallucinogenic species which are often difficult to distinguish from one another

Rusts and Smuts – parasites of higher plants with great economic impact on crop species

Jelly Fungi – gelatinous and most visible when wet

Puffballs – sometimes very large spherical fruiting bodies that emit massive clouds of spores when broken

Shelf Fungi – fan shaped brackets or shelves that grow on tree trunks or rotting logs, they lack a stalk, some are woody

1. Make some labeled sketches of the live molds and prepared slides that you look at indicating the various structures and different kinds of spores that fungi produce
2. What is the difference between a yeast and a mold?

3. Do yeasts reproduce sexually?

II. Collecting and Preserving Fungi:

Use the **Sabaraud's agar** plates to collect samples in order to grow fungi. This agar is selective for molds and yeasts and discourages the growth of bacteria.

If you want to investigate other fungi you can search your yard and nearby parks for different kinds of fungi; they are easiest to find a few days after a rain but some can also be found almost anytime growing on rotting wood, or in very rich organic soil. You may even find some in your indoor plant pots.

Another good source of fungi is stale bread, old fruit, or various kinds of parasitc fungi on both indoor and outdoor plants.

Collect mushrooms using a trowel or knife to 'dig out' the mushroom from its substrate. Some structures need for identification are at the very base of the stalk (stipe); if you just pull it up you may not get these parts.

Place your specimen in a box or paper bag (not a plastic bag) and allow it to dry. A light box will speed the drying process.

If you have a camera with a macro lens or a fairly good closeup lens you can try photographing them instead. But you will need good, crisp photographs at fairly close range to have any hope of identifying them accurately.

If you find mushrooms you might want to attempt to make a spore print. Spore prints can provide a permanent record of the gill pattern and spore color of the larger fungi:

Remove the stem by cutting it close to the cap.
Place the cap, gills down, on a white sheet of paper (some spores are white or light colored and would appear in better contrast on a darker color of paper).
Cover to prevent air drafts and leave undisturbed for several hours or overnight
Spray the finished print with clear laquer or fixative and label it

III. Observing Living Fungal Cultures:

1. Observe the demonstration plates of mold and compare to the plates you made.
2. Observe your fungal cultures and attempt to count the total number of colonies and the number of different fungal colonies.
3. Notice that each colony is made up of a matlike clump, the **mycelium**, of thin, whitish, threadlike **hyphae**.
4. Notice also that some colonies have darker colored areas in their centers that may be green, brown, black or some other color, these are the **spores**.
5. how many different kinds of colonies can you recognize
6. Place the plate under a dissecting scope to see if you can distinguish between the different colonies, can you recognize different kinds of fruiting bodies and spores
7. Take a scalpel and cut out a tiny piece of the mycelium, for now, try to avoid the spores.
8. Use forceps (tweezers) to pick up the small piece and place it in a drop of water on a slide to make a wet mount. Cover it with a cover slip and view it, describe it and draw what you see.
9. Repeat the procedure with several other mycelia on the plate and compare them with the first; are there any differences between the hyphae of the different colonies?
10. Now cut a small piece of colony, this time trying to get some of the spores as well as part of the mycelium and view it under the microscope. Draw and describe what you see.
11. Repeat with several other colonies that have different colored spores.
12. Compare the spores and 'sporangia' (a general term for any structure that contains spores) to the photographs in your atlas and try to identify the specific kind of spore; is it a sexual or an asexual spore?

IV. Prepared Slides:

Rhizopus sporangia wm
Morchella sec
Penicillium conidiophores sec
Peziza apothecium
Rhizopus conjugation
budding yeasts wm
Coprinus, mushroom cs

1. Study the prepared slides and attempt to distinguish between **asexual and sexual spores**. The table below indicates which spores are for sexual reproduction and which are for sexual reproduction. It also lists some of the fruiting bodies that produce these different kinds of spores and a reference to illustrations in your atlas.
2. Also observe the process of budding in the yeast cells. **Yeast** are single-celled fungi that reproduce asexually by budding.

Prepared Slide	Fruiting Body	Type of Reproductive Hyphae	Type of Spore	Atlas Figure
Asexual Reproduction				
Budding yeast	_____	Buds rather than spores	_____	5.7
Rhizopus sporangia	_____	sporangia	sporangiospores	5.2-4 5.3-5.5
Penecillium conidiophores *Peziza* apothecium	_____	conidiophores	conidiospores	5.15-17 5.20,5.23
Sexual Reproduction				
Rhizopus conjugation	_____	_____	zygospores	5.2,5.5-6 5.6-5.8
Morchella sec	cups, morels, saddle fungi, staghorns Fig 5.41	asci	ascospores	5.12 5.16
Coprinus mushroom cs	mushroom, shelf, toadstools Fig 5.25	basidia	basidiospores	5.22 5.30

V. Symbiotic Fungi

Some of the most important fungi are those that occur in symbioses with other lifeforms. Lichens and Mycorrhizae are examples of these symbioses

A. Lichens

Lichens are organisms that grow on rocks, trees, or soil and are often mistaken for some kind of moss. In fact, they are a symbiotic association between a fungus and either an alga or a cyanobacterium. Until recently this association has been described as mutualistic, where both species benefit. The algal or bacterial symbiont gets a protected environment, shading from intense sunlight, and protection from herbivores. The fungal symbiont gets free food in the form of sugars made by the photosynthetic algae, and, in the case of a cyanobacterial symbiont, a nitrogen supply since these are nitrogen fixing bacteria.

Because of these advantages, lichens are found in habitats where neither fungi nor algae would typically be able to survive. Many lichens are "pioneer species" on new rock and soil and some can tolerate severe cold. In dry desert conditions the lichen organisms can drastically slow their metabolism and "wait out" the dry spell, increasing their metabolism again when wet conditions return. In deserts, some of these slow growing lichens can be over 1000 years old!

More recent studies indicate that the fungal/algal association may not be equally beneficial to both types of organisms. Some algae found in lichens are found living freely in other habitats, however the fungal component of a lichen cannot apparently survive naturally on its own and may actually be weakly parasitic on the algal cells.

Because of this closely interdependent association of the two organisms, lichens are treated as separate species and given their own binomial names. So far, over 25,000 species of lichens have been described. Classification is based on the type of reproduction shown by the individual fungal and algal species; the characteristics of the soredia – a reproductive structure characteristic of lichens (atlas, p56); and the growth form of the lichen. Lichens exhibit three types of growth forms (Atlas, p55):

crustose - thin attached sheets growing over rocks and bark, etc
foliose - flattened, leaflike growths lifting off of the substrate
fruticose - shrublike or bushlike growths protruding from the substrate

1. Observe the following slides of lichens and compare to the illustrations in your atlas (fig 5.27-30) [5.39-5.48].

slide: *Physcia* thallus sec.
Lichen Ascocarps sec.
Note the fungal layers, the filamentous hyphae and the algal cells embedded in the fungus just below the upper layer.

Also not the fungi of the lichen association can reproduce independently by forming ascospores (a type of sexual reproduction). locate and identify the asci and ascospores if present.

2. Attempt to identify several lichen specimens by visiting the websites below
http://mgd.nacse.org/hyperSQL/lichenland/
http://www.ucmp.berkeley.edu/fungi/lichens/lichens.html
http://www.lichen.com/

These sites have photographs, identification guides and keys to help you identify them.

3. Study the websites and your text and write down and define some of the terminology used to describe and identify lichens:
4. Describe several different lichens then attempt to identify them using the websites provided or others that you have found.
5. Describe some of the economic values of lichens to human activities?

B. Mycorrhizae

Mycorrhizae are a symbiotic association between fungi and plant roots. The fungal hyphae grow within and on the surface of the root and root hairs and increase the surface area of the root thus making the plant more efficient at absorbing water and minerals from the soil. In return, the plant supplies the fungus with sugar which it uses for energy. Almost all seed plants have fungi associated with their roots. Most of the mushrooms and toadstools that appear after rain are the fruiting bodies of these fungi. Plants grown in the absence of these fungi appear smaller and less healthy.

1. view the slide below and distinguish between the fungus and the plant tissues

slide: endotrophic mycorrhizae, cs

2. What benefits do the two organisms get out of the relationship.

Name:_____

Due:_____

The Fungi

Data Sheet

Make some rough sketches and descriptions of the mycelia and fruiting bodies that you can see ***without a microscope***. Be sure to look at both fresh and preserved forms of fungi on display in the lab or that others have brought in. Can you determine to what group of fungi each belongs?

Common Name:

Description:

Common Name:

Description:

Common Name:

Description:

Common Name:

Description:

Common Name:

Description:

Common Name:

Description:

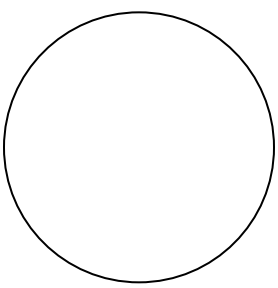
Look at your Sabaraud's Agar Plates and count the:

a. **total number** of mold colonies: _____

b. number of **different kinds** of mold colonies: _____

Describe (size, color, color of spores, unusual features, etc) some of the **colonies** that you see on the plate:

View the **slides** you made of your live fungal specimens and sketch and describe the fruiting bodies and spores from the colonies you collected. Can you identify the specific kinds of fruiting bodies (compare to illustrations provided)? If so indicate what kind of spore it is and which group of fungi probably produced it based on lab and lecture information.



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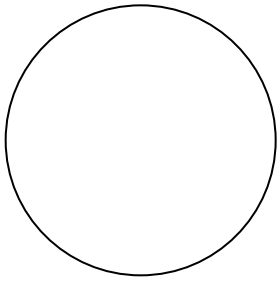

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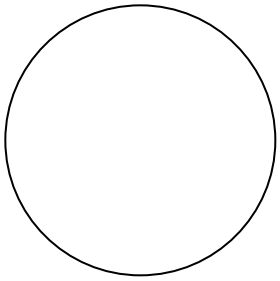

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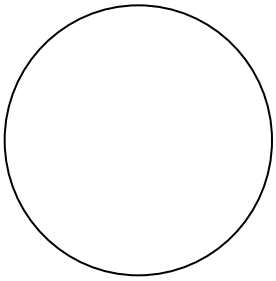

Magnification:_____

Describe the **microscopic appearance** of hyphae and spores from colonies on your SAB Plate, can you tell if the spores are **asexual** or **sexual**? Explain

Look at the various kinds of **prepared slides** and demonstration plates. See if you can determine what kind of spore and fruiting body each has produced (if any) by comparing what you see to the prepared slides and illustrations provided. Sketch and label the various kinds of **asexual** and **sexual spores**. Indicate the magnification you used and the kind of spore below each of your illustrations

Magnification:__________	**Magnification:**__________	**Magnification:**__________	**Magnification:**__________
Kind:_____________	**Kind:**_____________	**Kind:**_____________	**Kind:**_____________
Magnification:__________	**Magnification:**__________	**Magnification:**__________	**Magnification:**__________
Kind:_____________	**Kind:**_____________	**Kind:**_____________	**Kind:**_____________
Magnification:__________	**Magnification:**__________	**Magnification:**__________	**Magnification:**__________
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Kind:_____________	**Kind:**_____________	**Kind:**_____________	**Kind:**_____________

Describe and **sketch** the different kinds of lichens on display. label their form as crustose, foliose or fruticose using the descriptions provided.

Describe some of the human benefits of lichens and mycorrhizae.

The Plant Kingdom:

Biol 1409 Lab

Ziser, 2004

The Plant Kingdom includes multicellular organisms with true tissues and organs. Common examples are mosses, ferns, spruce & pine trees, cycads, grasses and flowering plants. Most are terrestrial, non motile, photosynthetic autotrophs. The plant and animal kingdoms are the two most complex groups of living organisms; both have true tissues and true organs, but plants are generally simpler, less complex life forms than are animals.

Members of the **Plant Kingdom** (Metaphyta) are distinguished by sharing the following characteristics:

1. **multicellular, eucaryotic** organisms with cells differentiated into tissues and organs
2. plant cells are surrounded by **cell walls** containing **cellulose;** large **vacuole** in center of cells store foods and water, and **plastids** including **chloroplast** are used for photosynthesis. Other plastids contain various pigments and storage materials.
3. as **autotrophs** they use **chlorophyll** as the main photosynthetic pigment,
4. **require free oxygen** for energy production
5. store excess foods as **starch** (a complex carbohydrate).
6. in most plants tissues are differentiated into tissue and simple organs
7. most plants have a distinctive **alternation of sexual and asexual generations**
8. all show herbaceous **primary growth**, and some vascular plants show woody **secondary growth**
9. Most plants have a developmental phase in a zygote (fertilized egg) becomes an **embryo** before growing into the mature plant
10. almost all plants are terrestrial and therefore show major adaptations toward a non-aquatic existence.

I. Plant Cells

Plant Cells: In addition to the basic **nucleus** and organelles found in typical **eucaryotic cells** plant cells usually contain some organelles and structures that can be considered "characteristic" of most plant cells such as **chloroplasts** and a large **central vacuole**.

Lab Activities:

1. Study the illustrations (Atlas p3, 1.3)[Fig 1.3], and model of plant cells to find the following organelles and structures:

cell wall	**nucleus**	**chloroplasts**
cell membrane	**vacuoles**	**mitochondria**
golgi complex	**nucleolus**	**endoplasmic reticulum**

2. Make a wet mount of an *Elodea* leaf. try to get the smallest thinnest leaf or piece of a leaf you can find. Study the cells of the Elodea under the microscope and find the structures as listed in your Atlas (p3)[Fig 1.5]

II. Plant Organs

Plant Organs: The plant is a collection of **vegetative** and **reproductive organs**. Organs are groups of interdependent tissues which, together, perform specific functions. The plant is a collection of **vegetative organs** – those that carry out the day to day plant activities, and **reproductive organs**– those involved in producing offspring. Compared to animals, plants have relatively few organs, however plant organs can be modified into a huge variety of sizes and forms and their functions can sometimes also be modified from their more common functions of roots, stems and leaves. Functionally, all three of the major vegetative organs of plants (roots, stems and leaves) are interrelated and the tissues within them are continuous throughout the plant.

a. Roots: are the part of the plant normally found below ground. They are nonphotosynthetic and

usually highly branched.In terms of functions:

1. They are the primary mineral and water gathering parts of the plant.
2. They also help to anchor and to support the above ground parts of the plant body.

most roots are either **fibrous roots** , with numerous branching roots, or **tap roots**, with one main root and several smaller side branches. The end of each root is covered by a protective **root cap**. Behind the cap are rapidly dividing cells that allow the root to elongate and penetrate the soil to absorb water and nutrients. Tiny microscopic **root hairs** extend from the outer cells lining the root. These root hairs greatly increase the surface area of the root and do most of the work of absorption.

b. Stems: There is no sharp line of demarcation between roots and stems; the stem is typically above ground and the roots, below ground but many variations exist. Each plant has a characteristic form depending on how the stem branches. Stems can be **herbaceous** and usually green, or **woody** with an outer layer of bark. General stem functions include:

1. support the leaves so they are exposed to sunlight
2. Conducting water and minerals from the root to other parts of the plant.
3. Conducting food, which is manufactured in the leaves by photosynthesis, to all other parts of the plant

At intervals along each stem are **nodes** where leaves, buds, branches or reproductive organs arise. the areas of stem between these nodes are **internodes**. Buds along the stem or in the axils of a leaf are called **lateral buds.** the buds at the tip of a stem or branch are **terminal buds**.

Herbaceous Stems. Plant stems can be either **herbaceous** or **woody**. Typically herbaceous stems are found on **annual** plants, or plants that only live one season then die, they are usually green and carry out photosynthesis. The outermost cells of the herbaceous stem secretes a waxy protective layer dotted with openings called **stomata** that allow oxygen and carbon dioxide to to move to and from the cells below.

Woody Stems. Woody stems are found in **perennial** plants, specifically shrubs, woody vines, and trees. Both conifers and some flowering plants are perennial and therefore produce woody stems. Woody stems often bear **scars** from the previous years growth; leaf scars, bud scars, etc. Also, since woody stems are covered with a protective corky layer which helps to waterproof the plant, they sometimes have pores called **lenticels** that allow gas exchange for the cells deeper inside.

c. Leaves: The main function of the leaf is to carry out photosynthesis. Photosynthesis uses energy from sunlight to convert carbon dioxide and water into sugar and oxygen gas. The sugar is then sent to all plant cells where it is broken back down into carbon dioxide and water to release the energy needed for the cells to perform their various functions. By making sugar the plant is able to "package" the sun's energy and send it tow wherever in the plant energy is needed. Functionally then leaves:

1. Carry out most photosynthesis for most plants
2. Evaporation of water from leaves serves as mechanism for transpiration which moves nutrients from roots throughout the plant

Of all the plant organs, leaves are the most variable in size, shape and function. A typical leaf is made up of a stalk-like **petiole** and an expanded flattened **blade**. At the base of the petiole is typically an **axillary bud** and one or two small **stipules**. Some leaves, called **simple leaves**, have a single blade attached to the petiole. Others, called **compound leaves** have several small leaflets attached to the stem by a single petiole. Most species of plants can be identified by the characteristic size, shape, color, margins, arrangement and veination of its leaves.

The upper and lower surfaces of each leaf are riddled with pores called **stomata** for gas exchange. Special cells called **guard cells** enclose the pore and can cause it to open and close to allow gas exchange or to conserve water. Many leaves also have distinctive microscopic hairs or spines called **trichomes** that are used for protection, to reduce desiccation, to excrete wastes, or for some other use.

Lab Activities:

1. Identify the three major vegetative organs, the **root, stem** and **leaf** on the 'typical' plants (living and preserved) and illustrations available [See your atlas pp84-92].
2. Identify the following structures on living and preserved plants and models available [Atlas p84, fig. 6.88; p87, fig 6.99; p88, fig 6.100 p90, fig 6.110]:

   a. root: **primary root, secondary root, root hairs, root cap** [Fig 6.159,6.160]

   b. stem: **terminal bud, node, internode, axillary bud, lenticel** [Fig 6.166]

   c. leaf: **veins, petiole, blade, stipule, axillary bud, trichomes** [Fig 6.180; 6.186-6.188]

3. Note the variety of leaf forms (Fig 6.110) in terms of venation, margins, complexity and their arrangement on the stem. Be able to use this figure to describe the leaves of plants available

III. Plant Tissues

C. Plant Tissues: Now that you are familiar with the basic plant organs we turn our attention to the various tissues making up these organs. Plants are composed of groups of cells that form fairly complex tissue layers that extend throughout the plant, since these tissue layers are fairly extensive and usually consist of several types of cells they are sometimes referred to as **Tissue Systems**. The **Dermal Tissue** covers the outside of all plant organs and protects them from damage and water loss. The **Vascular Tissue** consists of the **xylem** and the **phloem** which move water, minerals, sugars, and hormones throughout the plant. All the other cells in a plant represent the **Ground Tissue**. Ground tissues do most of the "work" of a plant; they are specialized into a variety of tissues and layers that carry out photosynthesis, gas exchange, food storage, etc. in the roots, stems and leaves.

Lab Activities:

Use the outline below to find various examples of the three tissue types in the following vegetative plant organs:

1. **Root** – slide: *Ranunculus* mature roots, cs (Atlas p86, 6.94)[Fig 6.151, 6.161, 6.162]
   a. The dermal tissue consists of a layer of **epidermis** cells around the outside of the section
   b. the vascular tissue is represented by the **xylem** and **phloem** in the center of the cross section. Be able to distinguish between the xylem and the phloem cells
   c. all the rest between the epidermis and the vascular tissue is **ground tissue**, called the **cortex**. In this case the ground tissue is used for food storage

2. **Stem** – slide: Typical monocot and dicot stem, cs (Atlas p88, 6.102) [Fig 6.169,6.170,6.173]
   There are two different cross sections on this slide, find the one that most resembles Fig 6.102 in your atlas
   a. again, the dermal tissue is represented by a couple layers of **epidermis**
   b. the vascular tissue is represented by **vascular bundles** composed of **xylem** and **phloem** cells scattered throughout the stem cross section. Be able to distinguish between the xylem and the phloem in the vascular bundles
   c. The cells between the epidermis and the vascular bundles are part of the ground tissue.

3. **Leaf:** slide: *Ligustrum* leaf, cs (Atlas 3.6, p91-92, 6.115-6.116)[6.190,6.191,6.196]
   a. The dermal tissue consists of a single layer of **epidermis** on the upper and lower surface of the leaf section. Look closely and find small pores (=**stoma**) in the epidermis, especially the lower epidermis. These pores allow for gas exchange. On each side of the **stomata** (pleural of stoma) are small **guard cells** that can open and close the pore
   b. The vascular tissue is represented by the "**veins**" of a leaf. Each branch of a vein is seen in cross section as a **vascular bundle** containing **xylem cells** and **phloem cells**
   c. In leaves the ground tissue is divided into two major layers; the **palisade mesophyll** which does most of the photosynthesis, and the **spongy mesophyll**, were gas exchange occurs.

II. Plant Life Cycles

All plants show an **alternation of generations** between individuals that reproduce asexually and those that reproduce sexually. The plant that reproduces asexually is called the **sporophyte** and the plant that reproduces sexually is called the **gametophyte.** In some primitive plants these two forms are completely separate individuals and one tends to dominate in the life cycle while the other is much smaller and rarely seen. In seed producing plants the sporophyte and gametophyte are part of the same individual plant specimen but the gametophyte has been greatly reduced and is now microscopic in size.

The gametophyte produces male and female sex organs, which in turn produce the **sperm** and **egg**. In primitive plants the sperm travels from the male to the female plant in water to fertilize the egg and produce a **zygote.** The zygote develops into the **sporophyte** plant. The **sporophyte**, in primitive plants, produces **spores.** Finally, the life cycle is completed when spores are released they grow into the **gametophyte** plant.

Lab Activities:

One of the most familiar plants that illustrates this alternation of generations is the fern. We will study the fern life cycle to understand the process. View the slides below of a fern lifecycle to see examples of the various stages in the life cycle of a typical plant.

1. In the fern life cycle [Fig 6.75] the **gametophyte** is a tiny heart-shaped organism which is rarely seen because of its small size.
   slide: fern prothallium male and female, wm [Atlas 6.43, 6.51]

2. Ferns do not produce flowers, their sexual reproductive organs are simple and very small. On the gametophyte are the male and female reproductive organs; the **antheridium** and **archegonium**
   slide: fern prothallium male and female, wm
   fern antheridium, wm (Atlas 6.51, 6.53)[Fig 6.75, 6.87]

3. The antheridium produces sperm cells which "swim" or are washed to the archegonium of another gametophyte to fertilize the egg. The zygote produced by fertilization of the egg grows within the **archegonium** on the prothallium into the young **sporophyte**
   slide: fern young sporophyte wm (Atlas 6.43)[6.75]

4. The young **sporophyte** eventually grow into the large familiar "**ferns**" commonly used as house plants. These are the sporophyte stage of the fern life cycle.

5. Ferns eventually produce **spores** from groups of special **sporangia** on the fern frond called **sori**. These groups of sporangia are covered by an umbrella-like **indusium**.
   slide: fern indusium sec (Atlas 6.44, 6.45)[6.75,6.85]

6. Each spore that is released will grow into the tiny prothallium **gametophyte** to complete the cycle

A Key to Common
Texas Trees & Shrubs

1a. leaves with distinct petiole and blade	2
b. small, scalelike leaves oppressed onto reddish brown twigs; with sticky resinous secretions	**Eastern Red Cedar** *Juniperous virginiana*
2a. leaves simple	3
b. leaves compound	19
3a. leaves alternate	4
b. most leaves opposite or whorled	17
4a. leaves linear	5
b. leaves not linear	6
5a. leaves _ to 3" long	**Poverty Weed** *Baccharus angustifolia*
b. leaves 3" to 6" long	**Gulf Black Willow** *Salix nigra*
6a. leaves obovate, oblanceolate or spatulate	7
b. leaves not as above	8
7a. leaves dark green glabrous above, tomatose below, no spines on branches	**Texas Persimmon** *Diospyros texana*
b. leaves dark green and shiny above, much paler and glabrous below; shorter branches terminate in spines	**Pyracantha** *Pyracantha angustifolia*
8a. leaves ovate-cordate to deltoid	9
b. leaves not as above	12
9a. leaf margins entire	10
b. leaf margins serrate to crenate	11
10a. leaf tips acuminate, base acuminate to acute	**Chinese Tallow tree** *Sapium sebiferum*
b. leaf tips broadly rounded to obtuse, base cordate	**Texas Redbud** *Cercis canadensis*
11a. leaf margins entire to sinuate, lower surface of leaf with white felty tomentum, some leaves modified into tendrils	**Mustang Grape** *Vitis candicans*
b. leaf tip distinctly acute to acuminate, leaf margins crenate-serrate, leaf base truncate, lower surface of leaf pale green and glabrous	**Eastern Cottonwood** *Populus deltoides*
12a. leaf margins deeply incised with 3 to 7 lobes	13
b. leaf margins entire to serrate	14
13a. leaves with 3-5 acuminate lobes with large teeth between lobes, bright green above, paler and densely pubescent along veins below	**Sycamore** *Platanus occidentalis*
b. leaves with 5-7 aristate lobes, terminal lobe often longest	**Texas Oak** *Quercus texana*
14a. leaf margins doubly serrate, apex acute or obtuse, dark green stiff , rough to touch above , pubescent below; twigs with brown thin lateral corky wings	**Cedar Elm** *Ulmus crassifolia*
b. leaf margins entire or mostly so, other characters not as above	15
15a. leaves thick, oblong or elliptical, dark green and lustrous, leaf margins often curled under; some leaves may have sharp spines	**Live Oak** *Quercus virginiana*
b. leaves otherwise	16
16a. leaves ovate-lanceolate, leaves thin, light green and	

glabrous above, paler and smooth beneath, conspicuously 3 veined on underside of leaf; leaf base wedge shaped and halves often unevenly meet petiole	**Hackberry** *Celtis laevigata*
b. leaves obovate-oval, base cuneate or rounded; short or absent petioles	**Crapemyrtle** *Lagerstroemia indica*
17a. all leaves opposite	18
b. leaves opposite, alternate or clumped; bright green and glabrous above and below	**Pomegranate** *Punica granatum*
18a. leaves 1-3"long, light green and pubescent above and below; base rounded or truncate	**Japanese Honeysuckle** *Lonicera japonica*
b. leaves 2 – 4.5" long; dark, dull green and leathery, glabrous above and below	**Japanese Privet** *Ligustrum japonicum*
19a. leaves palmately compound	20
b. leaves pinnately compound	23
20a. most leaves with 3 leaflets	21
b. most leaves with 5 leaflets	22
21a. leaflets deeply incised; thick and spiny	**Agarita** *Mahonia trifoliata*
b. mostly 3 but up to 7 leaflets; with serrate margins; blades thin, light green and pubescent	**Box Elder** *Acer negundo*
22a. leaves opposite; leaflets linear to lanceolate; margins entire	**Chaste Tree** *Vitex agnus*
b. leaves opposite adhesive tendrils; leaflets elliptical or oval and coarsely serrate	**Virginia Creeper** *Parthenocissus quinquefolia*
23a. leaves twice pinnately compound,	27
b. single pinnately compound leaves	24
24a. leaves 8-16" long; leaflets numerous (25-30 pairs) and small (<1/3"); twigs green	**Paloverde** *Parkinsonia aculeata*
b. leaves not as above	25
25a. leaflets elliptical to oblong or oval; 1-2.5" long, margins entire, short or no petiole on leaflets, 5-9 leaflets per leaf	**Mountain Laurel** *Sophora secundiflora*
b. leaves not as above	26
26a. leaves and leaflets opposite; 7-13 leaflets per leaf; leaflets 1-3" long	**Trumpet Creeper** *Bignonia radicans*
b. leaves alternate	27
27a. leaflets coarsely toothed, margins incised or lobed	**Pepper Vine** *Ampelopsis arborea*
b. leaflet margins not as above	28
28a. leaf with 12-20 leaflets; leaflets ~2" long; twigs with tout spines up to 2" long	**Mesquite** *Prosopis juliflora*
b. leaf with 9-17 leaflets, leaflets 4-8" long, with little or no petiole, leaves aromatic when crushed; orange/brown lenticels on twig	**Pecan** *Carya illinoiensis*

Name:_____

Leaf Identification Exercise

#	Sequence of choices you used to arrive at your identification	ID Common Name	ID Species
eg	1a‡2a‡3a‡4b‡6b‡8a‡9a‡10b	Texas Redbud	*Cercis canadensis*

III. Plant Diversity

The plant kingdom can be divided into four major groupings. Some of these groups consist of several related phyla; we will however only consider the largest phylum within each group.

1. **Mosses**
   These are small, nonvascular plants, that is, they have no conducting tissues (xylem and phloem) and therefore have no true roots, stems or leaves. The reproduce mainly by asexual spores

2. **Ferns** (Seedless vascular plants)
   Larger plants that have vascular tissues (xylem and phloem) but that still reproduce mainly by asexual spores

3. **Conifers** (Gymnosperms)
   Vascular plants that produce naked seeds, usually in cones

4. **Flowering Plants**
   Vascular plants that produce flowers and seeds enclosed within a fruit

A. Mosses [Fig 6.23 – 6.40]

The mosses represent the simplest members of the plant kingdom.

Mosses, because they lack vascular tissues, are typically only a few inches tall and found mainly in moist place. The **gametophyte** is the dominant, more permanent stage in their life cycle. The gametophytes of mosses appear as short leafy stems growing close to the ground. They have simple, nonvascular **leaves**, **stems** and rootlike **rhizoids**. At the tip of each leafy stalk are the sexual organs, either **antheridia** which produce the sperm or **archegonia** which produce the eggs. During rains the sperm cells travel to the archegonia to fertilize the egg producing a **zygote**. The zygote develops within the archegonium and produces a long, naked stalk with a **capsule** at the end. This stalk and capsule is the **sporophyte** stage of the moss (actually growing on the female gametophyte). The sporophyte is only a temporary structure and falls off after spores are released.

Lab Activities:

1. Observe several examples of living and preserved mosses. Use the illustrations in your Atlas (beginning on page 59) and others provided to identify the major vegetative organs on the **gametophyte** plant. On the true mosses you should be able to find:
   "leaves", **"stems"**, and **rhizoids** Fig 6.28]

2. On the same living and preserved mosses, look for the presence of the sexual reproductive organs on the gametophyte plant using a dissecting scope or hand lens:
   antheridium - produces sperm [Fig 6.28]
   archegonium – produces the egg [Fig 6.28]

3. You have slides of three different genera of bryophytes: *Polytrichium*, *Mnium*, and *Marchantia.* Observe the slides of each that show the sexual reproductive structures and note there similarities and differences:
   antheridia: **slide:** Moss Antheridial Head, *Polytrichium* ls (atlas 6.17,6.21) [Fig 6.36]
   archegonia: **slide:** Moss Archegonial Head, *Mnium* ls (atlas 6.17,6.19)[Fig 6.35]
   Note: You are not trying to be able to identify the different species, you should be trying to recognize and identify the antheridium and archegonium of various mosses.

4. In mosses, the sperm swims over the the archegonium to fertilize the egg and the egg, still in the

archegonium, develops into the **sporophyte**. The sporophyte remains attached to the gametophyte.
Do any of the living or preserved mosses have a **sporophyte** attached? If so, describe its shape on your data sheet.
The sporophyte consists of a spore producing **capsule** which may or may not be on a long **stalk**. Identify these structures in the specimens provided.

5. Observe the two slides below to see the **capsules** and the asexually produced **spores**, how are they similar in the two species, how do they differ, compare what you see on the slides to the illustrations in your Atlas?
capsule and spores:
slide: Moss capsule, *Polytrichium*, ls (atlas 6.17, 6.22)[Fig 6.37]

B. Ferns [Fig 6.75 – 6.91]

The ferns and their allies represent the simplest kinds of **vascular plants**.

Vascular Plants have **conducting tissues**, the **xylem** and the **phloem**, which move water and nutrients throughout the plant. Water and inorganic nutrients are absorbed by the roots and mainly move in the **xylem** up to stem to the leaves where some is used in photosynthesis and some evaporates into the air. Organic nutrients are move up and down the plant in the **phloem**. Some foods such as sugars are made in the leaves by photosynthesis and moved to other tissues for use as energy or to storage areas in the stem or root for later use by all parts of the plant.

These two vascular systems:
- allow a much more efficient distribution of materials throughout the plant body and thereofore allow the plant to grow considerably larger than most nonvascular bryophytes.
- also, the sclerenchyma of the xylem provides added support for the plant which also allows it to grow larger.
-the presence of a vascular system also allows these simple plants to grow in drier habitats than those in which mosses are found.

The ferns are the largest and most diverse group of **seedless vascular plants**. Most are tropical but many are used as house plants throughout the world. They have typical **roots**, **stems** and most lave large **leaves** called **fronds**. A portion of the stems of some ferns and most other seedless vascular plants grow underground and are called **rhizomes**. The sporophyte asexually produces spores int a sorus or in groups of sori called an indusium found usually on the underside of the forndl Sperm and egg are produced in antheridia and archegonia on the small heart-shaped gametophyte plant.

In addition to the presence of vascular tissues, the ferns and their relatives share several other important traits not found in the bryophytes:
- the sporophyte does not remain attached to the gametophyte, it is a completely separate organism that grows independently
- the sporophyte is the dominant, most visible stage in the life cycle. Most people have seen a fern 'sporophyte', few have seen a fern gametophyte

Like the mosses, however, the sperm of the **gametophyte** plant requires water to get to the egg. The small gametophytes , therefore, are still tied to water even though the **sporophytes** can grow in somewhat drier areas.

<u>Lab Activities:</u>
1. Observe and distinguish between the preserved and live specimens of any of the above plants that are available.

2. Observe the living and/or preserved fern sporophytes and locate **the frond, fiddle heads, rhizome sori** and **roots** using your atlas (p71-73)[Fig 6.75] and the attached illustrations.

3. Observe the slide below and identify the **vascular tissue** (xylem and phloem) as indicated on the attached illustration
   slide: Fern combination, root, stem, stipe [Fig 6.95]

4. Identify the **indusium, sori, fern spores** on the slide below:
   slide: Fern indusium (atlas 6.52) [Fig 6.85]

5. Identify the fern gametophyte, the **prothallium,** and find the **prothallium, antheridium** with **sperm cells**, **archegonium** with **egg cells** and **young sporophyte** growing from a fertilized egg in **archegonium** on the sldies below [atlas 6.51, 6.53, 6.43]:
   slide: fern prothallium, male and female [Fig 6.87]
   fern antheridium [Fig 6.87]
   fern young sporophyte [Fig 6.88]

C. Conifers [Fig 6.123 – 6.146]

Conifers are one of two major groups of vascular plants that produce **seeds** during their reproductive cycle. In ferns the zygote developed directly into the sporophyte without forming a seed. In conifers the life cycle is considerably different from the two you studied for the mosses and the ferns. In the mosses, the gametophyte was the dominant stage in its life cycle and the sporophyte was a temporarty structure that grew out of the gametophyte. In the ferns the sporophyte and gametophyte were completely separate organisms and the sporophyte was the larger, dominant most visible stage of the life cycle, the fern gametophyte was a tiny plant, rarely seen.

In **conifers** the **sporophyte** and **gametophyte** are again part of the same plant but now the **sporophyte is the dominant structure** with the gametophyte appearing only at certain times of the year. The gametophyte, which was represented in the ferns by the small haeart shaped prothallium, is even smaller in the conifers. Also, there are **separate male and female gametophytes**, both are produced in a kind of **strobilus** called a **cone**. The **male gametophytes** are now called **pollen grains**, are microscopic in size, and are produced by the **staminate (or male) cones**. The female gametophytes, which include the **ovule** and egg is borne on the **ovulate (or female) cones**.

The entire male gametophyte (the tiny pollen grain) is released from the male cone and travels by wind to the female cone to fertilize the egg. The seed plants are, therefore, no longer tied to water for sexual reproduction. Among other major adaptations that allow the conifers and their allies to grow in even drier habitats than their ancestors are:

- a well developed vascular system extending through more complex roots, stems and leaves
- the root system is much better developed and can extend much deeper into the soil or spread over a much larger area to absorb more water for the plant
- in the stem, production of woody tissues from the vascular sytem which allows much larger, stronger plants more resistant to drying and the wind
- most have narrow needle or scale like leaves with a thick cuticle to prevent water loss

The Conifers are distinct from the flowering plants in that the seeds are not produced in a flower and fruit, they are instead “naked seeds”. The seeds are borne on the female cone. The seed enhances dispersal and survival of the plant in harsh or dry conditions. At the center of the seed is the embryo, a dormant stage of the sporophyte. The embryo itself consists of an embryonic root and stem and embryonic leaves called cotyledons. The embryo is surrounded by stored nutrients called the endosperm. The dormant embryo and its food supply are enclosed within moisture resistant coatings to protect them.

Lab Activities:

1. Observe the examples of conifers and note the vegetative organs; the roots, stems and leaves, and the reproductive organs; the male and female cones.
2.
3. Observe the slide of a cross section of a pine leaf and find the following structures:
   Slides: **pine leaf – 3 needle , cs** (atlas p79, 6.78)[Fig 6.132]

Tissue layers:
Epidermis
Photosynthetic mesophyll
Endodermis
Xylem
Phloem
Resin Ducts
Stoma

4. Study the **life cycle** of a typical conifer on the attached illustrations and in your atlas, p 76 [Fig 6.123].

5. Observe examples of the **cones** [atlas p79, fig 6.79; p 80, fig 6.81]; be able to recognize and distinguish between **male (staminate)** [Fig 6.140] and **female (ovulate) cones** [Fig 6.135, 6.136]. Use a magnifying glass to determine whether any of the male cones still contain **pollen**. Do any of the female cones contain **seeds**?

6. Observe the slide:
Pine, staminate cone, ls (atlas p80, 6.81)[6.141,6.142]
note the structure of the **strobilus** and identify the **pollen grains** (=microsporangia of your atlas)

7. Observe the slide:
Pine mature pollen wm (atlas p81, 6.82)[Fig 6.123]
and compare to the illustrations attached to lab exercise; note the '**wings**' on each grain.

8. Observe the slide:
Pine young ovulate cone (atlas p 80, 6.80)[Fig 6.135, 6.136, 6.137, 6.138]
and again, note the structure of the **strobilus** and identify the **ovule** and **scales**

9. Observe a section of a **seed** on the slide:
pine mature embryo, ls (atlas p81, 6.84)[Fig 6.123]
and identify the embryo, cotyledons, endosperm, seed coats.

D. Flowering Plants [Fig 6.147 – 6.244]

Flowering Plants are the dominant members of the Plant Kingdom in the world today. Nearly all crop plants as well as most horticultural plants are flowering plants. The flowering plants are the last major plant group to appear in the fossil record and are the most complex and most diverse.

Flowering plants include the most diversified and complex members of the plant kingdom. They have **well developed vascular tissues** (xylem and phloem) and produce **pollen** and **seeds** like the conifers and their allies but differ from them in that the **ovules are enclosed within an ovary** which later becomes a **fruit**. Flowering plants have also developed greater diversity in methods of **pollination**. In conifers, pollen traveled by wind to the female cone. In flowering plants pollen can travel to the female structures not only by wind but by water, insects, birds, and mammals.

Variations in Vegetative Plant Organs

Part of the reasons for the success of flowering plants in the world today is the adaptability of their vegetative organs to perform a variety of additional roles. This allows flowering plants to adapt to a much wider variety of habitats and living conditions than that found in the other plant groups.

In lecture we discussed modifications of roots, stems, and leaves for a variety of functions. You will investigate some of these modifications in this lab exercise

Woody Stems

Plant stems can be either **herbaceous** or **woody**. Typically herbaceous stems are found on **annual** plants, or plants that only live one season then die, they are usually green and carry out photosynthesis.

Woody stems are found in **perennial** plants, specifically shrubs, woody vines, and trees. Both conifers and some flowering plants are perennial and therefore produce woody stems.

The internal structure of roots and stems that you saw in the last lab is typical of herbaceous annual plants. Plants that live more than one year, ie. perennials, produce **secondary growth** each year. In woody plants there are two major layers of **embryonic cells** called the **cambium**, that produces this secondary growth each year. One layer of cambium is found in the **vascular bundles** of the stem between the xylem and phloem. Each year this cambium produces new layers of xylem and phloem cells. Another layer of cambium is located between the cortex and epidermis, this produces **periderm**, which makes up most of the bark of woody plants. The bark replaces the epidermis for protection of the stem in large woody plants.

Xylem grows much faster than phloem and virtually all of the "wood" of a tree is dead xylem cells with the oldest cells closer to the center of the trunk, these older cells are often darker and are called **heartwood**. Each year the cambium lays down a new layer or xylem. Differences in the size of the cells produced throughout the growing season produce the familiar "**growth rings**" in the wood. Most of the strength of wood comes from the **sclerenchyma cells** of the xylem specifically the tracheids, vessel elements and **fibers**.

The **phloem**, on the "outer-side" of the cambium, the cortex and the periderm make up the **bark** of a tree.

Lab Activities:

General Flowering Plant Anatomy

see page 5, Fig 1.9; roots: 6.159-6.160; stems: 6.166; leaves: 6.187,6.187

Anatomy of Vegetative Organs of Flowering Plants: Monocots and Dicots

1. There are two major kinds of flowering plants, the monocots and the dicots [Fig 6.148]. They both have the same basic tissues and structures but the arrangement of these tissues vary in the two groups.

Roots:

Examine the slides of root cross sections and identify the internal strucutures and tissues of the plant root as indicated:

slides: Typical monocot and dicot roots, cs [monocot root, see illustration]
dicot (Atlas: p85, fig 6.93, p86, fig 6.94) [Fig 6.157,-8] monocots: [Fig 6.151-2]

epidermis, cortex, xylem, phloem

Stems:

Examine the slides of stem cross sections and identify the internal structures and tissues as indicated:

slide: Typical monocot and dicot stems, cs monocot – (Atlas, p88, fig 6.102)[Fig 6.170];
dicot – (Atlas, p89, fig 6.106)[Fig 6.173]

epidermis, vascular bundles (xylem and phloem), in monocot stem:
parenchyma cells, in dicot stem**: cortex and pith**

Leaves:

Examine the slide of the leaf cross sections, find the cross section that most closely resembles the illustration in your atlas, p 91, fig 6.115 & 6.116 [Fig 6.191] and identify the internal structures and tissues as indicated, this is a dicot leaf. Also compare the monocot leaf to the illustration provided:

slide: Typical monocot and dicot leaves, cs

upper epidermis, mesophyll, xylem, phloem, spongy mesophyll, lower epidermis, stomata, guard cells

2. Use a dissecting scope or hand lens to view examples of **trichomes**. Can you determine the function of each type of trichome you see?

3. Characteristics of woody stems:
   External features of Woody Stems: Examine the woody twigs provided and identify the following structures (atlas p88, fig 6.100) [Fig 6.166, 6.167]:
   terminal bud, internode, lenticel, lateral (or axillary) **bud, node** and **leaf scars**
   Wood Sections: Examine the pieces of logs and cut wood available.
   a. can you see the growth rings?
   b. use a magnifying glass or dissecting scope to examine the growth rings more closely
   c. examine the bark in the same way
   Bark: use a sharp scalpel or razor blade and make a very thin section of cork. Place this section on a slide and view it under scanning power of the microscope. Diagram and describe you see in the data sheet.
   Woody Stem at the end of the third year: Examine the slides below and find the structures indicated [atlas p89, fig 6.108]- understand the relationship between each growth ring and the layers of secondary xylem and phloem and periderm

   slides*:* *Tilia*, Basswood, third year stem cs [Fig 6.177]
   Basswood three year stem, *Tilia* cs

   Identify the following cells, tissues, and structures: **epidermis, periderm, cortex, phloem, cambium, three annual rings of xylem, summer wood, spring, wood, primary xylem, pith.**

4. Distinguish between **fibrous roots** and **tap roots** [Fig 6.149]

5. Familiarize yourself with the terms used for **modified roots** by looking up their definitions in your text or other source. Identify various examples of modified or specialized roots as available; see illustrations attached. Then note the modifications of roots in the specimens provided (See your atlas pp84-92)[Fig 6.149,6.150, 6.153]. These modified organs usually enhance one or more of the organ's major functions, or give that organ a completely new function.

   Know: **prop roots, adventitious roots, tuberous roots**

6. Familiarize yourself with the terms used for **modified stems** by looking up their definitions in your text or other source. Identify various examples of modified or specialized stems as available; see illustrations attached. Then note the modifications of stems in the specimens provided (See your atlas pp84-92)[Fig 6.164,6.165]. These modified organs usually enhance one or more of the organ's major functions, or give that organ a completely new function.

   Know: **tubers, rhizomes, runners, bulbs, corms**

7. Familiarize yourself with the terms used for **modified leaves** by looking up their definitions in your text or other source. Identify various examples of modified or specialized leaves as available; see illustrations attached. Then note the modifications of leaves in the specimens provided [See your atlas pp84-92]. These modified organs usually enhance one or more of the organ's major functions, or give that organ a completely new function.

   Know: **tendrils, pitcher plant leaves, spines**

Review Questions:

1. Does the function of the epidermis differ in the roots, versus in the stems or leaves? Explain.

2. Does the function of the vascular tissue differ in the roots, versus in the stems or leaves? Explain.
3. Diagram and distinguish between cross sections of Monocot and Dicot roots and stems:
4. Describe the main difference in structure between monocot and dicot leaves. Does the structure of one have any advantages over the structure of another?
5. In the tropics, the weather is continually warm and there are no real "seasons". Would you expect trees in the tropics to produce annual rings? would you expect them to have any kind of "growth rings" in their wood? Explain.
6 Can you see the differences in the size of the xylem cells in the cut logs and wood? are the larger cells produced in the spring and summer or in the fall and winter? Explain
7. Diagram and describe the cells of the bark section.
8. Can you distinguish between the cells of the bark and the cells of the wood? If so, how do they differ? If not, what makes them visibly different even though you can't actually see microscopic differencs in the cells?
9. Name all the cells and tissue types you would find in a piece of wood
10. Name all the cells and tissue types you would find in the bark.
11. Describe how the one year and three year stems of Basswood (*Tilia*) differ from each other.

The Reproductive Plant Organs: Flowers, Fruits, & Seeds

The flowering plant body is the **sporophyte** form of the plant and like the conifers, asexual spores are not produced by the sporophyte (remember that the sporophytes in the other two major plant groups *did* produce spores). Rather than producing spores, cells produced by the male and female parts of the flower **develop directly into male and female gametophytes**. The **male gametophytes**, produced in the **stamen** are eventually released as **pollen**. These tiny pollen grains, consist only of three cells yet they are equivalent to the tiny heart-shaped prothallium of the Ferns and Allies or the perennial "mossy" plant of the Bryophyte group. The female portion of the flower, the **pistil**, also produces a tiny (this time of 7 cells) gametophyte within the **ovule** of the pistil. One of these cells is the **egg** or ovum.

Most angiosperm flowers are a combination of both male and female reproductive parts. General flower structures include the **pedicel, receptacle, sepals** and **petals**; the male parts, referred to collectively as the **stamen**, include the **anther** and **filament**; the female parts, referred to collectively as the **pistil**, include the **stigma, style,** and **ovary** with **ovules**.

The pollen grains are released from the **anther** and travel by wind, water or animal to a **pistil** of another flower. The pollen lands on the **stigma** and sends a tube (=**pollen tube**) down the **style** into the **ovary**. When the pollen tube reaches the ovule the sperm joins with the egg to produce a **zygote**.

The cells surrounding the zygote begin to divide to form the **endosperm** which nourishes the development of the zygote. As the endosperm develops the zygote also begins to grow into the **embryo**. At the end of this short spurt of development the endosperm and embryo are encased within a tough **seed coat** to produce the **seed**. Each fully formed seed consists of the embryo within the endosperm surrounded by one or more seed coats. The embryo is a miniature version of the future plant and contains an embryonic root (=**radicle**), an embryonic stem (=**epicotyl**), and extending from the area between these two structures are the **cotyledons** (sometimes called the "seed leaves" or embryonic leaves.

Monocots (short for monocotyledons which include grasses, lilies, corn, rice, etc) have one cotyledon in the seed while **dicots** (short for dicotyledons which include all other flowering plants) have two cotyledons as part of their embryo.

The **fruit** is an adaptation of flowering plants that helps to protect the seed while enhancing their dispersal. While each **ovule** is developing into a **seed**, the **ovary** is maturing into a **fruit**. The stigma, style, stamens, sepals, and petals usually wither away and the ovary, containing 1 or more seeds, enlarges. A fruit may consist of up to three different layers that enclose the seed. There are many different kinds of fruits depending on the characteristics of the ovary walls from which each develops. Illustrations of several are provided in your atlas and in the attached pages.

Lab Activities:

Flower

1. Examine the flower model and identify the structures listed above and in your atlas, (p92, fig 6.119)[Fig 6.197 – 6.215]
2. Examine the fresh flowers and identify as many of the same structures as you can
3. Examine the slide of a lily fower bud cross section and identify the structures indicated:
   slide: *Lilium* ovary, general structure cs [Fig 6.228]
   sepals, petals, stamen, pistils
4. Examine the illustrations of other flowers provided in your atlas (pp 94-95)[Fig 6.228] and find the same structures that you located on the flower model

Pollen – The Male Gametophyte

5. compare the slide below to the illustration in your atlas (p96, 6.134, 6.135)[Fig 6.219 – 6.223]
   slide: mixed pollen grains
6. View the slide below and note the growing **pollen tube** as it would appear after it lands on a stigma of a pistil:
   slide: Lily pollen tubes, wm

Seed Development

7. View the series of slides below and compare them to the illustration provided. Each slide, in the order listed, shows the progressive development of the seed of Shepherd's Purse or *Capsella.* Note the development of the endosperm and the embryo [Fig 6.225 – 6.226]. Identify the **radicle, epicotyl, cotyledons, endosperm** and **seed coat**
   slides: **1st** *Capsella*: early embryo, ls
   2nd Shepherd's Purse embryo, *Capsella,* ls
   3rd Shepherd's Purse Mature embryo, *Capsella,* ls

Fruit Development

8. Study the slides of developing fruits of apples and tomatoes. Remember that the fruit is produced from the **ovary** of the pistil and encloses the seeds. Compare these slides to the slide you looked at earlier of the Lily flower bud and try to find the same structures. Use the illustrations in your atlas, (beginning on p97)[Fig 6.218], and others attached to identify the **seed, placenta** and **pericarp**.
   slides: Tomato Fruit *Lycopersicum* cs
   Apple Fruit *Malus* cs
9. Other fruits: study the variety of fresh and dried fruits and illustrations of fruits and try to determine the relationship between the structures of the fruit with the structures of the flower that produced it. Us the illustrations in your atlas, text and those attached [Fig6.232 – 6.244].

Review Questions:

1. Distinguish between flowers, fruits and seeds
2. Describe some of the differences you found between the different kinds of flowers provided.
3. Compare the life cycle of a flowering plant with the life cycle of a fern; how are they similar, how do they differ, be specific?
4. Compare the life cycle of a flowering plant with the life cycle of a gymnosperm (conifers and allies); how are they similar, how do they differ?
5. Sketch the development of the shepherd's purse seed and label its parts.
6. Shepherds purse is a dicot, if you were looking at a lily seed (a monocot), how would it differ
7. Describe and distinguish between the different kinds of fruits available; what are their similarities and differences in structure.
8. Can you suggest ways in which specific fruits enhance seed dispersal for its species? Be specific

Name:_____

Date:_____

The Plant Kingdom

Data Sheet

Plant Cells

1. Describe and draw typical plant cells

2a. List each of the major plant cell organelles and in a phrase describe the general function of each. Describe which organelles are visible in the wet mount. Why are only some visible and others are not?

2b. Which of the organelles found in the model could you NOT find in real plant cells

Plant Organs

3. Name the major vegetative and a few reproductive plant organs and describe the specific function of each vegetative plant organ.

4. How much variation is found in each type of vegetative organ; for example are there more different kinds of leaves than roots or stems? Explain

Plant Life Cycle

5. Diagram the life cycle of the fern indicating the sporophyte and the gametophyte stages and the main type of reproduction in each stage.

6. Where and when might you look if you wanted to find the gametophyte stage of a fern?

Plant Organs

Modified Vegetative Organs

There are several "fresh" examples of various modified roots, modified stems and modified leaves available in the lab. Place the name of each item in the column of the table below that best describes which vegetative plant organ has been modified *and* list the new function of each

Modified Roots	Modified Stems	Modified Leaves

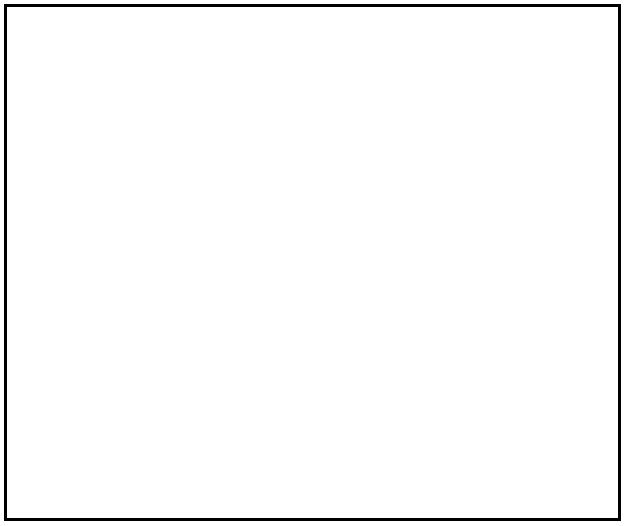
Flower Structure

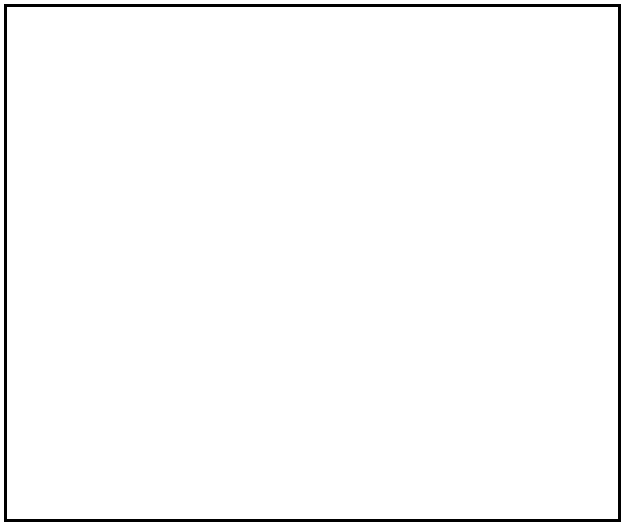
After studying the flower structure of the Lily. Dissect 5 of the other kinds of flowers available and indicate which of the 4 basic flower structures are present in each by checking the appropriate boxes.

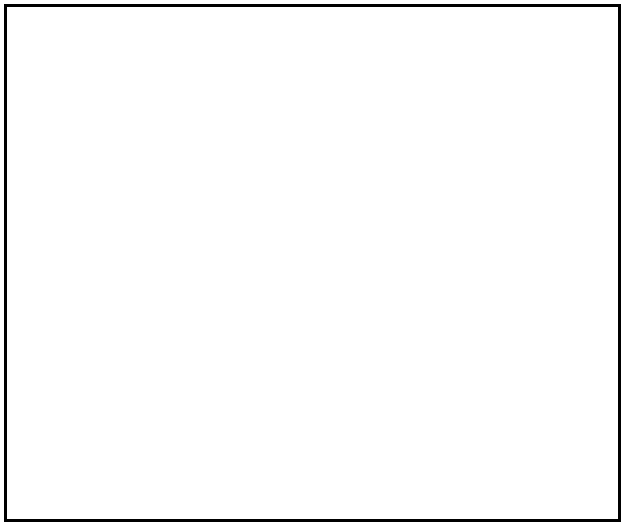
Flower	Sepals	Petals	Pistil	Stamen
Lily	**X**	**X**	**X**	**X**

Fruit Structure

Select three different fruits from the fresh fruits available, make a simple sketch of each. Then indicate where, on each, the parts of the flower (sepals, petals, pistil, stamen) are or once were







Diversity in Plant Structure

1. ***List*** a specific example of a food or a commercial product made from each of the following plant parts:

Vegetative Plant Organs		
Roots	**fibrous root**	
	tap root	
Stems	**whole stem**	
	periderm - bark	
	sap	
	axillary buds	
	terminal buds	
Leaves	**whole leaf**	
	blade	
	petiole	
	trichomes	

Reproductive Plant Organs		
Flower	**whole flower**	
	sepals	
	petals	
	pistils	
	stamens	
Fruit	**whole fruit**	
	seeds	

2. ***Describe*** a specific example of a plant with each of the modifications in the table below and explain the advantage or value of the modification to the plant
3. **Bring in an actual example or an illustration** of a modified root, a modified stem and a modified leaf that you have described. You will get a point ***extra credit*** if your example is unique (ie. no other student in the class brought in the same thing)

Modifications of Plant Vegetative Organs		
modified roots	**adventitious roots**	
	prop roots	
	aerial roots	
	parasitic roots	
	pneumatophores	
	tuberous roots	
modified stems	**twining vines**	
	spines	
	runners	
	rhizomes	
	succulent stems	
	corms	
	tubers	
modified leaves	**spines**	
	tendrils	
	bulbs	
	head	
	succulent leaves	
	insectivorous leaves	

The Animal Kingdom

Biol 1409 Labs

Ziser, 2002

The Last and by far the largest kingdom in terms of the number of different kinds of species is the **Animal Kingdom** (Metazoa). Animals are represented by a very diverse array of sizes, shapes and forms from very simple to extremely complex, including the "human animal". All animals are multicellular heterotrophs. Most animals have cells differentiated into highly complex tissues and organs. Whereas plants had tissue systems and relatively simple vegetative and reproductive organs, animals have complex tissues forming organs and elaborate organ systems. The greater specialization of cells and tissues increases the efficiency by which animals can carry out life's basic processes and allows for almost limitless opportunities for evolutionary variations and adaptations to numerous kinds of habitats and environmental conditions.

Members of the Animal Kingdom are distinguished by sharing the following major characteristics:

1. **multicellular eucaryotic organisms**
2. **no cell wall surrounding cells**
3. **cells differentiated into complex tissues, organs and organ systems.**
4. **heterotrophic nutrition (herbivores, carnivores, saprobes)**
5. **require free oxygen for energy production**
6. **most are motile at some point in their life cycle**
7. **reproduce both sexually and asexually**, aninals show a great diversity in kinds of reproduction. some with well developed alternation of generations.
8. **most have a relatively complex developmental phase** including an embryonic or a larval stage as they progress from zygote to adult

There are about 30 distinct phyla within the animal kingdom, many of these phyla contain only one or a few species, yet differ enough from other animals that they are given their own distinct "category".

Below are listed some of the largest, most common, or most recognizable groups of animals; categorized roughly in order of increasing complexity. The simplest animals, sponges, do not even have true tissues or organs, the most complex animals, the vertebrates, have elaborately developed organ and organ systems. Familiarize yourself with the phyla below and be able to recognize representatives from each one.

The major animals phyla:

I. Cellular level of organization:

Phylum: **Porifera** [Sponges]

II. Tissue level of organization:

Phylum: **Cnidaria** [Jellyfish & Corals]

III. Organ level of organization:

Phylum: **Platyhelminthes** [Flatworms]
Phylum: **Nematoda** [Roundworms]
Phylum: **Rotifera** [wheel animals]
Phylum: **Mollusca** [Molluscs]
Phylum: **Annelida** [Segmented Worms]
Phylum: **Arthropoda** [Arthropods]
Trilobita
Chelicerata (spiders, scorpions)
Crustacea [lobster, crab, crayfish, shrimp]
Uniramia [centipedes, millipedes, insects]

Phylum: **Echinodermata** [Echinoderms]
Phylum: **Chordata** [Chordates]
Vertebrata
Agnatha **(lampreys, hagfish)**
Chondrichthyes **(sharks and rays)**
Osteichthyes **(bony fish)**
Amphibia **(frogs, salamanders)**
Reptilia **(snakes, lizards, turtles)**
Aves **(birds)**
Mammalia **(mammals)**

I. Animal Cells, Tissues, and Organs

A. Animal Cells:

Animal cells share the same basic features as other eucaryotic cell. What distinguishes them from plants is their lack of a cell wall and chloroplasts

Lab Activities

1. Study the illustrations (atlas fig 1.16-1.56)[Fig 1.18] and find the following organelles on the animal cell model:

cell membrane	**endoplasmic reticulum**	**ribosomes**
nucleus	**mitochondria**	**centrioles**
nucleolus	**golgi bodies**	**vacuoles**

2. Compare and contrast the structure and organelles of plant cells and animal cells.
3. Are there any organelles that animals have but are lacking in plants?

Review Questions:

1. Describe and diagram a typical animal cell
2. List the major animal organelles and describe the functions of each
3. Describe how a typical animal cell differs from a typical plant cell

B. Animal Tissues:

The basis of animal diversity is the kinds of tissues found in the animal kingdom. there are four basic tissue types of the adult animals: **epithelial, connective, muscular** and **nervous tissues**. The four adult tissues are further differentiated into various subtypes.

Lab Activities:

Learn to recognize some of the various types of animal tissues. Use the illustrations provided in your atlas (fig 1.27) to learn to recognize each tissue type and subtype.

1. **Epithelial Tissues** – this is the most primitive, and presumably the first true animal tissue to evolve. It forms the outer coverings of animals as well as lines the inner and outer surfaces of all body organs. It functions in : protection, secretion, absorption, filtration; secrete cuticles, exoskeletons, shells, etc. The cells on the slide below should appear as large flattened, pancake shaped cells

slide: mammal simple squamous epithelium, smear [Fig 1.36]

2. **Connective Tissues** – are a very diverse group which includes tissues used for support like bone and cartilage, tissues used for storage like adipose tissue, as a kind of glue to hold things together like areolar tissue, or to transport nutrients, oxygen, wastes and hormones throughout the body like blood. Be able to distinguish between:

a. Areolar Connective Tissue

- "glue" to hold other tissues together; numerous fibers and cells criss-crossing the tissue

slide: mammal areolar tissue spread (atlas fig. 1.42)[Fig 1.44]

b. Adipose Connective Tissue

– large 'empty' looking cells for fat storage

slide: mammal adipose tissue sec (atlas fig. 1.41)[Fig 1.43]

c. Bone Connective Tissue

– rigid bulls-eye shaped Haversian canal system for rigid support

slide: Human compact bone ground cs select (atlas fig 1.50)[Fig 1.52]

d. Blood or vascular connective tissue
- transport of nutrients, wastes, oxygen, hormones, etc

slide: blood frog

3. **Muscle Tissues** – are elongated, spindle shaped cells used for movement both internal and external, both voluntary and involuntary such as swimming or running, and internal movements of various organs such as the pumping heart, and peristalsis of the digestive organs.

slide: amphibian smooth muscle – teased

4. **Nervous Tissues** – are used to conduct information throughout the body to sense internal and external environmental changes, and or coordination and control of muscles and glands. Nerve cells have a central 'cell body' and long processes to conduct impulses (transmit information)

slide: mammal neuron motor nerve cell sm (atlas fig 1.33)[Fig 1.65]

Review Questions:
1. Diagram the examples of each of the four major animal tissue types.
2. Describe some examples of where in the human body you would expect to find each of the four tissue types
3. Do any of the animal tissues correspond in function to any of the plant tissues, give examples?

C. Animal Organs and Organ Systems:

The animal kingdom contains the most diverse array of organs of any kingdom of life. Whereas plants capitalized on their basic tissue types to create tissue systems; animals instead developed a great variety of organs to perform specific functions. Each organ consists of several discrete tissue types but they do not share the "interconnectedness" seen between the various plant organs. While all animals must perform similar functions each phylum has developed different sets of organs to handle each function:

Below is a general synopsis of the major functions of animals. This information is provided to give you an appreciation for the diverse methods that animals use to perform similar life functions. It also provides an introduction to some of the terminology that will be used in describing animal groups in lectures and labs. You might also find it useful as a general summary of how animals "work".

1. Protection: In larger animals, particularly those who live in terrestrial environments the integument must provide an effective barrier to desiccation. The integument may also be used for protection from other environmental factors or as protection against predators.

2. Support: Aquatic animals require little support against gravity but terrestrial animals have invented a variety of support structures that not only counteract the forces of gravity but may play an important role in movement as well. [eg. humans Fig 9.10, 9.11]

3. Movement: Movement is one of the most distinctive characteristics of animals. Most animals move at least sometime in their life cycle. Movement is usually based on some kind of muscle tissue, often working against skeletal elements which can act as levers and fulcrums. There are many types of movements that have been described in animals such as swimming, 'jet' propulsion, flying and running and each requires specific adaptations to be most efficient. [eg. humans Fig 9.28, 9,29]

4. Feeding & Digestion: In many simple animals digestion is partly or completely intracellular (inside cells). Most higher animals have developed an alimentary canal; a protected cavity or tube into which food is first taken before extracellular enzymes (enzymes secreted from cells into the digestive cavity) break down large organic molecules to prepare them for absorption into the body. [eg. humans Fig 9.75]

5. Respiration: Virtually all animals require free oxygen gas for respiration and since animals are considerably more active than members of other kingdoms they require a greater supply of oxygen to generate energy. Aquatic and air breathing animals face different problems in acquiring this oxygen and so have developed different organs to accommodate these differences.

6.Circulation: Multicellular organisms must be able to get nutrients and oxygen to individual cells and get rid of wastes and carbon dioxide. In small animals simple diffusion can easily move things from place to place. Larger animals require some kind of circulatory system to do this. [eg. Humans Fig 9.60, 9.61]

6. Excretion: Animals do require some means to discard unwanted metabolic wastes. In small, simple animals this is usually done through the body wall with no specific excretory organs or structures. Metabolic wastes are removed by simple diffusion from individual cells. In the more complex animals some sort of processing system is required to collect and rid the body of metabolic wastes such as various minerals and salts, excess water and nitrogen wastes. The excretory system usually works closely with the circulatory system t collect and rid the body of its wastes. [eg humans 9.67]

7. Coordination and Control: As motile and generally active organisms, animals require a significantly greater degree of coordination and control for their complex systems. In addition to hormones, which are also found in the other (less active) kingdoms, most animals have some form of nervous system. Generally the hormones of the endocrine system regulate long term or cycling processes of growth and development while the nervous system coordinates activities that require immediate responses to environmental conditions. [eg humans 9.40,9.41,9.50]

8. Sense Organs: Animals must be able to monitor both their internal and external environments and to react and respond to the information that they collect. A diverse array of sensory organs has evolved in the animal kingdom ranging from simple cells to elaborate sensory organs. The Central Nervous Systems of animals process and use only one kind of information, electrochemical impulses, to coordinate and control all body systems. Each sensory cell is essentially a transducer and must be capable of converting a specific kind of input into an electrochemical impulse. Sense organs can be classified according to nature of the sensory information that they process. [eg humans 9.55, 9.58]

9. Reproduction: Most animals reproduce both asexually and sexually. Animals show many of the kinds of reproduction studied earlier in the class. Humans and other mammals are somewhat unusual animals in that they only produce offspring by sexual reproduction. [Fig 9.90, 9.91]

Lab Activities:

1. You will be given a list of a selected group of human organs to locate, identify, and describe their functions
2. Find the structures described above on the models, slides and preserved specimens that are available as you study the diversity of animal forms
3. Read the accompanying description of General Animal Functions. Many of these variations will be studied later in lecture and lab

Review Questions:

1. make a list of each of the terms in bold face above and briefly define the function of each, then list an example of an animal in which you would find each structure.
2. Make a table that compares the different organs used in different animals for the same specific functions
3. Make a list of the different kinds of sensory receptors found in the animal kingdom; which we we possess, which are not found in humans?

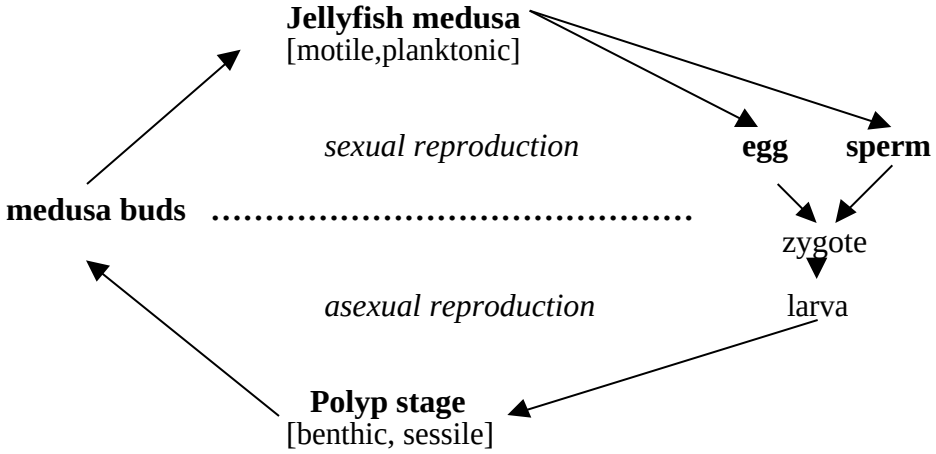
II. Animal Life Cycles

Just as there is a diversity of organs and organ systems in animals so there is also a variety of kinds of reproduction and life cycles.

A. Animal Life Cycles

The sequence of discrete, recognizable stages that animals pass through as they develop from a **zygote** (the fertilized egg) to the adults' production of **sexual gametes** (usually the **egg** and **sperm**) are referred to as its **life cycle**. All living organisms exhibit some form of life cycle. Animals typically show more variations in their developmental processes than those seen in the other kingdoms. Members of the animal kingdom have the most diverse life cycles of any living organisms. Like plants, some animals exhibit an alternation of asexual and sexual generations in which the animal exists in one form to reproduce asexually, and in another form to reproduce sexually. Even without a complete change in form, many animals reproduce asexually at one time of the year or under a certain set of conditions and sexually at other times of the year or under a different set of conditions. They produce a complex lifecycle where asexual and sexual types of reproduction alternate.

One good example of such alternation of generations is seen in jellyfish lifecycles. The large, familiar, planktonic jellyfishes are the sexually reproducing forms referred to as medusae. A much smaller, nonmotile polyp form that reproduces asexually, but is rarely seen. The typical lifecycle of these beasts is illustrated below:



Lab Activities:

Observe the slides and preserved animals below that show the various stages of this life cycle [Fig 7.17, 7.23 – 7.26, 7.27]:

preserved: adult jellyfish
slides: planula larva
scyphistoma
strobila
ephyra

1. Observe the jellyfish – these are the medusae stages of the lifecycle
2. Observe the slide of the planula larva. This is the larval stage of jellyfish produced by fusion of egg and sperm cells. The planula will swim in the plankton for a while then settle down on a solid substrate.
3. Observe the slides of the scyphistoma and strobila. These are the polyp stage of the jellyfish. Note how small they are compared to the jellyfish. The strobila is asexually budding new .
4. The young medusae are called the ephyra. They will grow into the adult jellyfish you saw in #1.

Review Questions:

1. Why are jellyfish considered part of the plankton? Are they phytoplankton or zooplankton?
2. Where would you find the polyp stage?

3. How does such a complex life cycle benefit these organisms?

B. Animal Reproduction:

Most animals reproduce both **sexually** and **asexually**. Asexual reproduction produces genetically identical copies (ie. clones) while sexual reproduction produces genetically unique offspring. There are advantages and disadvantages to both types of reproduction that will be discussed in lecture Even in animals which rely mainly on sexual reproduction for procreation (such as Vertebrates) asexual reproduction appears in the form of wound healing, tissue repair and replacement, or as more complex processes such as budding and regeneration.

Lab Activities:

1. Review the exercise we did earlier in the course on kinds of asexual and sexual reproduction. Be able to define the following types of reproduction that are common in the animal kingdom.

Asexual Reproduction in Animals	**Sexual Reproduction in Animals**
1. Fission	1. Monoecious Animals (=Hermaphrodites)
2. Budding	2. Dioecious Animals
3. Regeneration	a. Protandry
4. Fragmentation	b. Sexual Dimorphism
5. Polyembryony (twinning):	c. Parthenogenesis (Virgin Birth)

Review Questions:

1. Compare and contrast the sexual stages of plants and animals.
2. Compare and contrast development of the zygote in plants and animals.

C. Embryological Development

Sexual reproduction includes:

1. the development and maturation of the gametes; the egg and sperm
2. fertilization to produce the zygote
3. embryological development from single celled to multicellular form
4. and often a freeliving larval stage

After fertilization, the zygote typically goes through various developmental (or immature) stages as the life cycle progresses from the zygote to adult. Such terms as **larva**, **pupa**, **metamorphosis**, **nymph**, **fetus**, etc are used to describe these immature stages.

Lab Activities:

Embryological development includes the processes of **growth**, **determination**, **differentiation** and **morphogenesis.** Observe the slides indicated to follow these processes of animal development:

1. Gametes. The gametes are produced by the process of meiosis which differs from mitosis in that only one of each chromosome ends up in the cells after division. The male gamete, the sperm, is small and almost always flagellated. The female gamete us usually large since it contains yolk, and spherical.

slides: sperm smear [Fig 2.8]
starfish unfertilized eggs [Fig 2.11]

Distinguish between sperm and eggs and to find the following structures on **slides and illustrations:**

for **sperm** identify: head, middle piece, tail (flagellum)
for **egg** identify: cell membrane, nucleus, nucleolus

2. Fertilization. At fertilization only a single sperm penetrates and adds its chromosomes to those in the egg. The fertilized egg then has a pair of each chromosomes, one from the male parent and the other from the female parent. To prevent additional sperm from penetrating the egg a

fertilization cone is produced to move the original sperm into the egg quickly. Then a fertilization membrane expands around the egg and pushes away and "locks out" other sperm cells.

slide: starfish early cleavage, *Asterias* eggs

Distinguish between unfertilized and fertilized eggs [Fig 2.13]

3. Embryonic Development - identify the various stages of starfish embryology as illustrated in the lab manual and as seen on the following slides.

a. Cleavage. The first identifiable period of embryonic development occurs as the fertilized egg begins to divide. These early divisions are called cleavage divisions and each cell produced is a blastomere.

Slide: starfish –early cleavage [Fig 2.13]

Observe the slide of starfish eggs in early cleavage and be able to distinguish this stage from those that follow
-note 2,4,8 cell stages
-blastomeres

b. Morula: continued division leads to a solid ball of cells called the morula.

Slide: starfish, late cleavage [Fig 2.13]

Identify the morula stage. How does its size compare with that of the fertilized egg?

c. Blastula or Blastocyst: If the embryo is spherical it is called a blastula; if it is a flattened disc it is called a blastocyst, both are equivalent stages. At the blastula stage, the cells form a hollow sphere. The cavity inside is called the blastocoel.

Slide: starfish blastula; starfish development [Fig 2.13]

Identify the blastula and distinguish it from other embryological stages
-hollow ball of cells
-blastocoel

d. Gastrula or Primitive Streak: In the gastrula, a depression forms at one end of the embryo, cells move in to form a saclike pouch. The embryo is now essentially two layered. The cavity of this new pouch is called the archenteron which is surrounded by the original, now much smaller blastocoel. The archenteron opens to the outside through the blastopore. The blastopore will eventually become either the mouth or the anus of the adult animal.

Slide: Starfish gastrula, starfish development [Fig 2.13]

Identify the blastula and distinguish it from other embryological stages. Note the structures below
-invagination
-primary germ layers: ectoderm, endoderm
-archenteron
-blastopore

In the case of the blastocyst, the flattened embryo, this next stage is called the primitive streak stage. A slit forms in the center of the sheet of cells (= the primitive streak) and cells migrate into the slit and under the original layer of cells to form a double layered disc. This stage is equivalent to the gastrula above.

Slide: chick, 18 hr, wm [Fig 2.16]

Identify the primitive streak stage and understand what is occurring here. Note the following structures:
-original blastocyst
-primitive streak
-double cell layer; primary germ layers: ectoderm and endoderm

4. Larvae. Further development varies considerably in different animal groups. In some animals, especially marine animals, the embryo soon becomes a freeliving larva. While each phylum and sometimes each class usually has its own characteristic larvae, there are a few larval forms that are found in more than one phylum. Similar larvae imply similar ancestry; indicating that the phyla are relatively closely related. The larvae listed below are evolutionarily significant. You should be able to distinguish them from each other and name them. (You do not need to know to which group each belongs)

Slides: *Aurelia* **planula**, wm [Fig 7.23]
Patella **trochophore** larvae, wm
Nauplius, barnacle, wm

a. Planula. A simple multicellular, oval larva with no discernable organs its surface is covered with cilia

b. Trochophore. A top-shaped larva with a digestive tract beginning at the mouth and terminating in an anus. Tufts of cilia are found at each end and bands of cilia surround the wider central area of the larva. Unfortunately, the trochophore slides we have are not the best and very few of the larvae on the slide are oriented properly to show the above characteristics.

c. Nauplius. A triangular larva with three pairs of jointed appendages, eyespots, and digestive organs.

Review Questions:
1. How difficult is it to distinguish between the different stages of development.
2. What is the difference between an embryo and a larva
3. What kind of cellular reproduction is occuring during this development after the fertilized egg is formed
4. What are the advantages of having such a complex developmental cycle?
5. What are the advantages of having a free living larval stage?

III. Animal Diversity

Being the most diverse kingdom, there are numerous phyla of animals. Earlier you saw a list of only a few of the larger groups. Some of the characteristics that are used to characterize and distinguish between various animal phyla are;

the types of body symmetry
the presence and kind of body cavity
the design of various organ systems: skeletal, muscular, nervous, endocrine, respiratory, digestive, excretory, reproductive systems
the type of gut
the presence of segmentation

Because of the great diversity in animal form and function we will concentrate our study on a few basic designs seen in the animal kingdom by studying representative specimens of some of the larger groups (phyla).

1. Sponges [Fig 7.1 – 7.7]

Some of the simplest animal phyla lack either true tissues (for example the **Sponges)** or true organs (for example the **Cnidaria**)). **Sponges** are some of the simplest kinds of animals, they lack true tissues and organs and yet are a very successful group. Their body is riddled with pores and canals through which water is filtered for food. Most live in the ocean but some are found in freshwater lakes and streams. Sponges secrete small rodlike structures called **spicules**, for support. These **spicules** can be made **of silica, calcium carbonate** or a protein called **spongin**. Sometimes these spicules are interwoven to form a complex supporting frame such as in the glass sponge or the commercial sponge. Sponges are also atypical animals because they are **sessile** (nonmotile) as adults, however their larvae do swim around before settling down. Another characteristic feature of sponges is a unique kind of cell that they use to collect food called a **collar cell** or choanocyte.

Lab Activities:

A. Slide of *Scypha* (=*Grantia*)
B. Slide of spicules
C. Miscellaneous sponges on display

Lab Activities:

1. Observe the preserved specimens of *Scypha* (=*Grantia*)

2. Now, look a a slide of a cross section of this organism [Fig 7.4]

   slide: *Scypha* (or *Grantia*) cs

   and identify the large space in the center of the organism, the **spongocoel**. Note also how the "wall" of the sponge is made up of various **canals** through which water passes

3. Where in these canals would you expect to find **collar cells?**

4. Draw a collar cell and describe how it works and what it does

5. Look at the slide of spicules [Fig 7.6]; locate, identify and draw a few of them

   slide: Grantia spicules wm

6. Observe the variety of sponges on display and be able to recognize them as sponges. Note the kind of skeleton each has: spongin fibers, calcium carbonate or silica.

7. Note the symbiotic crabs trapped within the venus flower basket on display. How did they get there and why are they there?

8. Observe the holes made by boring sponges and draw a few examples. How did the sponge make this holes, and why?

2. Cnidaria (Jellyfish and Corals) [Fig 7.8 – 7.44]

The **Cnidaria** (Jellyfish and Corals) have two **true tissues** but no true organs. Their body structure takes the form of a simple sac with **tentacles** around a mouthlike opening pointed upward (called a **polyp**). Some have a thick layer of jelly like material between their tissue layers giving them their common name, the jellyfish, and with the mouth and tentacles pointed downward (called a **medusa**). Most cnidaria have a fairly complex life cycle where they alternate between two different forms; the **polyp** and the **medusae**. The polyp is sometimes **colonial**, usually **sessile**, and may reproduce sexually or asexually depending on the species. The **medusae** swims as **plankton** near the surface of the ocean and usually reproduces sexually. The medusa also has some simple sensory cells that detect light and help it maintain balance. While the cnidaria lack true organs the mouth does open into a sac-like **gastrovascular cavity** in which digestion takes place. They also have a very simple type of nervous system called a **nerve net**. Some Cnidarians (corals) secrete an **exoskeleton** of calcium carbonate which, over thousands or millions of years produces large coral reefs and limestone rocks.

Cnidaria are predators. The most unusual kind of cell in the group is a stinging cell which contains a poisonous harpoon-like structure called a **nematocyst** that they use to spear their prey and "reel" it into their mouth.

Lab Activities:

1. Living *Hydra* (if available)
2. Slides of *Hydra*; wm & cs
3. Slides of *Obelia* hydroid colony and medusae
4. Various examples of the group on display

Lab Activities:

1. If **living hydras** are available: Place a living specimen in a watch glass with a little water. Also place some daphnia (food for the hydra) in the same watch glass and place on a dissecting scope. [see Fig 7.10-7.11]

    a. Note the **tentacles** surrounding the mouth on the free or unattached end. These tentacles help to capture and hold food. Watch carefully what happens when a food organism makes contact with a tentacle. does the hydra use more than one tentacle to move the organism toward the mouth? Is the organism oriented a certain way before being swallowed? After swallowing the food does the hydra contract or remain elongated? What kind of organism is the daphnia? does it have complex organs? Can you identify any of the organs that it has? how does it move?

    b. The hydra may have attached itself to the bottom of the dish by its **basal disc**. Special adhesive gland cells secrete mucus which helps the organism to adhere to a surface. Carefully loosen the hydra from the dish with a blunt probe then describe its locomotion or reattachment.

    c. Note the variety of hydra in the jar. Observe and describe each of the different types, how do they differ? Why do they differ? What type of **symmetry** do hydras have?

    d. Take a hydra and place it on a depression slide. Place the slide on the dissecting scope and add a drop of methylene blue while watching through the dissecting scope, What happens? Place a cover slip on the slide and observe under scanning and low power on your compound microscope. Can you see any ejected **nematocysts**? Are they all the same or are there different kinds? explain. Diagram some of them. Both of the organisms, the hydra and its prey are freshwater organisms. Would they be part of the **plankton**? or part of the **benthos**? explain.

2. Observe the slides below of a Hydra, one of the simplest Cnidarian animals

slides: **Hydra wm** [Fig 7.10,7.11]
Hydra budding wm [Fig 7.10]

a. On the wm slides locate and identify the **tentacles** used for capturing food**,** the **mouth** in the center of the tentacles**,** the **basal disc** which it uses to attach to hard surfaces, and asexual **buds**, if present.

b. Look at the sections of Hydra on the slides below and compare it to illustrations.

slides: **Hydra cs & ls** [Fig 7.8,7.12,7.14]
Hydra nematocysts cs

Locate the **two true tissue layers** of these animals; the outermost **epidermis** and the inner **gastrodermis.** Look at the slide above labeled nematocysts and try to locate the nematocysts in the cell wall of the hydra. Draw and describe a nematocyst.

3. Observe the slides of *Obelia*, a colonial Cnidarian, that has both a **polyp** and a **medusa** stage

slides: ***Obelia*** **hydroid colony wm** [Fig 7.17-7.19]
Obelia **medusae wm** [Fig 7.20,7.21]

distinguish between the medusa and the polyp (=hydroid) forms. How many individuals are included in the piece of the hydroid colony that you have on the slide. Are they all the same shape? Explain. How easily can you distinguish between polyps and medusae? in solitary animals? in colonial animals?

4. Some members of this group are quite dangerous, even lethal to humans. Note the Portuguese Man-O-War on display; this is a colonial Cnidarian in which some members of the group are responsible for feeding, others for killing or stunning the prey, others for flotation, etc. Using the illustrations provided, can you recognize any individual polyps in the colony? What makes this organism so dangerous?

Observe other examples of jellyfish, soft corals and sea anemones. How are they similar, how do they differ? Be able to recognize them all as members of the animal phylum **Cnidaria**

3. "Worms" (Many Phyla)

Wormlike animals typically have elongated, usually **cylindrical** bodies with a mouth at the front end. Some live in burrows or tubes and most (but not all) have a complete digestive tract. As you learn the anatomy and characteristics of these animals compare them to the simple animals you have already observed. How do each of these phyla differ from each other? Can you tell if either is more or less specialized than the other?

A. Planarians (Flatworms) [Fig 7.45 – 7.48]

Planarians are some of the simplest wormlike animals that have true organs and organ systems. Most are relatively small (or at least thin due to their flattened bodies) with no body cavity or circulatory system but members of this group do have organs and organ systems. The flatworms have an **incomplete digestive tract** with a **mouth** but no anus. After absorption, undigested food is expelled through the mouth as in the hydra you looked at earlier. They have simple sense organs including **eyespots** which act as photoreceptors and **auricles** which are chemoreceptors. One group of flatworms lives in the ocean and freshwater lakes and ponds. There are also a few that are terrestrial, that is, they live on land. Both are common in the Austin area.

Lab Activities:

1. Live planarians (if available)
2. Slide of planarian (=*Dugesia*), wm and cs
3. Other living & preserved planarians in display

Lab Activities:

1. If live planarians are available use a wide mouthed dropper to pipette one or two into a small watch glass as instructed. View using the dissecting scope. Note the head end with the eyespots that detect light and the auricles, earlike flaps on the side of the head that detect chemicals in the water (so they are really more like a nose or taste buds)

   Observe the smooth gliding motion of the animal as it uses microscopic cilia and muscular contractions of the body wall to move. Gently touch the worm in various places with a toothpick and note its response. Does this animal have a nervous system?

   Place a ***very small*** piece of liver (beef or pork) in the watch glass and note the animal's response. Try to locate its mouth (It's NOT at the front end). The mouth is at the end of a straw-like, muscular throat or pharynx and is quite prehensile, like the trunk of an elephant. Describe how it uses its mouth to eat the food.

2. flatworms: **planarians**
   a. Stained whole mounts (atlas p107)[Fig 7.46]

      slide: *Planaria*, injected, wm

      Find the **head**, **eyespots**, and **auricles** on the slide mounted specimen. This animal has been stainded to show its highly **branched digestive tract** (=gastrovascular cavity). Note the three main branches with numerous side branches; since this animal has no circulatory system this branching is an alternate way to get food to all cells in the body. Note also the tubelike **pharynx** with the **mouth** at its end near the center of the animal. Describe the digestive system of the planarian; is it a complete or an incomplete system; where is the mouth; is there an anus?

   b. Cross sections of Planaria (atlas, p107)[Fig 7.47,7.48]

      slide: *Planaria* , cs

      This slide contains 2 or 3 cross sections of the same animal. Compare the cross sections to illustrations available. Notice that the "**skin**" (body wall) is more complicated than that of the hydra; the hydra was just a single layer of epidermis while the planarian has a layer of **epidermis and a couple layers of muscle tissue** just underneath the epidermis. How many different systems can you recognize in these cross sections? Can you find parts of the digestive system? Can you see the pharynx in any of the sections – how can you recognize it?

3. Compare any flatworms on display to the planarian you just studied; describe the similarities and differences

B. Vinegar Eels

Vinegar Eels are **Roundworms** (=Nematode Phylum) and are mostly free living worms with elongated cylindrical body tapered at both ends. They move with a characteristic "s" movement since their body wall has only longitudinal muscle layers which work against a **hydrostatic skeleton**. They have a simple but **complete digestive tract** with **mouth** and **anus** so that food travels in one direction only. They have a simple **body cavity** allowing for greater development and differentiation of body layers and internal structures. Vinegar Eels are small free living nematodes found in rotting fruits.

Lab Activities:

1. living vinegar eels

Lab Activities:

1. Vinegar Eels: *Anguillula aceti* **live:** vinegar eels

   a. . Place a drop of the culture on a clean glass slide and examine under low power.

   b. Note characteristic thrashing movement that the animal makes. Because they have only longitudinal muscles in the body wall nematodes can only flex the body from side to side. They can do little more than thrash in water. But add a few grains of sand to a slide and note their change in movement.

   c. To study their anatomy you may need to make another wet mount and add a drop of *detain* to a slide. Can you determine which is the front end of the animal? Note at the blunt end, the **mouth**, and the muscular **pharynx**. Can you see the intestine? Try to find a female and note the developing **juvenile worms** in the **uterus** (vinegar eels bear live young) Try to find the **ovary**. In the male try to identify the **testis**.

C. Earthworms [Fig 7.85 – 7.94]

Earthworms have elongated, wormlike bodies with repeating, **segments**. The efficiency of their digestive tracts has been improved by an infolding called the **typhlosole** which increases the surface area for absorption. Segmented worms also have a **circulatory system** with beating **hearts** which helps to distribute food and oxygen and works with the excretory system, the nephridia, to rid the body of metabolic wastes. *Lumbricus* is a common species of earthworm introduced into the US from Europe. Though it seems relatively large, some earthworms get as long as 10 feet.

Illustrations of earthworms and their relatives are in your atlas pages 116-118 to identify various anatomical features while observing and dissecting as described and listed below :

Lab Activities:

1. External anatomy of an Earthworm
2. Earthworm Dissection – internal anatomy
3. Earthworm relatives – other annelids

Lab Activities:

1. **External Anatomy of an earthworm:**
   Get an earthworm from the container, place it in one of the dissecting trays and gently rinse with water to remove some of the preservative. See [Fig 7.85, 7.87,7.88]

   The most conspicuous feature is the presence of body **segments**. Find the **mouth** at the anterior end. The anterior end can be most easily identified by the presence of a lighter, thicker area of the body, the **clitellum,** a reproductive structure, about a third of the way back from the mouth. Note the **anus** at the other end of the animal. Gently rub your fingers down the sides of the earthworm and feel the bristle-like **setae**. Use a dissecting scope or magnifying glass to see them. For the earthworm, these setae allow it to hold itself into its burrow when a bird is pulling on the other end!

2. **Internal Anatomy of an earthworm:** see[Fig 7.86, 7.90,7.91]
   Use a razor blade or scalpel to make a *shallow* incision on the dorsal body wall from behind the **clitellum** up to the **mouth**. Spread the body wall and pin it open as demonstrated (see illustration). Note that the **segments** that you can see on the outside of the animal are divided inside the animal by thin walls. Most of the body cavity is filled with the **digestive tract** running through each segment from **mouth** to **anus** (a **complete digestive tract**). The mouth opens into a muscular pharynx just as in roundworms. If you dissected the animal carefully you might be able to see two small whitish bulbs at the very front of the pharynx: this is the animal's **ganglia** which act as a simple brain.

Look at the **slide** on demonstration of an earthworm nervous system and you will see how the **ganglia** are attached to two **nerve cords** which extend down the length of the animal

Return to your dissection and note the 5 pairs of **hearts** just behind the **pharynx**. Earthworms have a **closed circulatory system**, meaning that blood flows inside of vessels (**arteries-capillaries-veins**). The hearts keep the blood circulating within these vessels. The blood of earthworms contains the same red oxygen carrying pigment as human blood, **hemoglobin**.

Surrounding the digestive system around and just behind the area where you found the hearts are various reproductive organs. Earthworms are **hermaphrodites** and therefore have both **ovaries** and **testes**. The ovaries and testes are quite hard to see and you don't need to find them, but you should be able to notice several pairs of large whitish structures, these are the **seminal vesicles**, storage sacs where sperm mature before they are released, and much smaller, **seminal receptacles**, where sperm are received during copulation. When earthworms mate, they align themselves in opposite directions (see illustration) so each can fertilize the eggs of the other worm.

Behind the area where the hearts and reproductive organs surround the digestive tract you will find two enlargements of the tract. The first is a storage area called the **crop**. The second is a muscular area called the **gizzard** that helps grind up the food for easier digestion.

Behind the **gizzard**, the **intestine** continues for the rest of the length of the animal. In the intestine digestion is completed and nutrients are absorbed into the blood. Cut the intestine across its length and note an infolding of the intestine (called the typhlosole, see illustrations) that increases the area available for absorption; making the process more efficient.

When you are finished with your dissections, rinse and dry pan, pins, tools, and discard the animals in the white bucket marked **"scraps"**

3. **Sand Worms, Tube Worms, Fan Worms:**
   These marine worms are relatives of the earthworm. Note that they are also segmented and most lack a distinct head. Most marine worms have a pair of appendages on each segment that can be used for swimming and gathering food. In some marine worms some of these appendages are modified into large showy fans and other kinds of food gathering organs. they might also be used as "gills" or for protection. Compare the preserved sandworm, *Nereis*, to the illustrations in your atlas (p 116; Fig 7.63 & 7.64) [Fig 7.81-7.84] and other illustrations provided. Locate and identify the following external structures: **mouth, jaws, pharynx, parapodia, segments,**

   Look at the other examples of marine worms on display and note how the appendages (parapodia) have been modified in a variety of ways

4. Shelled Animals (Many Phyla)

A wide variety of animals including clams, snails and their relatives secrete and live inside some kind of shell. This shell is a type of **exoskeleton** that is used for support and sometimes for protection from predators.

A. Clams [7.70 – 7.73]

Clams secrete two shells that are hinged together and can completely enclose the animal's soft parts. Most clams are benthic filter feeders and either spend their lives attached to some hard substrate such as rocks or pilings or burrowing in soft sediment.

Lab Activities:

1. Shell anatomy
2. Internal Anatomy of a clam
3. Demonstration: Other animals that secrete shells

Lab Activities:

1. Study the **shell** of a clam (whole shells and broken pieces) and identify the three layers of the shell; the outermost **periostracum** – usually a covering of soft, organic material, the middle **prismatic layer** – this is the thickest layer that provides most of the strength for the shell, and the inner **nacreous layer** – usually a pearly white, blue or other colored, smooth layer. This inner layer is often used to make jewelry and buttons. The same kind of shell material is used by the animal to cover irritants such as sand grains and may eventually produce **pearls**, also used for jewelry.

2. With your instructor's help, open the clam to identify some of the internal structures. Clam shells are usually difficult to open because of one or two strong **adductor muscles** that contract to hold the 2 halves closed. These muscles are cut to be able to open them. Find the **adductor muscles** near the **hinge** of the shells. Note the thin sheets of tissue just inside the shells. This is the **mantle** and actually secretes the shells as the animal grows. Determine the posterior end of the animal (Ask for help if you can't figure it out) and note that the edges of the mantle are thickened into two **siphons**. Most clams are **filter feeders** and create a continuous flow of water that comes in one **siphon** and out the other. As the water passes over the **gills**, two thin sheets of tissue toward the hinges, nutrients are filtered out and sent to the **mouth**. The mouth is located at the front of two pairs of smaller sheets of tissues called the **labial palps**.

   The **gills** also remove O_2 from the water. In some clams the gills also become a brood chamber (=marsupium) for the developing embryos.

   Extending from between the two pairs of gills is a hard, muscular structure called the **foot**. Clams are able to extend this out of the shell to burrow into the sediment or to move around on its surface. The mass of tissue above the foot contains the digestive & reproductive systems of the clam.

3. Observe the variety of shelled animals. Sometimes the shell is secreted as an outer covering over the animal. Other animals produce an internal shell that is covered with some kind of skin or epidermal tissue. Distinguish between animals with an exoskeleton versus those with an endoskeleton.

   eg. One group of arthropods, the barnacles, typically secrete 'living quarters' that consist of several shell-like plates fused together with a moveable "trap door" that can be opened for the animal to feed. Sometimes this home is fused directly to a substrate such as a rock, coral or a whale; others are attached by a fleshy stalk to the substrate.

   eg. In the case of starfish and sea urchins the internal shell, or endoskeleton, is composed of numerous calcium carbonate plates found just under the skin. These plates may be completely fused together as in sea urchins or sand dollars, or be loosely jointed and flexible such as in starfish and brittle stars.

   Note the number of shells secreted by the animal. Which animals produce a stalk that attaches the shell to a substrate? Compare and contrast the internal anatomy of the various forms of "shelled animals".

5. Arthropods [Fig 7.106 – 7.143]

Arthropods are the largest and most successful group (phylum) of organisms (of any kingdom!) on the planet. Fully two thirds of all life on earth are arthropod species. They include; spiders, crabs, shrimp, insects, centipedes, millipedes and numerous other groups all of which share the basic characteristics of having a chitinous exoskeleton, body divided into segments, and paired jointed appendages. Of all the **invertebrates**, the arthropods are the most complex and diverse in terms of structures and physiology. One of the sources of the diversity of the group is the diversity of form and

function of the paired appendages. They have been modified in various groups for feeding, walking, swimming, web building, reproduction, and as sensory structures.

Three of the major groups of arthropods are the **chelicerates** (horseshoe crabs, spiders and scorpions), the **crustaceans** (crabs, crayfish and shrimp) and the **uniramia** (centipedes, millipedes and insects. The members of each group can be distinguished by a characteristic body plan and a few distinctive organs as described below.

A. The Chelicerates

Except for the horseshoe crab, most chelicerates live on land and most have only simple eyes. Chelicerates do not have a distinct head, instead, it is part of a **cephalothorax** which includes the head and the part of the body with most of the internal organs. Chelicerates also have distinctive feeding appendages called **chelicerae** that are pincher like or fang like, and a second pair of feeding appendages called **pedipalps**. Chelicerates are also the only arthropods that **do not have antennae**.

Lab Activities:

1. anatomy of a horseshoe crab
2. anatomy of a spider
3. anatomy of a scorpion
4. examples of other chelicerates

Lab Activities:

1. The horseshoe crab: *Limulus*

The horseshoe crab is is an ancient animal and has been around for 100's of millions of years. Today they are common in shallow waters along the Atlantic coast. See illustrations in your atlas (fig 7.78) [Fig 7.107].

The body is subdivided into the larger shield-like **cephalothorax**, **abdomen** and a long spinelike **telson**. On the cephalothorax, note the two kinds of eyes, the large **compound eyes** and the much smaller **simple eyes**. The compound eyes can form crude images and detect movement (of an approaching predator for instance) the simple eyes detect only light and dark.

On the underside of the cephalothorax are 4 pairs of walking legs and various other appendages. *Limulus* eats worms, clams and other small invertebrates that live in and on the sediment. The mouth of the horshoe crab is located within the circle of appendages. Note the stiff spines on the bases of the legs (called **gnathobases**) used to push food into the mouth. The first pair of appendages are the **chelicerae**, small appendages with a pair of pinchers on the end that are used to grasp food and place it into the mouth. The second pair of appendages are called the **pedipalps** which also help in feeding.

The underside of the **abdomen** has the **gills**, called book gills in *Limulus* because if you lift some of the flaps you will see the gills appearing as many thin pagelike sheets underneath. The anus is in the soft tissue between the abdomen and the **telson**.

When you have completed your observations return the specimen to the bucket.

2. The garden spider, *Argiope*

A common spider worldwide and in the Austin area is the large garden spider. It is brightly colored and weaves a large intricate web to trap prey. see [Fig 7.108, 7.111]

Again note the **cephalothorax** and the **abdomen**. The **cephalothorax** contains several pairs of **simple eyes** (no compound eyes) and the feeding appendages; the **chelicerae** and **pedipalps**. The chelicerae are very small and have retractable fangs which inject venom into the prey to immobilize or kill it. The pedipalps are slightly smaller appendages to the sides of the fangs.

The **abdomen** contains the **spinnerets** that produce silk for the web.

3. The scorpion

Scorpions are also common in our area, Central Texas is home to two species of scorpions. Refer to illustrations and descriptions in your atlas, (fig 7.83) [Fig 7.113], as you study these animals

Again, note the **cephalothorax** that contains the sense organs, feeding appendages and legs. The segments behind the cephalothorax are considered the **abdomen**, note how the last several segments are much smaller and more flexible than the larger, first ones and that the smaller segments terminate in a **stinging barb** (=aculeus). Near the front of the cephalothorax are a pair of small **eyes**. In front of that are the feeding appendages the small pincherlike **chelicerae** and the much larger pincherlike **pedipalps** that resemble the pinchers of a crab or crayfish. Also note that scorpions, like spiders, have 4 pairs of legs.

4. Note other examples of chelicerates that are on display

B. The Crustacea

Most crustaceans are aquatic, in both marine and freshwaters. They make up a significant part of the **plankton** and the **benthos** of aquatic habitats. Only a few have moved onto land, the common sowbugs and pillbugs. Like the chelicerates, most crustaceans also have a **cephalothorax** rather than a distinct head. They differ from chelicerates in that their main feeding structures are jaw-like **mandibles**. They also have several other pairs of feeding appendages that help to take in food. Crustaceans also usually have **two pairs of antennae**.

Lab Activities:

1. External anatomy of the crayfish
2. Internal anatomy of the crayfish
3. Other Crustaceans

Lab Activities:

The Crayfish: *Procambarus*: **preserved:** crayfish

1. **External Anatomy:** (atlas 7.85-8)[Fig 7.118, 7.121, 7.122. 7.123, 7.126]. Observe that the crayfish body is subdivided into a **cephalothorax** and an **abdomen**. Near the front of the cephalothorax are a pair of **compound eyes** and **two pairs of antennae**. Near the bases of the antennae are several pairs of feeding appendages, gently move them aside with a probe or forceps and note to hard, whitish **mandibles** (jaws) that serve as the animals main feeding structures. On the underside of the cephalothorax are 5 pairs of **walking legs**, the first pair are much larger with large pinching **claws** at the end. The abdomen contains pairs of smaller appendages called **swimmerets** used in swimming and, in females to care for the egg mass. In males, the first two pairs are modified and are used to transfer sperm to the female during reproduction. At the end of the **abdomen** is the fan like **telson** (uropod) used in swimming. How many different functions do the crayfish appendages perform?

2. **Internal Anatomy:** [Fig 7.119, 7.120, 7.124, 7.125] Carefully remove the top of the cephalothorax by peeling it upwards and off or by cutting an oval area around the top of the entire cephalothorax and carefully lifting it off. Looking down into the body you should see a diamond shaped **heart** near the surface, which may be inside a clear membranous sac. Note the two holes or slits in the heart; arthropods have an **open circulatory system** The body fluids of crustaceans contains an oxygen carrying proteins that contains copper so the fluids appears bluish in living animals. The body fluids enter the heart through these openings and are then pumped through vessels to various parts of the body.

On each side of the body cavity are numerous feathery **gills** that are attached to the bases of the walking legs. The gills are used to exchange oxygen and carbon dioxide.

In front of the heart is a sac with hardened ridges and teeth inside, this is the **stomach**. The teeth inside are called the gastric mill since they grind up the food. Behind the stomach and underneath the heart are the reproductive organs, either **ovaries** or **testes**. Beneath them is a large **digestive gland** that secretes digestive enzymes into the stomach.

The **abdomen** of crayfish and shrimp are referred to as "tails". Why is this an incorrect term? Cut through the exoskeleton of the abdomen. Note that it is packed with **muscle tissue**. Crayfish (and shrimp) move quickest by moving backwards with these powerful muscles and the flipper-like **telson**. This is also the part of the crayfish (or lobster, or shrimp) that seafood lovers enjoy the most. How does this compare with the abdomen of a crab? On the upper surface of the abdomen is a dark tube, the intestine filled with undigested wastes, that is referred to as the "vein" in more polite circles where they remove it before cooking the animals.

3. Look at the other examples of crustaceans on display. Can you locate the cephalothorax, the two pairs of antennae, etc?

C. The Uniramia

All members of this group have a distinct **head** rather than a cephalothorax.
Members of this group also have **mandibles** as their main mouthparts. And most have a **single pair of antennae** and **compound eyes**. **Centipedes** and **millipedes** look distinctly different from the **insects** within this group.

This third arthropod group consists of two distinctly different kinds of animals;
a. the centipedes and millipedes
b. and the insects

Centipedes and millipedes have a **head** and a long **segmented body** with one or two pairs of **legs** arising from each segment.

Insects have a distinct **head, thorax** and **abdomen** with legs only on the thorax portion of the body. All insects have **three pairs of legs**. Most insects have **two pairs of wings.**

Lab Activities:
1. Centipedes and Millipedes
2. Anatomy of a grasshopper
3. Honeybee modifications
4. Diversity in insect anatomy

Lab Activities:

1. **Centipedes** [Fig 7.142] **and Millipedes** [Fig 7.143]
Centipedes and millipedes are typically long, segmented animals with legs on most segments. They are generally found in soil and leaf litter and in protected areas under rocks and logs. Their body has a **distinct head** with a **pair of antennae** and, usually, with a **pair of eyes**. The rest of the body consists of **similar segments**, each with one or two pairs of l**egs**. Their primary mouthparts are **mandibles** as in insects.

Centipedes [Fig 7.142] are generally predators. The first pair of legs is modified into **poison claws** which, in some species, can cause extremely painful stings. They typically have a flattened body and can be distinguished from millipedes in that they typically have **one pair of legs per body segment**.

Millipedes [Fig 7.143] are herbivores and are generally harmless to humans. Their body is typically more cylindrical although in our area species with flattened bodies are common. They are most easily distinguished from centipedes in having **two pairs of legs per body segment**.

2. **Grasshopper (**preserved): (atlas 7.96-7) [Fig 7.138, 7.139, 7.140]**preserved:** grasshoppers
slide: insect spiracle, wm

Grasshoppers are typical examples of true insects. Their body is divided into a **head**, **thorax** and an **abdomen**. The head contains a pair of **compound eyes** and several smaller ocelli or **eyespots**. They also have a pair of **antennae**. Of their several kinds of mouthparts their primary feeding structure is the **mandible**. The **thorax** bears **three pairs of walking legs** with the hindmost pair modified for jumping. The thorax also has **two pairs of wings**. The segmented **abdomen** contains a **tympanum**, an organ of hearing, on its first segment. Along the sides of most of the abdominal and thoracic segments are **spiracles**, openings to the **trachea** – a series of hollow branching tubes that takes oxygen to individual body cells. At the end of the abdomen are the genitalia; a pair of thick, tweezer-like **ovipositors** in the female and a pair of short **cerci** in the male. Make sure that you have seen and can distinguish between the male and the female grasshopper.

3. **Honeybee anatomy** (use a dissecting scope) **slide:** honeybee legs, wm

Many insects have become highly specialized for a particular lifestyle or feeding habit. Honey bees are social insects that have become specialized for collecting and carrying pollen from flowers to their hive. Use a dissecting scope to compare the legs of the honeybee to those of the grasshopper. Note how the legs of the honeybee have been modified in various ways to better carry pollen.

Pollen Basket - on outer surface of tibia of hind legs
Pollen Brushes - stiif haired, on most proximal tarsal segment of fore and middle legs
Antenna Cleaner - at jct of tarsus and tibia of foreleg
Pollen Comb - rows of stiff hairs in inner surface of first tarsal segment of hind legs

The bees that actually collect pollen for the hive are **sterile female workers**. Remember the **ovipositor** of the female grasshopper that is used to lay eggs. In worker bees this ovipositor is modified into a protective **stinger** with **poison gland**. When the colony is threatened the bees will sting the attacker, sometimes individually or sometimes in groups (killer bees are notorious for the aggressive way they attack and sting victims in large numbers). Because the stinger often has barbs, it is left behind in the victim and the worker dies. Find and identify the stinger and poison gland on the slide.

slide: Honey Bee Stinger [Fig 7.132]

4. **Diversity in insect anatomy.**
As you look at the slides below note the variation and diversity of each organ; how the same part can be modified in a variety of ways to perform different functions

a. Insect Leg Types **slide:** Insect Leg Types, wm

note how the same basic parts are modified in a variety of ways; the structure of the legs is an important characteristic for classification

b. Insect Wing Types **slide:** Insect Wing Types

note the variation and diversity of wing types in insects; certain wing types are characteristic of specific insect orders

c. Insect Antennae **slide:** antennae types, wm [Fig 7.135]

note the variation in structure of the antennae, some of these characteristics are important in identifying orders and species of insects

d. Modifications of Insect Mouthparts **slides:** butterfly proboscis [Fig 7.137a]
Culex, wm
Musca domestica,

compare the mouthparts of a butterfly with that of a mosquito and compare to the mouthparts of the grasshopper

6. The Vertebrates

All the animals we have looked at so far and the vast majority of all animals are called **invertebrates** because they lack a backbone. Most of the animals you are familiar are members of a group we call the **vertebrates**. All vertebrates have an **internal skeleton** (=endoskeleton) of bone and/or cartilage, including a **skull** and a backbone of **vertebrae**. Vertebrates also have a nervous system with a **brain** and **spinal cord**. Most have a well developed **head**, a **mouth with closing jaws,** and **two pairs of appendages**. The major classes or groups of vertebrates with some of their major features are listed below:

A. Fishes (lampreys, hagfish, sharks & rays, perch, sailfish, seahorses, eels, trout, salmon, catfish)
-all are aquatic, either freshwater, marine, or migrate between both
-most have scales under their skin and therefore seem 'slimy'
-most have appendages in the form of fins
-respiration through gills that extract oxygen from water
- with simple nervous and circulatory systems

B. Amphibians (frogs and salamanders)
-all are aquatic at some stage in their life cycle but many live on land in moist soil or near creeks and ponds
-all have to return to water for reproduction
-most have thin delicate skin, without scales, that must be kept moist
- most with appendages in the form of 4 legs
-get oxygen through gills, if aquatic, or lungs, if on land, and also by exchange through the skin
-nervous and circulatory systems still rather simple and 'fishlike'

C. Reptiles (snakes, lizards, turtles)
-oldest group of vertebrates who are completely adapted to land
-surface of skin covered with dry waterproof scales to prevent them from drying out
-reproduction not tied to water since they produce a shelled egg in which the embryo develops
-many care for their eggs and their young
-all respiration through lungs, lack gills and cannot breath through skin
-brain and circulatory system is more complex and more efficient

D. Birds (songbirds, woodpeckers, ducks, geese, hawks, herons, owls, pelicans, penguins, loons)
-live on land but many with various aquatic adaptations to swim and feed in water
-can fly, front pair of appendages are modified into wings
-feathers replace scales over most of body surface
-warmblooded; higher metabolic rate to accommodate the energy demands of flight
-bones of skeleton reduced, hollow and fused to decrease weight while maintaining strength
-respiratory system very efficient with extensively branching air sacs
-circulatory system with 4 chambered heart and two circuits of blood flow
-lay reptile like eggs; most care for their young

E. Mammals (mice, squirrels, cats, dogs, bears, whales, bats, porcupines, moles, humans)
-all are air breathers with lungs, but live on land or in water, some fly
-appendages modified into legs, wings, or arms with claws, nails or hoofs
-most bear live young, feed the newborns with milk from mammary glands, and care for them for a relatively long time
-efficient circulatory system with a four chambered heart and two circuits of blood flow
-efficient respiratory system with a muscular diaphragm to inflate and deflate the lungs
-warmblooded; higher metabolic rate to accommodate the energy demands of very active lifestyles and ability to range over entire planet regardless of climate

-hair in place of feathers or scales, used for insulation in cold weather, also coloration is important in camoflage or displays

Lab Activities:

A. Fishes – lamprey
B. Fishes – shark
C. Fishes – perch
D. Amphibian – frog
E. Birds – pigeon
F. Mammals – fetal pig

Lab Activities:

A. Fishes - The Adult Lamprey: (atlas p131-132) [Fig 7.167 – 7.174]

Preserved lampreys, plastimount

Lampreys are in the most primitive class of vertebrates in the Phylum Chordata. They show a mixture of primitive and advanced traits. The adult lamprey attacks fish by attaching at its buccal funnel to the side of the fish and using its teeth to rasp a wound. It then sucks blood from its prey. It spawns in freshwaters where the eggs hatch into an ammocetes larva which lives for up to seven years before becomming an adult.

1. **External Anatomy** [Fig 7.167, 7.168, 7.169]
   The lamprey body is divided into the **head**, **trunk** and **caudal** regions. It has no appendages, only two **dordal fins** and a **caudal fin**. The **mouth** lacks a lower jaw, it cannot close, and it lined with horny (ie. not bony) **teeth**. A protrusible **tongue** is located near the center of the funnel. A single median **nostril** is located behind the **eyes** on the dorsal surface of the head. External **gill slits** are located laterally behind the eyes.

2. **Internal Anatomy** Fig 7.171, 7.172]
   Look at the mounted sections of lampreys and identify the **teeth** within the mouth, the small **brain** and the **nerve cord**. The **notochord** is the only internal skeleton that lampreys have, it is made of **cartilage**. Note also the **gills** for gas exchange, and the **heart** which pumps blood through a simple **circulatory system**

Do not discard lampreys, return to bucket when you complete your observations

B. Sharks: The Dogfish Shark (atlas, p172) [Fig 8.2 – 8.15] preserved: shark

Sharks have an internal skeleton that is composed completely of **cartilage**. They are very efficient swimmers since a large proportion of their body consists of muscle tissue. In addition to **dorsal** and **tail fins**, they have 2 pairs of fins as appendages. They also have **hinged jaws** that are packed with **teeth** making most sharks efficient **predators**.

1. **External Anatomy** [Fig 8.2]
   Locate and identify the following structures: **eyes, nostril, mouth, gill slits, spiracle, dorsal, caudal, pectoral and pelvic fins, claspers** (in male)
2. **Internal Anatomy** [Fig 8.8]
   dissect as instructed and find: **gills, liver, stomach, intestines, heart, testis/ovaries, kidney**

Do not discard sharks, return to bucket when you complete your observations

C. Bony Fish: The Perch (atlas p178) [Fig 8.16 – 8.18] preserved perch

Most fish, most vertebrates, are in the group called bony fish because their internal skeleton is usually made of **bone**. As in sharks, the skeleton is divided into an **axial skeleton** (**skull, rib cage, vertebrae**) and an **appendicular skeleton** (**2 pairs of fins**) but the appendages are much more flexible and agile allowing much finer control of body motions

1. **Fish Skeleton** (atlas fig. 9.17) [Fig 8.16]
   view the fish skeleton and distinguish between the **axial** and **appendicular** skeletons

2. **External Anatomy** [Fig 8.17]
The fish body is divided into the **head, trunk** and **tail**. note the **dorsal**, **ventral** and **caudal fins** and the pairs of **pectoral and pelvic fins**. also note the **eyes**, **mouth** and the **operculum** covering the **gills**. The **scales** of most bony fish are located under a slimy layer of epidermis. Remove a scale and place it on a dissecting scope and note the growth rings – these rings can be used to determine the age of fish.

3. **Internal Anatomy** [Fig 8.17, 8.18]
Dissect the fish as described and note the **gills, swim bladder, stomach, liver, intestine, heart, gonads (ovaries or testes).** Note also how the muscles of the fish are organized into bundles called **myotomes** that contract to produce the "S" – like swimming motion characteristic of fish.

D. Amphibians: The Frog (atlas p176) [Fig 8.19 – 8.30] preserved frogs
Amphibians are the first vertebrates to make the transition onto land. To do this they needed a stronger skeleton to support their body weight against gravity, appendages that would allow them to move across the surface and a respiratory system able to extract oxygen from air rather than from water. Their transition to land, however, was not complete since their skin must usually be kept moist they are not very well protected from drying out, their lungs are not very efficient and they must therefore get much of their oxygen through their thin skin. Also, most must return to water to reproduce

1. **Frog Skeleton** (atlas fig 9.21, 9.22) [Fig 8.19, 8.20]
Observe the frog skeleton on display and distinguish between the axial and the appendicular skeleton. The axial skeleton is much less flexible than in the fish since it must support the animal against gravity. Abdominal organs are suspended from the **axial skeleton** which bears most of the body weight. Also the bones of the appendages are much better developed into jointed legs for support on land; they are divided into **upper** and **lower legs** and **feet**. How do the frog's legs differ from the paired fins of fish? How has the frog skeleton been modified for jumping?

2. **External Anatomy** (atlas fig 9.20) [Fig 7.182]
Locate and identify the head and trunk, note that adult frogs don't have a tail (but their larvae (tadpoles) do). Find the large prominent **eyes**, the **nostrils** and **mouth**. Note that frogs do not have any teeth and swallow their prey whole. Also note the **eardrum** (=tympanic membrane) behind the eyes. Amphibians rely much more on vision and hearing than do fish.

3. **Internal Anatomy** (atlas p 183-184) [Fig 8.25, 8.26]
Dissect the frog as instructed and find the following structures: the **heart,** the **lungs** are on each side of the heart and are essentially two small thin balloon-like sacs, frogs take in much of their oxygen by exchange through their **skin** and the lining of their **mouths**. The digestive system is similar to that seen in the fish with a prominent **liver** and **stomach**, although the intestine is considerably longer and is subdivided into a **small intestine** and a **large intestine.** Can you explain why the intestine is so much longer in the frog than in the fish? Note the many fingerlike strands of **fat** surrounding the internal organs. Remember that animals generally store energy in this form (whereas plants stored excess energy as starch). Note also how the digestive organs are held in place by transparent sheets of tissue called **mesenteries** to keep them from getting tangled. Find the pair of **kidneys** and (urinary) **bladder** used to get rid of metabolic wastes and the **testis** or **ovaries**. Amphibians must return to water for reproduction; generally the female extrudes 100's of eggs into the water and the male covers them with clouds of sperm.

E. Birds: pigeon

1. **Feathers** (atlas p 136) [Fig 7.190] assorted feathers & study skins
The **feather** is the most distinctive characteristic of birds. They form the **flight surface** and improve the flight efficiency of the body plan. They also provide excellent **insulation** to maintain a high internal body temperature and reduce heat loss. The feather is

essentially a modified reptilian scale. A typical feather consists of the **shaft (**or **rachis)** and the **vane**.

2. **Bird Skeleton** (atlas p188) [Fig 8.40] pigeon skeleton
The basic bones are homologous to those of other vertebrate classes. Many of the bones are fused together and the overall size and mass greatly reduced over the condition seen in amphibians and reptiles., Overall, the skeleton has been lightened by the loss of various elements and the decrease in bone mass of each individual bone. Distinguish between the bones of the **axial and the appendicular skeletons**

3. **External Anatomy** [see illustration provided] preserved pigeon
Using the illustration provided find the following structures: **eyes, bill, nostrils, ear, throat, primaries, secondaries, thigh, tarsus (=shank), scales, toes, claws, vent, tail.**
Note also that the "**thigh**" is equivalent to the "drumstick" of a chicken; the true thigh is close to the body beneath the contour of the feathers. Also, the **tarsus**, which acts as the functional equivalent to our "shin" is actually homologous to our foot.

4. **Internal Anatomy** (atlas p189) [Fig 8.42, 8.43] preserved pigeon

i. Digestive System

Modern birds lack teeth. The **beaks** and **tongues** of birds are therefore modified for a variety of feeding habits. From the **mouth** food passes to the **esophagus**. In many birds, an offbranch of the esophagus, the **crop**, is used for storage. This allows birds to quickly ingest large amounts of food and then move to a safer area to complete digestion. Beneath the crop is the **stomach** or **gizzard.** The **gizzard** has muscular walls which grind the food into smaller pieces. Like reptiles, some birds swallow small pebbles to facilitate this grinding process. From the gizzard, food enters the **small intestine** where most digestion and absorption occurs. Secretions from the **liver** and **pancreas** aid in this process. The **liver** consists of two lobes each of which has a duct that drains into the intestine shortly past the gizzard. The intestine empties into
the **cloaca** before exiting to the outside through the **vent**.

ii. Respiratory System

The respiratory system begins at the **nostrils** which open into the **nasal cavity**. From these air passes into the **pharynx** or throat area. At the bottom of the pharynx the digestive system separates from the respiratory system. Air passes into the **trachea**. Birds have no larynx or voice box. The trachea divides into smaller and smaller tubes inside the lungs and end in small saclike structures called alveoli where gas exchange occurs. This design creates a much larger respiratory exchange surface than that found in the lungs of amphibians or reptiles.

iii. Other internal organs

Also try to find the **heart, kidneys, and gonads**

Do not discard birds, return to bucket when you complete your observations

F. Mammals:

1. **Modifications of Hair** – one of the main identifying characteristics of mammals is the presence of hair. Mammal hair is homologous to the scales of reptiles and the feathers of birds, it grows from follicles in the skin.

i. Horns and Antlers. Misc. horns & antlers

Observe and distinguish between horns and antlers. **Horns** are produced mostly in hoofed animals and grow around a core of bone throughout the animals life. The tough, horny layer surrounding the bony core is *homologous* to the hair on the rest of the body. In contrast, the **antlers** of deer, elk, caribou, etc are made of bone. As they first begin growing they are covered with a layer of "fuzzy" or hairy epidermis called **velvet**, which eventually falls away. Antlers are shed and regrown anually. They are not homologous to the keratinized horn

above.

ii. Armor armadillo
The protective flexible carapace and scutes of the armadillo are formed from fused hairs.

iii. Defensive hairs porcupine; if available
Porcupines and hedgehogs have thick sharp hairs called **quills** that it uses in defense. While the porcupine cannot "shoot" its quills, they do break off easily once embedded in the attacker.

2. Mammal skeletons human skeleton

i. Human.
Like other vertebrates, the basic bones of the skeleton in all mammal are the same regardless of various adaptations and lifestyles and can be grouped into the **axial skeleton** consisting of the **skull, vertebrae, ribs and sternum**, and the **appendicular skeleton** consisting of the **pectoral** and **pelvic girdles** and the **pectoral** and **pelvic appendages**.

ii. Bat wing bat skeleton
Compare the skeletal structure of the bat wing with that of the bird.

iii. feeding adaptations miscellaneous mammal skulls
Just as the beaks of birds are modified for various feeding types, the teeth of mammals are variously modified for various types of foods. Carnivorous mammals typically have large canines to hold onto prey, sharp incisors to cut pieces of flesh and pointed premolars to help chew meat. Herbivore typically have small canines or no canines, nipping incisors and broad flat premolars and molars for grinding the tough plant fiber before swallowing. Omnivores' teeth share some of the characteristics of both feeding types. Observe the teeth in the various skulls and determine whether the animal is a **carnivore** (a meat eater), an **herbivore** (a plant eater)or an **omnivore** (eats both plant and animal foods).

3. External Anatomy - fetal pig (atlas p199) [8.59, 8.60] fetal pig
Identify the following structures**: eyes, nose, mouth, teeth, tongue, ears, umbilical cord, tail, anus, hoof**

4. Internal Anatomy - fetal pig (atlas p199 – 205) [Fig 8.68 – 8.72] fetal pig
Identify the following structures: **larynx, trachea, heart, lungs, diaphragm, liver, pancreas, stomach, small intestine, large intestine, spleen, kidney, ovaries/testes**

5. Nervous system cat nervous system, human brain ,rabbit brain model
Study the preserved cat nervous system and distinguish between the central and peripheral nervous systems. Compare the structure and size of the mammal brain with that of the other classes of vertebrates. How is the human brain different from the brain of other mammals?

Demonstrations

1. The Evolution of Jaws: Understand the origin of jaws from agnathans
2. Examples of the Class Chondrichthyes
3. Examples of the Class Osteichthyes
4. Representative Amphibians - be able to recognize the class of each of the animals on display
5. Representative Reptiles - be able to recognize the class of each of the animals on display in pictures and preserved
6. The Amniotic Egg - note the general structure of the **amniotic egg**. What is the advantage of this type of egg over that produced by fish and amphibians.
7. Comparative vertebrate brains - compare the relative size of the **olfactory lobes, cerebrum, optic lobes, cerebellum,** and **medulla** to the brains of other vertebrate classes
8. Comparative vertebrate hearts and circulatory systems - compare and contrast the structure of

the **heart**, the number and structure of the **chambers**, and the **circuits** of blood flow in the vertebrate classes.

9. Various illustrations of mammalian diversity

Review Questions:

1. As you study each of the major vertebrate groups compare the structure, function and efficiency of each of the systems. What changes are occurring as we progress through the simplest to the more complex classes? Can you see any advantages to these changes?
2. Which features are simply specializations for the animal's particular lifestyle and which represent evolutionary advances first appearing in a particular vertebrate class?
3. Make a list of all the vertebrate organs you studied, give the function of each and indicate which classes of vertebrates have that organ
4. Make comparisons with representatives of the other vertebrate classes in terms of skeletal systems, heart and circulatory system, brain and nervous system and senses
5. What anatomical modifications are most important in allowing birds to fly?
6. How closely do birds resemble reptiles; do you see any similarities?

8. Parasites

Parasites are found in all kingdoms of life but the animal kindgom contains, by far, the greatest variety and diversity of parasitic organisms. **Parasitism** is a kind of **symbiosis** in which one organism, the **parasite**, benefits from the relationship and the other organism, the **host**, is harmed by the relationship. The actual kind of parasitic relationship varies in several ways. **Ectoparasites** live and feed on the external surface (the skin) of their hosts, **endoparasites** live completely inside the host.

Living within the host, endoparasites are found in environments every bit as variable as those experienced by aquatic animals; each host and each internal organ differs in the range of conditions to which the parasite is exposed. The life cycle of many parasites includes more than one host and more than one larval form. Any host in which the larval parasites are found is referred to as an **intermediate host**. The host of the adult parasite is referred to as the **definitive** or **final host**.

Parasites have developed a variety of **adaptations** to be successful in such environments. Some of the most important adaptations seen in parasites are:

1. Presence of various **attachment organs**, eg. hooks, spines and suckers, to adhere to host
2. Nutritional modifications; anticoagulants, anasthetics, etc
3. Reduction in 'nonessential' organs and organ systems such as sensory organs and various digestive organs
4. Great increase in reproductive capabilities such as the number of eggs produced and the ability of larvae to reproduce asexually
5. Development of **complex life cycles** in which larval forms often infect hosts that will become prey for the definitive host to ensure completion of the parasite's life cycle

The effects of the parasite on its host also varies considerably. Evolution favors those parasites who do the least harm to their hosts since the longer the host lives, the better the chances that a parasite can produce successful offspring. The most successful parasites are usually those who occupy their hosts with little significant impact. Typically the most critical time for the host is during the infection process when the larvae are migrating through the body before they reach their preferred organ. Parasites occasionally cause problems by producing **toxins** which can cause fever and organ damage.

Lab Activities:

1. **Liver and blood flukes**: The flukes are parasites found in the digestive organs or the blood of their hosts. These often have complex life cycles that enhance their abilities to get from one host to another. These life cycles usually include several **intermediate hosts**, in addition to the **definitive host** of the adult. They also generally produce numerous eggs and larvae to insure their success in finding new hosts. For this reason the reproductive system is often very well developed in these animals. Also, since they absorb food from their host, they don't need a very complex digestive system – the food is already digested, so you will notice that the digestive system is not as elaborate as was the one in the nonparasitic planarian.

a. *Clonorchis*, the liver fluke: review the life cycle of this organism in your atlas (p109) [Fig 7.52, 7.53] and in the illustrations on display. Note the number of different larval stages and the different hosts of each. What is the advantage of such a complicated life cycle?

slide: *Clonorchis sinensis*, wm

know: oral sucker, ventral sucker, intestine, testes, uterus with eggs

What structures does this organism use to attach to its host?

Compare the size and complexity of the digestive system and the reproductive systems; why the difference?

This animal is a **hermaphrodite** (monoecious), what is the advantage of this?

2. **Tapeworms**: Tapeworms are also intestinal parasites but are even better adapted for a parasitic lifestyle. They have completely lost any trace of a digestive system, their sense organs and nervous system are greatly reduced, they have additional structures for attachment and an even more efficient reproductive system. Their life cycle is not as complicated as in the flukes, the tapeworms usually produce just one larva that is in one intermediate host

slides: *Taenia solium*, scolex, wm (atlas p110) [Fig 7.58 – 7.62]

Taenia pisiformis gravid proglottid, wm

know: scolex, hooks, suckers, proglottids, reproductive organs, uterus

List some of the general ways that the organs systems of this animal differ from those of the flukes

Is this animal a hermaphrodite?

3. **Roundworm Dissection:** *Ascaris* is a common parasite in the intestine of pigs, horses, and humans. It is the largest roundworm parasite. Dissect a male and female roundworm as described below:

External Features: [Fig 7.96, 7.97]

Males can be distinguished from **females** by their smaller size and the curled posterior end. Males often have a pair of setae protruding from the anus. The **mouth**, at the anterior end, is surrounded by three **lips** (use a magnifying glass to see). The **anus** is on the ventral side near the posterior end.

Internal Organs: [Fig 7.95, 7.98, 7.99]

Place the worm in a dissecting pan and add enough water to cover the worm.

Use a small, sharp pin to penetrate the body wall directly opposite the anus. Push the pin in just enough to pierce the body wall, do not push it all the way into the animal. Drag the pin foreward being care3ful not to injure ay of the internal organs.

As one person slits the skin, one or two others should use dissecting pins to carefully spread the body wall open and pin it to the tray to expose the internal organs. The body wall and the organs are very thin and delicate. You will probably need to place pins every inch or two to keep the body wall open.

The body is covered by a tough **cuticle** that is secreted by the **epidermis**. Beneath the epidermis is a layer of **longitudinal muscles**. This single layer of muscles in the body wall is what causes the animal to make the characteristic side to side whiplike movements. The digestive system is simple and consists of a **mouth**, a white muscular **pharynx**, a long, nonmuscular and very fragile **intestine**, and a ventral **anus.**

Filling up most of the body are the reproductive organs (remember, this critter is a parasite). The female reproductive system is basically "Y" shaped and consists of a short **vagina** which opens on the ventral side about one third back from the anterior end of the body. The vagina splits into two long, thick **uteri** where eggs are stored. At the end of each uterus is an **oviduct** which continue on as very thin, threadlike, highly tangled **ovary** where the eggs are produced.

The male reproductive system consists of a single long tube which gets progressively smaller. The **ejaculatory duct** opens at the **anus**. Attached to it is the **seminal vesicle**, followed by a smaller (in diameter) **ductus deferens**, and ending in a very thin, tangled **testis** where the sperm are made.

Make diagrams of the male and female reproductive systems and compare their organs

Demonstrations:

1. Observe other examples of parasites on display
2. Look at the slides below of other parasitic roundworms. Learn where they are found and how they are spread to their final hosts. Compare them to *Ascaris* in size and general structure.
   slides: *Trichinella spiralis* muscle wm [Fig 7.103]
   Enterobius vermicularis wm

Lab Journal:

1. Compare the internal anatomy of the male and female roundworms, what are their similarities and what are their differences
2. Make some diagrams of the slides you see to be able to tell them apart for the practical.
3. Describe some of the special adaptations seen in the parasitic classes that enhance their ability to find and survive in a host
4. How do the larval forms of the trematodes and the cestodes differ and how do their life cycles differ in general (you don't need to use specific terms or larval names)?
5. Describe some of the other examples of the group
6. Do you think you would know if you were infected by one of these parasitic critters? Why or why not?

Name:_____

The Animal Kingdom

1. Exactly how do animal cells differ from plant cells?

2. Do any of the animal tissues have functions similar to those of any plant tissues; Explain?

3. Both plants and animals have true tissues and organs. How exactly do animal tissues and organs differ from plant tissue and organs

4. Describe the differences between **invertebrates** and **vertebrates** and give five examples of each. Which of these two categories contains the most species?

5. Name and describe a specific example of:
   a. an animal with no true organs or tissues

   b. an animal wit true tissues but no true organs

   c. an invertebrate with all organ systems listed in course packet

   d. a vertebrate that is lacking some of the systems listed in the course packet

   e. a vertebrate that has all the organ systems listed in the course packet

6. Describe 5 animal sense organs that humans do not have.

7. How does the movement of a vinegar eel differ from the movement of an earthworm?

8. Describe some of the special adaptations parasites have made to enhance their ability to find and to survive in their hosts.

9. a. How has the honeybee adapted to collecting pollen and nectar?

b. How has the plant adapted to being pollinated by bees?

10. a. How do birds resemble reptiles?

b. How do birds resemble mammals?