The Diversityof Life Lab Manual

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for

BIOL 1409 General Biology:

The Diversity of Life

Lab Activities,
Homework & Lab Assignments
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Biol 1409: Diversity of Life
Ziser - Lab Manual

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Biol 1409: Diversity of Life
Semester Activities

Lab Exercises

The schedule for the lab activities is posted in the Course Syllabus and on the instructor's website. Changes will be announced ahead of time. The Photo Atlas is used as a visual guide to the activities described in this lab manual

Introduction & Use of Compound Microscope & Dissecting Scope

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 disadvantagesof 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

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

Cells: The Basic Units of Life

observe and distinguish between prokaryotic and eukaryotic 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

Reproduction, Development & Life Cycles

learn the general terminology for the different kinds of sexual and asexual reproduction
understand what a life cycle is and the term 'alternation of generations'
learn to recognize some of the different stages of development in plants and animals

Ecosystems of Texas

research the biotic and abiotic characteristics of selected Texas ecosystems

The Bacteria (Archaea & Eubacteria)

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 diversity 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,Shelled Animals, 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 Lab Orientation

The laboratory portion of this course is designed provide you with "hands-on" experience with the diversityof life on earth. This method of 'hands on' learning should also enhance and strengthen the knowledge you gain in lectures.

At times you will be working individually, in pairs or in groups of three or four. Each lab period is loosely structured to begin with a short introduction to the exercise that highlights the activities of the day, what materials are available for use and any changes in procedures. After that you will work independently to learn the material.

There is never enough time in lab to go over each and every item that you are assigned. The lab is a designated a time when you have access to materials that you will not have available during home study time. Some of the information assigned in lab you can learn at home, other items, particularly anatomical terms identified on dissected organs, animals and models and microscopic details viewed with a microscope can only be learned adequately in the lab room.

General Lab Rules:

1. **Read the lab exercise** before you come to lab. There is not time to review every aspect of each exercise and still give you time to work on your own. I will assume that you know what the exercise covers in general and I will only review changes or specific materials that you will use.

2. **Before each lab** familiarize yourself with the highlighted terms and review the illustrations cited in your atlas to familiarize yourself with the day's material.

3. **Read and memorize the laboratory safety rules**. The preservatives are irritants and some of you may be allergic to them. Gloves must be used during dissections and will be provided. Your dissecting tools will be provided for you as well.

4. The PIN lab room is open on Fridays, 8:00 am to 12:00 pm for **extra lab study time**.

Dissections:

Dissections are an integral part of the biology lab experience. There is no substitute for handling and dissecting real tissues and organs as a way to learn the material.

The term "dissection" means "to expose to view". Many beginning students assume that dissecting automatically means "cutting things up" but actual cutting is rare and then it will usually be done with scissors, not scalpels. Scalpels more often damage the material and make things harder to see and their use is discouraged in most cases. While you will occasionally use scissors to begin the process of dissection your primary tools of dissection will be forceps and blunt probes and fingers.

Any dissections will be performed as a group. Typically one person reads the instructions and one or two other students will actually do the dissection. Your instructor will be watching to ensure that this is a *shared* project. Rolls should be rotated frequently. Generally, the person actually doing the dissection is the one who learns the material best.

Dissecting tools are provided in the student drawers. Any dissected materials to be discarded must be placed in the designated container; NOT in the sinks. You will be expected to rinse your i tray, rinse and dry your pins and utensils and replace them where you found them and clean off your counter with disinfectant spray.

Biology Lab Safety Procedures 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 environmental, health and safety procedures and agree to follow the ACC science safety policy. You are expected to conduct yourself professionally with respect and courtesy to all. You can read the complete ACC science safety policy at: *http://www.austincc.edu/sci_safe/*

All safety policies and procedures apply to scheduled lab classes as well as open labs.

Consequences for not complying with safety procedures:

1. You will not be able to participate in a lab activity if:
    a. you are late for class and have missed safety training specific for that day's lab or field activity;
    b. you have forgotten your personal protective equipment;
    c. you refuse to wear personal protective equipment;
    d. you have not followed safety policies and procedures for that lab or field activity.
2. You may be withdrawn from the class and not reinstated if:
    a. you missed required safety training at the beginning of the semester;
    b. you repeatedly fail to follow lab safety policies and procedures.
3. You may be expelled from ACC if you thoughtlessly or intentionally jeopardize the health or safety or another individual.

Emergencies

If there is a life-threatening emergency (fire, major chemical spill, explosion, injury):

1. Report the situation and your specific location (campus, room) by
    - using the safety phone in a lab classroom; it will automatically connect you to ACC Police Dispatch (location of safety phone _____)
    - calling 222 from any ACC phone to reach ACC Police Dispatch
    - calling 512-223-7999 from a cell phone or non-ACC phone to reach ACC Police Dispatch

2. Evacuate if necessary:
    a. take your personal belongings with you if possible;
    b. on your way out, close but do not lock the classroom door;
    c. go to the designated rally point for your campus and building.
        Directions to nearest exit: _____
        Location of rally point:_____

In the event of an extreme emergency or impending threat, ACC Emergency Alert can send critical voice and text messages to your cellphone. Verify and update your ACC Emergency Alert information. For non-emergency calls, dial 512-223-1231.

Safety Equipment and How to Use It:

- Information about chemicals used in this laboratory can be found in Material Safety Data Sheets (MSDSs) and in a chemical inventory located _____.
- The emergency gas shut-off for this lab is located: _____. Shut off the gas immediately if gas nozzles or valves are damaged or if there is a fire.
- Fire extinguishers are located: (1) _____.
  (2) _____.

  To use a fire extinguisher:
  1) twist the pin and then pull it out of the handle
  2) hold the end of the hose and point it at the base of the fire
  3) squeeze the handle
- Fire blankets are located: (1) _____.
  (2) _____.

  If you are on fire, stop, drop and roll. Let someone else to get the fire blanket.
- A safety shower is located _____. If you spill a significant quantity of chemical, especially an acid or base on yourself immediately stand under the shower and pull the handle. Disrobe. The instructor will evacuate the room and close the doors for your privacy. Someone of your gender will stay to help you. Stand under the shower for at least 20 minutes. You will be given clothing after the shower.
- An eyewash is located _____. If a chemical is splashed or rubbed into your eyes you must use an eyewash for at least 20 minutes with your eyes held open. Someone will help you with this.
- If a person is experiencing electrical shock from touching wires or equipment, use a belt or other non-conducting material to pull them away from the electrical source.
- First aid kits are located: (1) _____.
  (2) _____.

  a. Only minor cuts and burns will 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.
  b. The instructor must fill out a report describing your injury.

Personal Protective Equipment (PPE)

1. <u>Required when biological, chemical or physical hazards are present on the lab benches, open shelves or counters:</u>

a. Safety Eyewear
- You must wear non-tinted safety eyewear (safety glasses or goggles) marked Z87 when directed to do so by the lab instructor or lab safety instructions.
- You must bring your protective eyewear with you to every lab class. If you forget your eyewear and the lab room does not have a pair to loan to you, you will not be able to participate in the lab and may forfeit your lab grade for that day. ACC cannot guarantee that loaned safety glasses or safety goggles are uncontaminated by microbes or chemicals.
- People who wear contact lenses must wear goggles and may not wear safety glasses.

b. Gloves – You will be provided with nitrile gloves for handling <u>biohazards and</u> hazardous chemicals. Please notify the instructor if your skin is irritated by these gloves.

c. Shoes – Shoes must cover the top, front and sides of your feet. They must be impervious to liquids.

d. More specific requirements may exist for labs in which unique hazards are present (for example: BSL2 organisms or physical hazards such as sharps, open flame, UV light, pressurized gases, or liquid nitrogen.

2. Recommended when biological, chemical or physical hazards are present on the lab benches, open shelves or counters:

a. Apron or Lab Coat – You may be instructed to wear an apron or lab coat over your clothes when handling biohazards or hazardous chemicals.
b. Wear natural fiber clothing for any lab activity involving open flame (synthetic material melts onto skin in a fire).
c. Before putting on gloves remove watches, rings, and bracelets that could either puncture the glove from the inside or interfere with rapid removal of the gloves.
d. Tie back long hair.
e. Do not wear clothing with long, loose sleeves.

Waste Disposal

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

- Hazardous chemical waste containers are located:
  solids _____
  liquids _____
- Biohazard bags are located: _____
- Sharps containers are located: _____
- Glass (rinsed test tubes and broken glass) disposal boxes are located: _____
- Regular trash containers are located: _____

Lab Conduct

1) At the beginning of any class held in a lab room, do not enter the room until your instructor is present. Wait in the hall, even if the door is open.
2) Do these things:
   - follow all procedures in manuals, in handouts, and as given by the instructor;
   - store backpacks, coats, and other personal items as directed;
   - report broken glass and chemical spills to your instructor immediately.
3) Do NOT do these things:
   - come to class while intoxicated or while under the influence of drugs that impair your ability to safely perform the lab or field activity;
   - horse around or perform unauthorized experiments;
   - eat, drink, or chew (tobacco or gum);
   - bring drinks or food (even in closed containers) into the lab;
   - pipet by mouth;
   - taste chemicals or directly smell chemical fumes.

Lab Hygiene

- Clean up your individual work area/equipment and community work areas/equipment (e.g., sinks, balances).
- Put lids back on bottles and containers immediately after use.
- Do not put excess chemicals back into original containers.
- Dispose of chemicals and waste only as directed by the instructor.
- Turn off equipment as instructed.
- Wash your hands prior to leaving lab.
- Assume that chemicals used in lab are corrosive or irritating. If at any time chemicals come into contact with your skin wash the affected area immediately.

Disease

Diseases such as HIV and hepatitis can be transmitted from person to person through contact with human blood or other body fluids. Follow the Universal Precautions whenever exposure to human body fluids is possible:

- Consider all body fluids (saliva, blood, urine, feces, vomit) to be potentially infected with a harmful pathogen.
- Do not touch or come into contact with anyone else's body fluids.

Student Accident Insurance

All students enrolled in lab classes are covered by Student Accident Insurance that pays for injuries occurring from school sponsored activities related to the class. It does not pay for illnesses such as allergies or the flu, or fainting. All faculty and students should read the guidelines at http://www.austincc.edu/ehs/pdf/Procedure303006StudentAccident012611.pdf

Chemical Hazard Labels

- Label all containers and test tubes as directed.
- Inform your instructor immediately if a label is damaged in any way.
- Read all labels and pay special attention to hazard information.

A typical chemical hazard label conveys two kinds of information: 1) the category of the hazard (flammable, toxic, reactive, or corrosive) and 2) the level of the hazard. There are two main types of labels: those shaped like diamonds and those shaped like bars. In both types the category of hazard is represented by a color and the level of the hazard is represented by a number.

1. Hazard categories are coded by color:

red	fire hazard, flammability
blue	health hazard, toxicity
yellow	reactivity
white diamond	provides more specific information about the hazard
white bar	tells you what kind of protective equipment (PPE) is required for handling that chemical

2. Hazard level is coded by a number:

0	1	2	3	4
minimal	slight	moderate	severe, serious	extreme

3. Refer to the training poster in your lab for examples.

4. Other types of hazard warning labels you must recognize are:

a. biohazards	b. radioactive materials
	

Course Specific Precautions (PIN Biol 1409)

1. Do not bring food or drinks into the lab room.

2. Learn the locations of the vent switch, safety shower, extinguisher, glass disposal boxes, discarded tissue buckets, first aid kit and spill kits and be able to use each

3. Wash lab benches with lysol spray BEFORE and AFTER each lab period

4. Place your books beneath the lab bench, if you have a jacket or sweater there are hooks available on which to hang them. Keep your countertop clear of all but your lab manual and materials you are actually working with.

5. Check your lab stool to be sure the back is tightened

6. If you drop and break a beaker or other glassware do not pick it up, notify me and I'll take care of it.

7. If the floor is wet cover it with paper towels and notify the instructor

8. Follow the procedures as directed for proper handling and care of microscopes and slides

9. Do not have more than one or two prepared slides at your bench at any time.

10. Slides and coverslips that you prepare should be discarded in the glass disposal boxes, do not attempt to clean them ***(Do not discard any of the prepared slides)***.

11. Make sure the venting switch is on when dissections are being done.

12. Use latex or nitrile gloves while dissecting since the preservatives used can be quite strong and may be toxic.

13. Aprons are available as needed to protect your clothes, we recommend that you wear older clothes for lab.

14. Wash and dry any dissecting utensils that you used and return them to the case in your lab drawer.

15. Wash your hands after dissecting.

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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 Prokaryote 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

Laboratory Safety & Lab Equipment

Familiarized yourself with the various supplies and equipment in the labroom by describing the location of each item in the table below. Keep this sheet with you; you do not need to turn it in.

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

	Describe The *Specific* Location of Each
latex gloves	
safety glasses/goggles	
eyewash station	
microscopes	
dissecting scopes & hand lenses	
disinfectant spray bottles	
paper towels	
biohazard bag	
glass disposal boxes	
deionized water spigots	
fire extinguisher	
first aid kit	
hazardous materials spill kit	
dissecting tools	
microscope slides & cover slips	
prepared microscope slides	

Microscopy

Biol 1409 Lab Exercise

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 the term **"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 objects at all appropriate magnifications
-understand the meanings of common abbreviations: cs, ls, sec, wm, etc
-know where to dispose of slides and cover slips

B. The Dissecting Scope

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 (Hand Lens)

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

Taxonomy and Classification

Biol 1409 Lab Exercise

Taxonomy and **classification** involves describing and naming new organisms and comparing their similarities and differences with other organisms. Linnaeus was the first to develop a workable system of classification. Two of his main contributions to the science of taxonomy was to provide a **unique scientific name** for each and every known species of life. He then categorized each of these organisms into nested groupings based on their similarities and differences; called the **Hierarchy of Classification**.

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*. For example, all humans are members of the species, *Homo sapiens*; *Mus musculus* is the binomial name of a common mouse; and *Escherichia coli* is the scientific name of a common intestinal bacterium. 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.

Once a species has been collected, described and named it is placed into a **hierarchy of classification** which indicates similarities and differences between it and other organisms. The hierarchy is a nesting of groupings that categorize species according to their similarities and progressing from least similar to more similar; **Kingdom, Phylum, Class, Order, Family, Genus, Species**. For example, two species in the same genus are *more* similar than two species in different genera but in the same family; two genera in the same family are *more* similar than two genera in different families, etc.

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 categorize them according to their overall similarities to each other by placing them into appropriate levels in the classification hierarchy.

Clams & snails are animals that lives within the shells that they secrete. When these animals die 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:

- some of these shells 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 clams & snails grow, therefore a difference in size alone is not always a good 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

Lab Activities:

1. **Remove** the shells from the bag and **sort** them by number

2. Attempt to **describe** each different species based on the shells and illustrations provided. Your description should be accurate enough that anyone could read your description and select exactly which of the shells you are describing.

3. **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.

4. Now, using your descriptions, attempt to group shells, by their numbers, together into the hierarch of classification by categorizing according to the criteria given.

Name:_____

Due Date:_____

'Species' Names & Descriptions:

#	Binomial Name	Species Description

Hierarchy of Classification:

Now, using the shell numbers and your description of the characteristics of each shell, try to place all of them into the hierarchy of classification:

a. Are any of the shells that you decided were separate species in the **same genus** (for example: the coyote and the red wolf; *Canis latrans* & *Canis rufus*)?

b. Which shells (if any) are in different genera but should be in the **same family** (for example: The coyote, *Canis latrans* and the kit fox, *Vulpes velox* are in different genera but both are in the family CANIDAE)?

c. Which shells (if any) are in different families but should be in the **same order** (for example: the coyote and the lion are both in the order Carnivora)?

d. Which shells (if any) are in different orders but should be in the **same class** (for example the coyote and humans are both in the class mammalia)?

e. Which shells (if any) are in different classes but should be in the **same phylum** (for example the coyote and the lamprey eel are both in the Phylum Chordata)?

f. Which shells (if any) are in different phyla but should be in the **same kingdom** (for example the coyote and a sponge are both in the Animal Kingdom)?

Cells: The Basic Units of Life

Biol 1409 Lab Exercises

All living matter is composed of **cells**. Many organisms exist as only a single cell and are referred to as **unicellular**, some unicellular species are frequently found in informal groupings of cells called **colonies**, and other species are *always* 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 archaea and the eubacteria) are composed of **prokaryotic cells**. All other kingdoms (protists, fungi, plants and animals) are composed of **eukaryotic cells**.

Prokaryotes

Prokaryotic cells are smaller and structurally simpler cells than eukaryotic 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**, 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 molecules, droplets of fats and oils, etc. Some bacteria produce a resistant structure called an **endospore** which is inside some cells. and some prokaryotic cells have one or more **bacterial flagella** for movement.

Some Prokaryote Cell Structures	
Cell Wall	protects cell; gives cells its basic shape
Cell Membrane	selectively allows materials to enter and leave cell
Cytoplasm	the fluid material inside the cell membrane
Bacterial Capsule	sticky outer layer for attachment
Bacterial Flagella	motility
Endospores	great resistance to adverse conditions
Pili	attachment and conjugation

Eukaryotes

Eukaryotic cells are usually much larger and structurally more complex compared to bacterial cells. 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 eukaryotic 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. Eukaryotic 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 eukaryotic 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 eukaryotic 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.

Some Eukaryote Cell Structures	
Cell Wall	protects cell; gives cell its basic shape
Cell Membrane	selectively allows materials to enter and leave cell
Cytoplasm	the fluid material inside the cell membrane
Nucleus	contains genetic material in the form of chromosomes
Chloroplast	organelle used for photosynthesis
Mitochondria	organelle used for aerobic respiration
Ribosomes	protein factories of the cell
Vacuoles	storage containers for water, food, etc
Cilia & Flagella	motility
Cyst	resistant structure formed by some eukaryote cells

All bacteria are **unicellular**, consisting of individual prokaryotic cells, or **colonial**. Members of the eukaryotic kingdoms can be unicellular, colonial 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 prokaryotic and eukaryotic cells lets look at a couple different kinds of **tissues**.

In most multicellular eukaryotes, those in the plant and animal kingdoms, 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 with the high power lens]

Remember: do not use the 100X lens

A. Prokaryote Cellular Structures:

1. Examine the slide below. 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?

Slide: Bacteria Types, wm
(see handout)

2. Examine the slide below. These cells have been stained so that the capsule appears as a 'clear' area around each cell. What is the function of a capsule?

Slide: Bacterial Capsules wm

(Atlas: 4th fig 3.19)

3. Examine the slide below. Try to find flagella on the bacterial cells. How many flagella seem to be present on each cell?

Slide: *Proteus vulgaris* flagella stain
(Atlas: 4th fig 3.12; 5th Fig 3.11)

4. Examine the slides below. Try to find the **endospores** within some of the bacterial cells. What is the function of these spores?

Slides: *Bacillus subtilis* spore stain, smear
***Clostridium botulinum* subterminal spore, smear**
(see handout)

B. Eukaryote Cellular Structures:

5. Examine the **models** of plant and animal cells. Identify the cellular organelles mentioned in the above table. How do these two different kinds (plant vs animal) of eukaryotic cells differ? How are they similar?

Model: plant cell
(Atlas: 4th Table 1.1, fig 1.3; 5th Table 1.1, fig 1.3; 6th Table 1.1, fig 1.3; 7th fig. 103)

Model: animal cell
(Atlas: 4th fig 1.16; 5th fig 1.18; 6th fig 1.18; 7th fig 1.18)

6. Now examine the slide of amoeba below. *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

Slide: *Amoeba proteus*, wm
(Atlas: 4th fig 4.10; 5th 4.19; 6th fig 4.20; 7th fig 4.22)

7. Examine the **slide below.** *Spirogyra* is a colonial (filamentous) algal protist common in ponds and ditches. Compare what you see on your slide to the illustrations in your atlas. The organism on your slide has been stained so it 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?

Slide: *Spirogyra* wm
(Atlas: 4th fig 4.37; 5th fig 4.61; 6th fig 4.63; 7th fig 4.66)

8. In Eukaryote cells most of the genetic material is located on chromosomes within the nucleus. Most of the time the chromosomes are not visible but during cell division they may become easily visible. 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. 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?

Slide: Onion mitosis root tip *Allium*, ls
(Atlas: 4th fig 2.2; 5th fig 2.5; 6th fig 2.5,7th fig 2.5)

Slide: Drosophila chromosome squash
(see handout)

9. 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. 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.

Live: *Elodea* leaves
(Atlas: 4th fig 1.5; 5th fig 1.5; 6th 1.5; 7th fig 1.5)

10. 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. 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.

Live: cheek cells
(Atlas: 5th Fig 1.29; 6th fig 1.29; 7th fig 1.29)

C. Some Plant and Animal Tissues:

11. Plant Dermal Tissue

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. Examine the slide below. Since this is a plant tissue you will see a cell wall surrounding the cell which are roughly rectangular in shape. 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?

Slide: Typical Monocot and Dicot Leaf epidermis, wm
(Atlas: 4th fig 6.118; 5th fig 6.195/6; 6th fig 6.215 /6; 7th figs 6.215/6)

12. **Animal Areolar Tissue**

The slide below 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. Can you distinguish between the cells and the various fibers in this tissue? What organelles can you identify?

Slide: mammal areolar tissue spread
(Atlas: 4th fig 1.42; 5th fig 1.44; 6th fig 1.44; 7th fig 1.44)

13. **Animal Blood Tissue**

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. Looking at the slide below, do the blood cells have a cell wall? What organelles can you identify?

Slide: blood, frog
(see handout)

14. **Animal Adipose Tissue**

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.When you first look at the slide below the tissue appears somewhat like a honeycomb. The center of the cell is filled with a large oil droplet or fat vacuole where fat is stored.

Slide: adipose tissue fat (lipid) stained wm
(see handout)

Asexual & Sexual Reproduction

Biol 1409 Lab Exercise

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 & illustrations 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.

Lab Activities:

A. Asexual Reproduction

Asexual reproduction makes identical copies (clones) of the parent. Only a single parent is required and the process is much quicker than in sexual reproduction. Asexual reproduction is beneficial when resources are abundant

Some Terms Related to Asexual Reproduction

1. **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: 4th p17,34; 5th fig 4.31; 6th fig 4.32; 7th fig 4.35)

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

3. **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.

   Slides: *Hydra* budding wm
   ***Hydra* budding adult, wm**
   (Atlas: 4th p102; 5th fig 7.10; 6th fig 7.10; 7th fig 7.14)

4. **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.

Slide: *Rhizopus* sporangia wm
(Atlas: 4th p46,47; 5th fig 5.4/5; 6th fig 5.4/5; 7th figs 5.4/5)

Preserved: fern frond with sori
(Atlas: 4th p71,72; 5th fig 6.81 & 6.84; 6th fig 6.90; 7th fig 6.86)

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

Preserved: various examples of runners, rhizomes, etc
(Atlas: 6th fig 2.2)

6. **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.

Illustrations: fluke life cycle; armadillo quads
(Atlas: 6th 7.58; 7th fig 7.66)

7. **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: regenerating starfish
(see handout)

B. Sexual Reproduction

Sexual reproduction results in genetically unique individuals or offspring. 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. Sexual reproduction provides much of the genetic variation required for evolution and adaptation

Some Terms Related to Sexual Reproduction

1. **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.

Slide: *Paramecium bursaria* conjugation wm
(Atlas: 5th fig 4.32; 6th 4.33; 7th 4.35)

2. **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
(Atlas: 5th figs 5.7/8; 6th figs 5.7/8; 7th figs 5.7/8)

Preserved or Live: misc. mushrooms, brackets, truffles, etc
(see handout)

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.

3. Heterogamy: When the 'male' and 'female' sex cells (=gametes) differ from each other (**sperm** in males, **egg** in females) 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
(see handout)
egg cells: Mammal ovary Graafian Follicle
(Atlas: = 'oocyte' in 4th fig 8.109; 6th fig 9.102; 7th fig 9.106)

4. 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: 4th p96; 5th p131; 6th figs 6.246-250; 7th figs 2.257-261)

5. 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 slow, 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: 4th p109; 5th fig 7.53; 6th figs 7.53/4; 7th 7.761)

Model: flower structure
(Atlas: 4th fig 6.85 & 6.119; 5th fig 6.218; 6th 6.217; 7th fig 6.231)

Illustrations: misc. hermaphroditic organisms:
snail (Atlas: 4th fig 7.54; 5th fig 7.68; 6th fig 7.69; 7th fig 7.76)
earthworm (Atlas: 4th fig 7.68 & 7.72; 5th fig7.86; 7th fig 7.107)

6. **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

Illustrations: miscellaneous

7. **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**
(see handout)

Preserved: misc. birds and mammals
male and female pine cones
Ascaris **male and female**
(Atlas: 4th fig 7.42-7.46; 5th fig 7.95, 7.97; 6th 7.99; 7th fig 7.118)

Illustrations: miscellaneous

8. **Protandry**: is the ability in some dioecious animals to actually change their sex based on size, age, loss of a mate, environmental cues such as changes in temperature, etc. Most common in aquatic animals such as sponges, corals, brittle stars. The only vertebrates known to switch genders are fish such as clownfish.

Illustrations: misc. invertebrates, amphibians and fish

9. **Parthenogenesis** 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, brine shrimp 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: misc. social insects (bees, ants)

Illustrations: misc. insects and other inverts

Development & Life Cycles

Biol 1409 Lab Exercise

A. Development and Embryology

All living organisms exhibit some form of growth and development. In Prokaryotes such changes are hardly noticeable and relatively simple and straight forward. Eukaryotes, however, and especially multicellular eukaryotes (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 and eventually lead to the mature form (see Atlas 4th 6.84 & 6.147). In the animal kingdom, also, various developmental stages occur before maturity is reached. Such terms as **embryo, larva**, **pupa**, **fetus,** , **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.

1. **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, and some illustrations of vertebrate embryos below.

   Slides: *Pinus* mature embryo median ls
   (Atlas: 6th fig 6.166; 7th fig 6.617)

   chick embryo, 72hr
   (Atlas: 5th fig 2.16; 6th fig 2.16; 7th fig 2.16)

   Model: human embryo

2. **Fetus:** Following embryonic development, vertebrates (higher animals) produce an immature stage that does resemble the adult but that is still completely dependent on the mother for nutrition and protection for an extended length of time.

   Preserved: misc. vertebrate fetuses: human, shark, horse, etc

   Model: human fetus

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

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

Slides: cercaria wm *or* redia & cercaria wm
(Atlas: 4th fig 7.34 & 7.37; 5th fig 7.54: 6th fig 7.55; 7th fig 7.66)

mussel glochidia
(see handout)

nauplius barnacle wm
(see handout)

Preserved: caterpillars, maggots, grubs, etc
(Atlas: 4th figs 7.91/3; 5th fig 7.128 & 7.130; 6th fig 7.136-7.138; 7th 7.155)

tadpoles
(Atlas: 4th fig 2.11; 6th fig 2.15)

4. **Pupa:** A transformational stage in some insects between the larval and adult stage during which metamorphosis occurs in which the larvae acquire their adult characteristics

Illustrations: miscellaneous

5. **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: 4th fig 7.91; 5th fig 7.128; 6th fig 7.137)

B. Life Cycles & Alternation of Generations

Life cycles vary tremendously among the kingdoms. Even some protists have rather elaborate life cycles. The life cycles of most eukaryotes typically include both **asexual** and **sexual** reproduction. Higher animals are an exception in that they only produce offspring by sexual reproduction. Many organisms 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 thus producing a complex life cycle where asexual and sexual types of reproduction alternate. Members of all three multicellular kingdoms contain species that alternate between sexual and asexual reproduction. In some life cycles 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 and is referred to as an **alternation of generations.**

1. Alternation of Generations in Plants:

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: =mature gametophyte in 4th fig 6.51; 5th fig 6.75; 6th fig 6.79; 7th fig 6.80)

Preserved: fern fronds with sori
(Atlas: 5th fig 6.81; 6th 6.86 & 6.89; 7th fig 6.86)

2. Alternation of Generations in Animals:

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

Slide: *Aurelia* scyphistoma wm
(Atlas: 5th fig 7.24; 6th fig 7.24; 7th fig 7.28)

***Aurelia* strobila wm**
(Atlas: 5th fig 7.25; 6th fig 7.25; 7th fig 7.29)

***Aurelia* ephyra wm**
(Atlas: 5th fig 7.26; 6th fig 7.26; 7th fig 7.30)

Preserved: jellyfish (moonjelly, *Aurelia*)
(Atlas: 5th fig 7.27 & 7.28; 6th fig 7.27 & 7.28; 7th fig 7.31)

Ecosystems of Texas

Biol 1409 Lab & Homework Exercise

Ecologically, Texas can be subdivided into ten distinct ecosystems (also sometimes referred to as 'ecoregions' or 'biotic provinces' or 'habitat types'): 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 is characterized by a specific kind of soil type, rainfall, temperature among other distinctive features. These physical, geological and chemical features (=the abiotic environment) result in distinctive plant communities for each ecosystem as well as characteristic animals and other organisms.

In this exercise you will use field guides from the lab or library or information from the internet 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. The best place to start is with the field guides made available in the lab.

1. Abiotic Components

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

2. Biotic Components

Now, for only the three central Texas ecosystems, find one or two examples of living organisms that are found in each of the categories listed in the attached table for the three 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**. This should be relatively easy for vertebrate animals (eg. mammals, birds, reptiles, amphibians, fish) and plants. Identification guides are easily available for these groups.

You will probably have a little more difficulty with invertebrate animals such as insects and other invertebrates (eg. clams, snails, spiders, scorpions, worms, etc.) but try to at least find species that are characteristic, if not exclusive, to each particular ecosystem.

Identification guides and web information or bacteria, fungi and protists (algae and protozoa) are usually not region or ecosystem specific sincet these organisms tend to have much more cosmopolitan distributions (ie. they have distributions across whole continents or worldwide). For these groups, just name one or two species that you know would be found there.

3. Summary of Central Texas' Ecosystems

Finally, on a separate sheet of paper, write a short summary of the abiotic and biotic characteristics of the three central Texas ecosystems. **Stress the differences** rather than the similarities of each in such things as climate, diversity of habitats, diversity of the kinds of plants and animals an microorganisms living in each.

Name:_____

Due date:_____

Ecosystems of Texas

Biol 1409 Report

1. Abiotic Components

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

2. Biotic Components

	Cross Timbers	Blackland Prairie	Edward's Plateau
Bacteria			
Protist			
Fungus			
Herbaceous Plant			
Tree or Shrub			
Invertebrate Animal			
Vertebrate Animal			

The Bacterial Kingdoms

Collecting & Identifying Bacteria

Biol 1409 Lab Exercises

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. While individual bacterial cells are extremely small and require the use of a microscope to see, they are sometimes visible to the naked eye as massive **microbial communities** composed of millions of cells. Some of the terms used for such groupings visible without a microscope (macroscopic) are **colonies, blooms, biofilms, stromatolites,** etc.

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 prokaryotes 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.

Laboratory Objectives:

- Be able to recognize these organisms as prokaryotes (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

Lab Activities: NO FOOD OR DRINK IN LAB

A. Basic Bacterial Shapes & Cellular Structures

Use the first page of your lab report to illustrate some of the prepared slides below.

1. Examine the slide of three different shapes of bacteria. 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?

   Slide: Bacteria Types, wm (see handout)

2. Examine the slide of the bacterial capsule. These cells have been stained so that the capsule appears as a 'clear' area around each cell. What is the function of a capsule?

   Slide: Bacterial Capsules wm (see handout)

3. Examine the slide of bacterial flagella. Try to find flagella on the bacterial cells. How many flagella seem to be present on each cell?

   Slide: *Proteus vulgaris* flagella stain (see handout)

4. Examine the slides below of bacterial spores. Try to find the **spores** within some of the bacterial cells. What is the function of these spores?

   Slides: *Bacillus subtilis* spore stain, smear
   ***Clostridium botulinum* subterminal spore, smear**
   (see handout)

B. Bacterial Pathogens

Most of our knowledge of and experience with bacteria are in the form of **human pathogens**. Look at the slides listed below. Can you see anything distinctive about any of these species? Use the first page of your lab report to illustrate some of the prepared slides below.

1. The bacterial agent responsible for **anthrax**.

Slide: ***Bacillus anthracis*** **wm** (see handout)

2. The bacterium responsible for causing **tuberculosis**

Slide: ***Mycobacterium tuberculosis*** **wm** (see handout)

3. The agent responsible for **syphilis**

Slide: ***Treponema*** **wm** (see handout)

4. The agent that causes **gonorrhoeae**,

Slide: ***Neisseria gonorrhoeae*** **smear** (see handout)

5. A bacterial agent of **botulism**, a type of food poisoning

Slide: ***Clostridium botulinum*** **subterminal spore, smear** (see handout)

C. Economically Important (nondestructive) Bacteria

Use the first page of your lab report to illustrate some of the prepared slides below.

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: Legume nodule sec

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

2. 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.

Slides: Yogurt wm or **Yogurt smear**

3. ***Spirulina*** is commonly used as a protein supplement. Make a wet mount of a small amount of the powder

Preserved: *Spirulina* powder
(7th fig 3.31)

D. Cyanobacteria (=blue-green bacteria)

Even though these are prokaryotic cells, cells of blue green bacteria are generally much larger than the bacteria you have seen so far. Many species are also colonial; forming long filaments. 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". Use the first page of your lab report to illustrate some of the prepared slides and wet mounts of live cultures below.

Live: mixed culture of blue-green bacteria
(Atlas: 6th fig 3.15 - 3.32)

Live: pure cultures of one or more of the following species will also be available:

***Anabaena* sp.**
***Oscillatoria* sp.**
***Eucapsis* sp.**
***Tolypothrix* sp.**
***Merismopedia* sp.**
***Fisherella* sp.**
***Nostoc* sp.**

Slides: *Oscillatoria*, wm
(Atlas: 4th fig 3.6; 5th fig 3.20 & 3.21; 6th fig 3.21; 7th fig 3.23)

Nostoc
(Atlas: 4th fig3.2; 5th fig 3.19; 6th 3.19; 7th fig 3.20)

E. Collecting & Culturing Live Bacteria (Part I)

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.

NO FOOD OR DRINK IN THE ROOM

Possible Culture Media you might be using:

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) or 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 a **differential medium** 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.

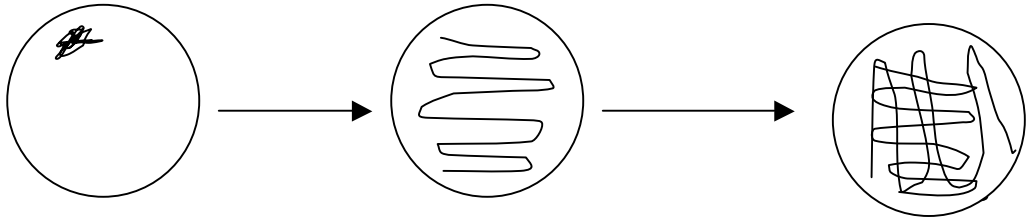
Spirit Blue Agar(SBA)
This agar is a **differentia medium** that contains a relatively high concentration of **lipids (fats)** used by many species of bacteria as an energy source. The agar contains the indicator, **spirit blue**, which loses its color and becomes clear if the lipids are being utilized by a colonies on the plate.

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
SBA	Take samples from soil

2. Take the tubes of nutrient broth and/or thioglocyllate broth and 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

F. Identifying Bacteria From Your Cultures (Part II)

Three major types of identification techniques will be presented:

1. **Characteristics of Colonies (=colonial morphology)**
2. **Cellular Characteristics (=microscopic morphology)**
3. **Biochemical testing**

1. Colony Characteristics.

a. Count and record the total number of colonies growing on each agar plate

b. Estimate the number of different kinds of colonies on each plate based on any distinctive characteristics as discussed by instructor

c. Record whether any of the colonies on the MSA plate are utilizing the **mannitol**.

d. Also, record whether any of the colonies on the MacConkeys plate are utilizing the **lactose**.

e. Measure and describe up to 3 different kinds of **colonies** that you find on each of the plates that you incubated (use descriptive terms from the handout provided). Record your results in the table provided on your data sheet

[NOTE: If there are no bacterial colonies on one or more of your plates then borrow a plate from your classmate to describe several different colonies on the second table. Be sure to indicate whose plate you borrowed and what the source of their sample was.]

2. Cellular Characteristics of colonies from the agar plates

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 a small amount 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 completely 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 10 seconds
f. remove from the staining jar and place the slide in deionized water for another 10 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
h. view the slides under the microscope and draw and describe the microscopic

morphology using the illustrations provided. Can you recognize any "groupings" of cells?

i. record your results on your lab report

3. Nutrient Broth Culture.

a. 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.

b. **Draw** some examples of the different kinds of bacteria that you found in the **nutrient broth** on the space provided on your lab report. Be sure to indicate the total **magnification** that you used to view the bacteria.

c. Could you see any of the bacterial cells actually moving? (Your instructor will describe how to distinguish random movements from true motility). **Describe** any kinds of movements that they were making. Are any of your bacteria actually motile?

4. Thioglycollate Broth

a. Sketch the pattern of growth that you see in the tube. Based on information from the instructor, what can you say about the oxygen requirements of the organisms that you culture?

b. Make a wet mount from your broth and sketch some of the bacterial cells you find.

When you are finished working with your live bacterial cultures:

→ **discard the plates in the biohazard bag,**
→ **place the tube(s) of broth back in the test tube rack,**
→ **discard the any slides you made in the glass disposal box**
→ **spray a little disinfectant onto a paper towel and wipe off the stage of your microscope**
→ **spray down your work area with disinfectant**
→ **wash your hands good**

Name:_______________

Date Due:___________

The Bacterial Kingdoms

Lab Report

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

Magnification:__________ **Magnification:**__________ **Magnification:**__________ **Magnification:**__________

Name:____________ **Name:**_______________ **Name:**______________ **Name:**______________

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Recording Results of Your Own Cultures

Summary of Colony Characteristics

(Colonial Morphology)

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

Source of Sample	plate	Total # of colonies on plate	How Many Different kinds of colonies	
	NA			
	TSA			
	MSA			can any colonies metabolize mannitol? _____
	SBA			can any colonies metabolize fats? _____

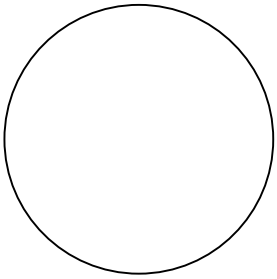
2. Measure and describe up to 3 different kinds of **colonies** that you find on each of the plates:

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

Cellular Characteristics
(Microscopic Morphology)

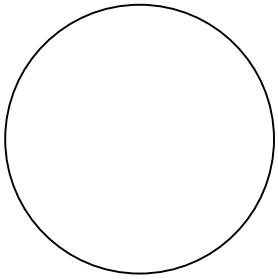
1. Agar Plate Cultures

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



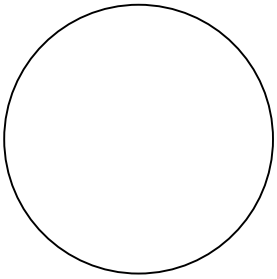
Magnification:_____

from NA colony



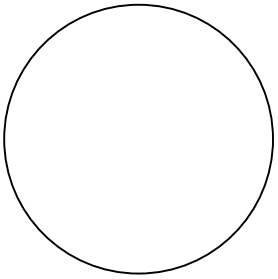
Magnification:_____

from TSA colony



Magnification:_____

from MSA colony



Magnification:_____

from SBA colony

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

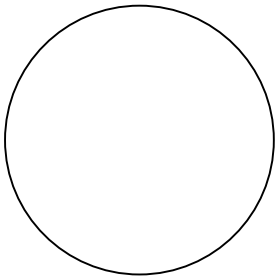
NA Plate:

TSA Plate:

MSA Plate:

SBA Plate:

2. Nutrient Broth Culture



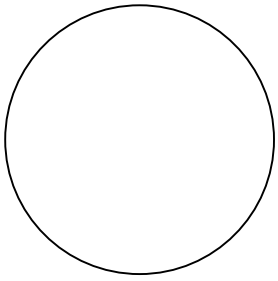
Magnification:_____

Describe their shape (microscopic morphology):

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

3. Thioglycollate Broth

Sketch the **growth pattern** in the tube below & describe oxygen requirements; then make a wet mount and draw some of the cells you see. Area any motile?



Magnification:_____

The Protists

(Single Celled Eukaryotes: Algae, Protozoa, Slime Molds)

Bio 1409 Lab Exercises

The "kingdom" Protista includes a diverse assemblage of simple, single celled or **colonial** eukaryotes. Most protists are **unicellular eukaryotes** and have a variety of organelles including a **nucleus**. They are generally considerably larger than bacterial cells. Photosynthetic forms contain **chloroplasts**. Protists are abundant in most aquatic habitats where they form an important part of the **plankton**. Other protists are found in wet soil and other damp environments. 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.

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**, usually of **cellulose**, but sometimes made of silica or proteins. Most species of algae are **unicellular** or simple **colonial** forms. Many common algae form filaments of cells joined end on end. Some unicellular algae are motile with flagella or gliding movements. A few algae are large **multicellular** forms, including the marine **seaweeds** that can be 100's of feet long. But even these very large algae **do not have true tissues** or organs as do true plants. In addition, the algae have a much more diverse array of **photosynthetic pigments** than do plants which gives some of the groups their names. movement.

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.** A few are **nonmotile**. Many have formed important **symbioses** with other organisms. Some of the parasitic forms have rather elaborate life cycles and are of special concern. Some of the major groups (phyla) of protozoa are listed below.

The Slime Molds & Water Molds: fungus-like protists

This small group of organisms includes some of the most interesting but more cryptic protists. The slime molds are found mainly in damp terrestrial habitats, the water molds include species that are aquatic and others that are terrestrial plant parasites. At some point in their life cycles most form long fungus-like filaments called hyphae. Some grow fungus-like **fruiting bodies** and reproduce by **spores** as fungi do. But some species also spend part of their life cycle as protozoan like single celled organisms that lack cell walls.

Lab Activities:

2 pts extra credit; bring in a water sample that has a good variety of protists. You must verify with the instructor that you produced a rich sample.

A. General

The prepared slides and live specimens are organized into the tables below under the general group to which each belongs. Use the tables to find which materials are available, which are live cultures and which are prepared slides and to locate an illustration of the organism you are trying to find in your Atlas. ***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 of protists in this lab.*** But we will discuss each of these groups in lecture.

You should be able to recognize all of these organisms as **Protists**. You should also be able to tell 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 mentioned below.

When viewing the **live protists** 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

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 (if any), 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. Could you find chloroplasts? nucleus? vacuoles?

B. Examples of Unicellular and Colonial Algae

You do not need to recognize individual groups or species of algae in lab, you are only trying to be able to recognize slides and living examples of Protists and to be able to distinguish the three main groups of protists from each other.

Algae:

organism	live	prepared slide	atlas
dinoflagellates		dinoflagellates wm	6th 4.18;7th 4.21; HO
Peridinium		*Peridinium* wm	4th fig 4.7; 5th fig 4.17; 6th fig 4.17; 7th fig 4.20
diatoms		-diatoms wm mixed fw forms -marine diatoms wm -diatom test plate	5th p34; 6th fig 4.5-4.10; 7th figs 4.5-4.13
Synedra	**x**		HO
Euglena	**x**	*Euglena* wm	4th fig 4.16-19; 5th fig 4.25; 6th fig 4.26-28; 7th 4.29-4.31
Volvox	**x**	*Volvox* sexual stages wm	4th fig 4.25-28; 5th fig 4.41-43; 6th fig 4.42-45; 7th fig 4.45
Oedogonium	**x**	*Oedogonium macrandrous* wm	4th fig 4.32-35; 5th fig 4.54; 6th fig 4.56-62; 7th fig 4.59
Spirogyra	**x**	*Spirogyra* wm	4th fig 4.37-38; 5th fig 4.61; 6th fig 4.63-65;

			7th fig 4.66
Pandorina		*Pandorina* wm	
Chlamydomonas	**x**	*Chlamydomonas* wm	4th fig 4.23; 5th fig 4.35; 6th fig 4.36; 7th fig 4.39
Ulothrix		*Ulothrix* wm	4th fig 4.30-31; 5th fig 4.48-49; 6th fig 4.49-51; 7th fig 4.52
Chlorella	**x**		
Closterium	**x**		4th fig 4.40; 5th fig 4.70; 6th fig 4.73; 7th fig 4.76; HO
coccoliths			HO

C. Examples of Multicellular Algae including Seaweeds

Recognize the preserved and dried specimens below as multicellular, algal protists.

Find the following structures in the appropriate specimens: **blade, stipe, holdfast, float (bladder)**

Sketch some examples of the seaweeds in the lab report and label the above parts as appropriate

Algae: The seaweeds & multicellular algae (brown algae, red algae, and some green algae)

organism	preserved	atlas
limeweed, *Corallina*	**x**	
Chara	**live**	
Irish moss, *Chondrus*	**x**	
Laminaria	**x**	4th fig 4.45; 5th fig 4.83; 6th fig 4.85; 7th fig 4.92
giant kelp, *Macrocystis*	**x**	5th fig 4.82; 6th fig 4.88; 7th fig 4.91
Gracilaria	**x**	
Sea lettuce, *Ulva*	**x**	4th fig 4.42; 5th fig 4.74; 6th fig 4.78; 7th fig4.81
Nemalion	**x**	
gulfweed, *Sargassum*	**x**	4th fig 4.45-49; 5th fig 4.86; 6th fig 4.92; 7th fig 4.95

D. Examples of Protozoa

You do not need to recognize individual species or groups of **protozoa** in lab, you are only trying to be able to recognize slides and living examples of Protists and to be able to distinguish the three main groups of protists from each other.

Be able to find various organelles and cellular structures in appropriate specimens such as: **cell membrane, nucleus** (sometimes more than one), **oral groove, contractile vacuole**

Be able to find the **cilia**, **flagella** or **false feet** (pseudopodia) on appropriate protozoa

Distinguish between the two major types of reproduction in *Paramecium* from the slides of each: asexual reproduction = **fission**, and sexual reproduction = **conjugation**

Sketch some examples of the protozoa from living specimens and prepared slides in the spaces provided in the lab report

Protozoa:

organism	live	prepared slide	atlas
Amoeba	**x**	*Amoeba* wm	4th fig 4.9/10; 5th fig 4.19; 6th fig 4.19/20; 7th fig 4.22/3
radiolarians		radiolaria wm	HO
foraminiferans		-foraminifera wm -foraminifera strew -foraminifera fossil	HO
termite flagellates	**x**		HO
Trypanosoma		*Trypanosoma gambiense* smear	4th fig 4.15; 5th fig 4.24; 6th fig 4.25; 7th fig 4.28
Paramecium	**x**	*Paramecium caudatum* wm	4th fig 4.19/20; 5th fig 4.29; 6th fig 4.29/30; 7th fig 4.36
Paramecium fission		-*Paramecium* in fission -*Paramecium* fission wm -*Paramecium caudatum* wm fission stages	4th fig 4.22; 5th fig 4.31; 6th fig 4.32; 7th fig 4.35
Paramecium conjugation		*Paramecium bursaria* conjugation wm	5th fig 4.32; 6th fig 4.33; 7th fig 4.35
Stentor	**x**	*Stentor* wm	5th fig 4.34; 6th fig 4.35; 7th fig 4.3d
Spirostomum	**x**		HO
Vorticella	**x**	*Vorticella* wm	HO
Plasmodium		*Plasmodium vivax* smear	5th fig 4.107-113; 6th fig 4.22; 7th fig 4.25

E. Examples of slime molds and water molds

You are only trying to be able to recognize slides and living examples of Protists and to be able to distinguish the three main groups of protists from each other.

Identify the **fruiting body**, **hyphae** and **amoeboid stage** on slides and illustrations provided

Sketch some examples of the slime molds from the prepared slides in the space provided in the lab report

Slime Molds & Water Molds

organism	live	prepared slide	atlas
Arcyria		*Arcyria capillitum*, wm	(see 6th fig 4.113-125)
Stemonitis		*Stemonitis* fruiting body wm	(see 6th fig 4.113-125); 7th 4.118

Name:______________________
Due Date:____________

The Protists

Lab Report

B. The Algae

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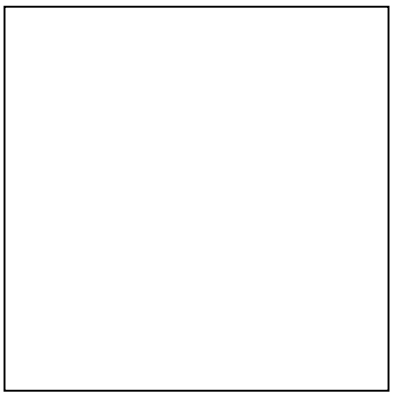
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:______________	**Name:______________**	**Name:_____________**	**Name:_____________**

1. How do blue-green bacteria differ from the algae?

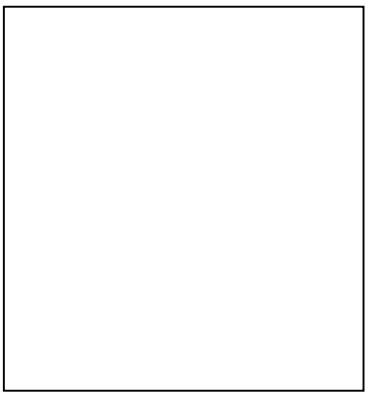
2. In what ways are they similar?

C. Drawings & Descriptions of several seaweeds &/or multicellular algae:



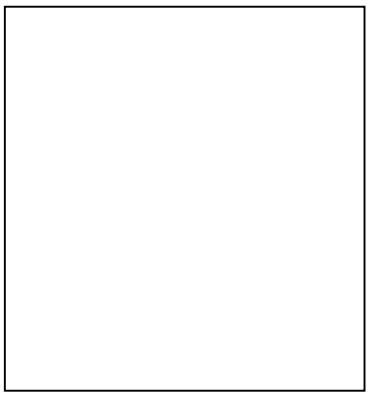
Name:_____

Kind of algae:_____



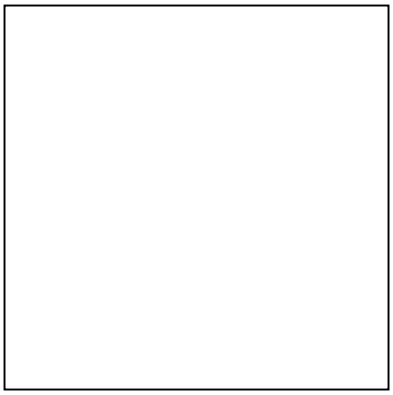
Name:_____

Kind of algae:_____



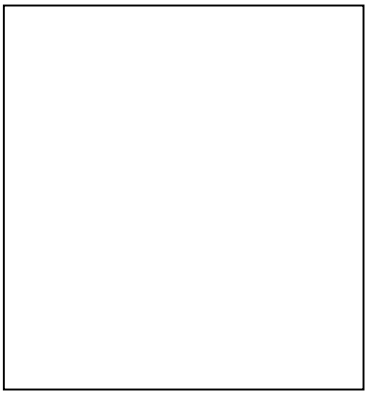
Name:_____

Kind of algae:_____



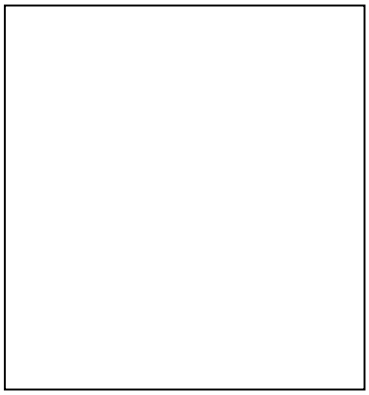
Name:_____

Kind of algae:_____



Name:_____

Kind of algae:_____



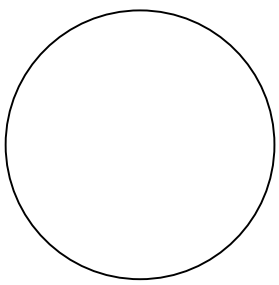
Name:_____

Kind of algae:_____

3. Why are seaweeds considered algae and not plants?

4. Define **unicellular**, **colonial** and **multicellular** and and name one *specific* protist (of the ones you viewed in lab) that is a good example of each of these terms

D. The Protozoa



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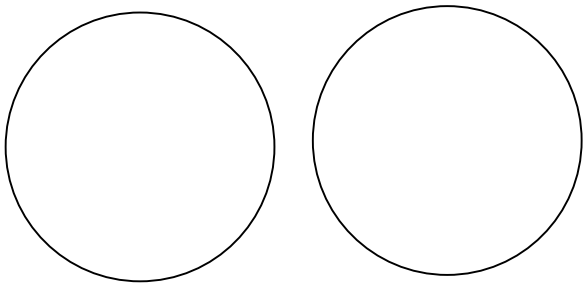
Name:_____ **Name:_____** **Name:_____** **Name:_____**

5. In what ways do protozoa differ from algae?

6. In what ways do protozoa differ from bacteria?

E. The Slime Molds & Water Molds



Magnification:_____ **Magnification:_____**

Name:_____ **Name:_____**

7. In what specific ways do slime molds differ from algae? in what ways are they similar?

8. In what ways do slime molds differ from protozoa? In what ways are they similar?

9. List the best ways that YOU can figure out (for the practical!) to distinguish between the three major kinds of protists and how to distinguish the algal protists from the blue green bacteria if you were to have to identify them on a lab practical

The Fungi

The Simplest Multicellular Eukaryotes

Biol 1409 Lab Exercises

The fungi belong to one of the three **multicellular eukaryotic** kingdoms of life and in terms of their structure, are the simplest of the three. The kingdom is mainly **terrestrial** and includes **yeasts** and **molds**. Their **nonmotile** nature and the fact that many grow from the ground and seem to have root-like and stem-like 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 **absorptive heterotrophs**. Fungal cells are surrounded by **cell walls** made of **chitin**. While there are some predatory and parasitic forms, most feed on decaying organic matter, especially plants. 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.

Some fungi, the **yeasts,** are unicellular, existing mainly as single cell. ,Most fungi are multicellular and are called **molds**. Molds lack true tissues but are comprised of several different types of cells. But these cells form only very simple structures. In most molds 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 **mycelium** is the entire group of hyphae from a single individual.

Fungi reproduce by both **sexual** and **asexual spores.** The yeasts also reproduce asexually by budding. Most fungi have a life cycle that involves the alternation of sexual and asexual stages. Sexual spores are usually produced on large, easily recognizable **fruiting bodies** made out of millions of reproductive hyphae and commonly called mushrooms, shelf fungi, truffles, etc. Asexual spores are more often produced on individual reproductive hyphae that can only be seen with magnification.

Laboratory Objectives

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 to recognize the difference between sexual and asexual fungal spores
- Learn to recognize the general characteristics of some of the major types of the more familiar fungi and symbiotic fungal associations

Lab Activities:

1 pt extra credit: bring in a live "wild" mushroom (**not** from the grocery store). Verify with the instructor before lab.

A. Familiar Fungi: Mushrooms and Other Fruiting Bodies:

1. Identify the **cap** (pileus), **ring** (annulus), **gills**, and **stalk** (stipe) of a typical mushroom; if present.

Fresh and Dried Fruiting Bodies

(Atlas: 5th fig 5.27; 6th fig 5.26; 7th fig 5.25-5.27)

2. The Diversity of Fungal fruiting bodies:

Look at the fresh and preserved specimens available. Use the illustrations provided to identify some of the common types of fruiting bodies. Then record this information along with th number of the specimen and a sketch of each on your lab report

B. Prepared Slides of Reproductive Hyphae and fungal spores

1. View each of the slides in the table below and learn to distinguish between the **reproductive hyphae** that produce **asexual spores** and those that produce **sexual spores**. Draw the reproductive hyphae in the places provided on your lab report and indicate whether they have **sexual** or **asexual** spores

2. Observe the process of **budding** in living yeast cells. **Yeasts** are single-celled fungi that reproduce asexually by budding instead of by asexual spores.

Prepared Slides	**Fruiting Body** **(if any)**	**Atlas Figures of Reproductive Hyphae & spores**
Asexual Reproduction		
Budding yeasts wm	_____	4th fig 5.7; 7th fig 5.10
Rhizopus sporangia wm	_____	4th fig 5.2-4; 5th fig 5.3-5.5; 6th fig 5.3-5; 7th fig 5.4-5
Penecillium wm	_____	4th fig 5.15-17; 5th fig 5.20 & 5.23; 6th fig 5.20-21; 7th fig 5.20
Sexual Reproduction		
Rhizopus conjugation wm	_____	4th fig 5.2 & 5.5-6; 5th fig 5.6-5.8; 6th fig 5.6-8; 7th fig 5.6-8
Morchella sec	cups, morels, saddle fungi (5th fig 5.14; 6th fig 5.14)	4th fig 5.12; 5th fig 5.16; 6th fig 5.16; 7th fig 5.16
Coprinus mushroom cs	mushroom, shelf, toadstools (5th Fig 5.25; 6th 5.25)	4th fig 5.22; 5th fig 5.30; 6th fig 5.30; 7th fig 5.30

C. Living mycelia with reproductive hyphae and spores

Make **wet mounts** of the sample plates of living molds. In the molds notice the hyphae. Try to find some reproductive hyphae with spores to determine if they are producing **asexual** or **sexual** spores. On the yeast wet mount look for asexual budding. Record your observations in the lab report.

D. Living Yeast Cells and Asexual Budding

Make a **wet mount** with a drop of live yeast culture and observe budding cells

E. Collecting your own Fungus culture:

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.

F. Observing Living Fungal Cultures:

1. Observe your fungal cultures and notice that each fungus is made up of a mat-like clump, the **mycelium** consisting of thin, whitish, threadlike **hyphae**. 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**.Count the total number of **mycelia** (individuals) and the number of different kinds (species) fungi growing on your plate and record this information on your lab report

2. Place the plate under a **dissecting scope** to see if you can distinguish between the different mycelia, can you recognize different kinds of reproductive hyphae and spores? Can you see indivdual hyphae at this magnification?

3. Use your tweezers or toothpick to pinch off a tiny piece of the **mycelium**. For now, try to avoid the spores. 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 in the appropriate place on your lab report.

4. 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?

5. Now pinch off another small piece of a mycelium, 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. Compare the reproductive hyphae and their spores with the illustrations provided and the figures in your atlas to determine if the spores are **asexual** or **sexual spores**. Record this information in your lab report.

When you are finished with your plates of fungi: dispose of them in the Biohazard Bag

G. Symbiotic Fungi

Some of the most important fungi are those that occur in symbioses with other life forms. **Lichens** and **Mycorrhizae** are two important examples of fungal symbioses.

1. 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 and the growth form of the lichen. Lichens exhibit three types of growth forms:

crustose ('crusty')	-	thin attached sheets growing over rocks and bark, etc
foliose ('leafy')	-	flattened, leaf-like growths lifting off of the substrate
fruticose ('shrubby')	-	shrub-like or bush-like growths protruding from the substrate

a. Observe the following slides of lichens and compare to the illustrations in your atlas. Note the fungal layers, the filamentous hyphae and the algal cells embedded in the fungus just below the upper layer.

Slides: *Physcia* thallus sec. (Atlas: 7th fig 5.41)
Slide: Lichen Ascocarps sec.
(Atlas: 4th fig 5.27-30; 5th fig 5.39-5.48; 6th fig 5.39-5.48; 7th fig 5.43).

b. 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.

c. dye extracts from Lichens are used to make **litmus paper**, litmus paper is commonly used in science labs to detect acids and bases. Follow the instructions given in lab to test the pH of several solutions using litmus paper.

2. 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.

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

slide: endotrophic mycorrhizae, cs

Name:_____

Due:_____

The Fungi

Lab Report

A. Familiar Fungi: Mushrooms and Relatives

Make some rough sketches and descriptions of the **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 common group of fungi each belongs based on the identification guide?

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

Specimen #:

Common Name:

B, C & D. Observing Other Living Yeast & Fungal Cultures and Prepared Slides:

Use this page to sketch and label the various kinds of **asexual** and **sexual spores** from slides and live cultures. Indicate the magnification you used and the kind of spore below each of your illustrations

Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Sexual/Asexual	**Sexual/Asexual**	**Sexual/Asexual**	**Sexual/Asexual**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Sexual/Asexual	**Sexual/Asexual**	**Sexual/Asexual**	**Sexual/Asexual**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Sexual/Asexual	**Sexual/Asexual**	**Sexual/Asexual**	**Sexual/Asexual**
Magnification:__________	**Magnification:__________**	**Magnification:__________**	**Magnification:__________**
Name:_____________	**Name:_____________**	**Name:_____________**	**Name:_____________**
Sexual/Asexual	**Sexual/Asexual**	**Sexual/Asexual**	**Sexual/Asexual**

F. Collecting and Preserving Fungi

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

   a. **total number** of mycelia or yeast colonies: _____

   b. number of **different kinds** of fungi on your plate: _____

2. Use a hand lens to **Describe** (size, color, color of spores, unusual features, etc) some of the different kinds of **fungal mycelia** that you see on the plate):

   a.

   b.

   c.

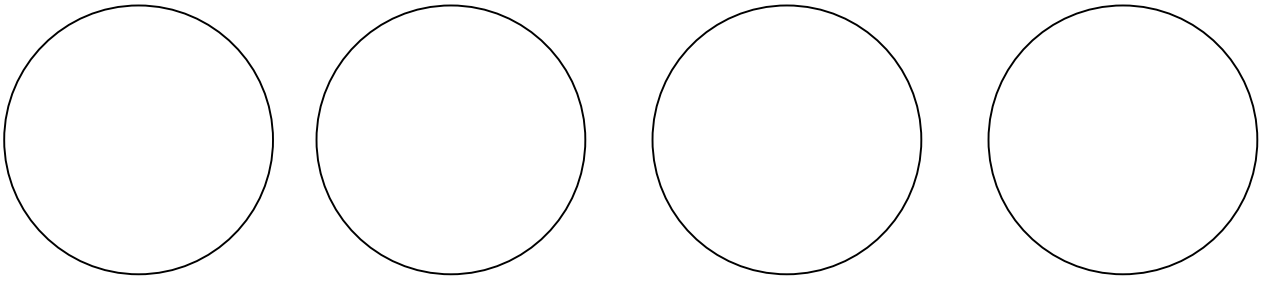
   d.

   e.

3. View the **wet mounts** you made of your live fungal specimens from your plate

   a. Can you distinguish between mold mycelia and yeast colonies on your plate, if so, how?

   b. Sketch the reproductive hyphae and spores of the fungi you collected. Can you determine whether any spores present on a particular mycelium are **sexual** or **asexual**?



Magnification:_____ **Magnification:_____** **Magnification:_____** **Magnification:_____**

Sexual/Asexual **Sexual/Asexual** **Sexual/Asexual** **Sexual/Asexual**

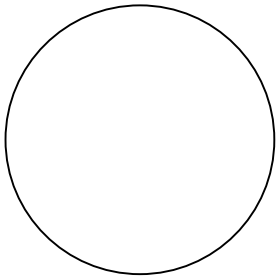
c. How are individual fungal cells similar to the cells of algae, protozoa, and slime molds?

d. How do individual fungal cells differ from the other three cell types?

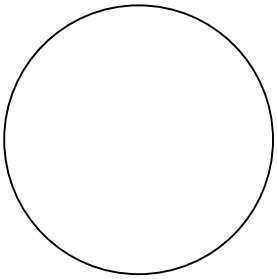
G. Symbiotic Fungi

1. Lichens:

a. After sketching what you see on the two slides use arrows to indicate which are the **fungal cells** and which are the **algal cells**

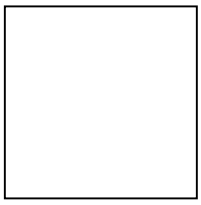


slide: *Physica* thallus

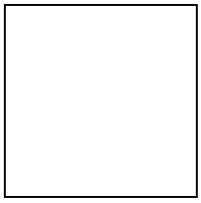


slide: Lichen Ascocarps

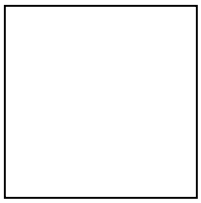
b. **Describe** and **sketch** each of the three kinds of lichens on display; crustose, foliose & fruiticose. If you were able to identify the lichen include its scientific or common name here.



Crustose:



Foliose:

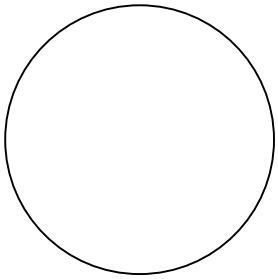


Fruiticose:

c. List the advantages/disadvantages of this symbiosis to the fungus and the advantages/disadvantages to the algal cells

2. Mycorrhizae

a. sketch what you see on the slide and use arrows to indicate the plant cells and the fungal cells



endotrophic mycorrhizae cs

b. List the benefits of this symbiosis to the fungus and the benefits to the plant below:

c. Describe some of the human benefits of lichens and mycorrhizae.

The Plant Kingdom

Biol 1409 Lab Exercises

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. The Plant Kingdom includes autotrophic multicellular organisms with true tissues and organs. Common examples are mosses, ferns, cedar & pine trees, cycads, grasses and flowering plants.

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

1. **multicellular, eukaryotic** 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 (=aerobic respiration)
5. store excess foods as **starch** (a complex carbohydrate).
6. in most plants cells are differentiated into **tissue** and simple **organs**
7. almost all plants are terrestrial and therefore show major adaptations toward a non-aquatic existence.
8. all plants show herbaceous **primary growth**, and some vascular plants show woody **secondary growth**
9. most plants have a distinctive **alternation of sexual and asexual generations.** The asexual stage is referred to as the **sporophyte**; the sexual stage as the **gametophyte**.
10. in the gametophyte stage, most plants go through **development** in which a **zygote** (fertilized egg) becomes an **embryo** (within a seed) before growing into a seedling and finally into the sexually mature plant

I. The Anatomy of Plants

A. Plant Cells

Plant Cells: In addition to the **nucleus** found in typical **eukaryotic cells** plant cells contain some organelles and structures that can be considered "characteristic" for the kingdom. These include a **cellulose cell wall**, **chloroplasts** containing **chlorophyll**, **plastids** that store **starch** and other materials and a large **central vacuole**.

B. Plant Tissues

Tissues are groups of cells that have become **specialized** for particular functions. The fact that they have become specialized also means they have become **interdependent** on each other and cannot survive on their own as can the cells of simpler multicellular organisms such as seaweeds and fungi. Most plants are composed of three main kinds of **tissues** that extend throughout all organs of the plant: **dermal tissue, vascular tissue** and **ground tissue**.

Dermal Tissue covers the outside of all plant organs and protects them from damage and water loss. Dermal tissue is also important in gas exchange and absorption. There are two kinds of

dermal tissue depending on whether a plant is an **herbaceous** or a **woody** plant. Typically, **herbaceous** plants are **annuals**, or plants that only live one season then die. The stems of annuals are usually green and carry out photosynthesis. The dermal tissue of these annual, herbaceous plants is called **epidermis**; it is a thin clear layer of cells with pores or stomata. **Woody** plants are **perennial**, plants that live for many years, specifically shrubs, woody vines, and trees. The dermal tissue on woody stems is called **periderm**; most of the "bark" of a tree is this periderm; it is thick, corky, not transparent, and offers better protection for larger plants that may live dozens or hundreds of years.

Vascular Tissue is the "plumbing" of a plant and consists of the **xylem** and the **phloem** which move water, minerals, sugars, and hormones throughout the plant.

Ground Tissue does most of the "work" of a plant; it is specialized for a variety of functions such as photosynthesis, gas exchange, and food storage. Most of the cells in a plant between the dermal and vascular tissue is ground tissue.

C. Plant 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.

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.
3. They are also important in food storage, usually in the form of starch

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. A kind of root is **adventitious roots**; these include all roots that do not grow underground from the base of the stem.

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 epidermis of the herbaceous stem secretes a waxy **cuticle** and is 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. The dermal layer on woody stems is called periderm; a much thicker, opaque, corky protective layer. 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.

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. Exchange of gasses; carbon dioxide in and oxygen gas out
3. Evaporation of water from leaves serves as mechanism for transpiration which moves nutrients from roots throughout the plant
4. Leaves can also absorb water and minerals to some degree

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.

Lab Activities:

2 pts. Extra Credit: On the first day of the plant kingdom labs bring in 3 different examples of living plants that each show roots, stems and leaves. Check in with the instructor before the beginning of class

A. Plant Cells

1. Study the illustrations and model of plant cells to find the following organelles and structures: **cell wall, nucleus, chloroplasts, cell membrane, central vacuole, mitochondria, plastids**

Model: plant cells
(Atlas: 4th fig 1.3; 5th fig 1.3; 6th fig 1.3; 7th fig 1.4)

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 as many of the above organelles as you can.

   Also, notice that in many of the cells these organelles are moving in a circular motion within the cell.

   Live: *Elodea*
   (Atlas: 4th p3; 5th fig 1.5; 6th fig 1.5; 7th fig 1.5)

B. Plant Organs

1. Identify the three major vegetative organs, the **root, stem** and **leaf** on the 'typical'plants (living and preserved) and illustrations available.

   Living & Preserved plant material

2. Identify the following structures & terms on living and preserved plants and illustrations:

   a. root: **fibrous root, tap root, adventitious roots**

   b. stem: **node, internode, terminal bud, axillary bud, lenticel, leaf scars**

   c. leaf: **petiole, blade, stipule, axillary bud, veins, leaf hairs**

   Living & Preserved plant material

3. view the slides below and identify the **root cap** at the tip of the growing root and **root hairs** (if visible):

   Slide: root hairs (Atlas: 7th fig 6.179)
   Slide: corn root tip zea ls
   (Atlas: 5th fig 6.159-160; 6th fig 6.178-179; 7th fig 6.179-81)

4. View the slide below and be able to recognize: **stomata, guard cells, leaf hairs** (trichomes). 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 **stoma** (pleural = stomata) are small **guard cells** that can open and close the pore. On this same slide note the **leaf hairs** or trichomes.

   Slide: monocot & dicot leaf epidermis wm
   (Atlas: 5th fig 6.196; 6th fig 6.216; 7th fig 6.219-20)

5. Study the dried and fresh materials and note the variety of leaf forms 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.

   Be able to recognize the difference between **simple** and **compound** leaves.

   Living & Preserved leaves
   (Atlas: 4th fig 6.110; 5th fig 6.184; 6th fig 6.203)

C. Plant Tissues

Use your atlas and illustrations provided to find each of the three tissue types in the slides of roots, stems and leaves below.

1. **Root:**

   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

   Slide: *Ranunculus* mature roots, cs
   (Atlas: 4th fig 6.94; 5th fig 6.151, 6.161-162; 6th fig 6.180-181; 7th fig 6.183)

2. **Herbaceous Stem:**

   a. again, the dermal tissue is represented by a layer 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**.

   Model: stem cross section

   Slide: Typical monocot and dicot stem, cs
   (Atlas: 4th fig 6.102; 5th fig 6.169,6.170,6.173; 6th fig 6.189-96; 7th fig 6.191-4)

3. **Leaf:**

   a. The dermal tissue consists of a single layer of **epidermis** on the upper and lower surface of the leaf section.
   b. The vascular tissue is represented by the "**veins**" of a leaf. Each branch of a vein is seen in cross section (cs) as a **vascular bundle** containing **xylem** and **phloem cells**
   c. In leaves the ground tissue is called **mesophyll** which does most of the photosynthesis, and where gas exchange occurs. Identify the mesophyll on the leaf model and the slide labeled cs.

   Model: leaf section

   Slide: *Ligustrum* leaf, cs *or* Privet Leaf cs
   (Atlas: 4th fig 6.115-6; 5th fig 6.190-1,6.196; 6th fig 6.215-6; 7th fig 6.125-6)

II. Plant Life Cycles

Many 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.

III. Plant Identification

Typically the distinctive reproductive organs of a plant are used to identify its species. Plants produce only a few kinds of true vegetative organs. But even vegetative organs vary in such diverse ways that the most common species, at least, can be identified from these structures as well. Leaves are one of the most characteristic and distinctive organs of each plant species and it is relatively easy to identify a plant species with just a few of its leaves and twigs.

In this exercise you will practice identifying several common central Texas woody plants by using a **dichotomous key**. That is, a key that asks you to select, from a pair of choices and proceeding through couplets of choices until you arrive at the species name.

You must always begin at the first couplet and then proceed to the couplet indicated by each choice that you make.

You will need a **hand lens** or a **dissecting scope** to be able to see some important structures.

Because of the diversity of leaf shape, size, surface features, etc a list of terminology is provided to help you interpret each pair of choices. You do not need to learn or memorize these technical terms.

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A Key to Some Common
Central Texas Trees, Vines & 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 or lanceolate	5
b. leaves obovate, obdeltoid or spatulate	6
5a. leaves up to 3" long	**Poverty Weed** *Baccharus angustifolia*
b. leaves 3" to 6" long	**Gulf Black Willow** *Salix nigra*
6a. leaves dark green glabrous above, tomatose below, no spines on branches	**Texas Persimmon** *Diospyros texana*
b. leaves not as above	8
8a. leaves cordate to deltoid	9
b. leaves not as above	12
9a. leaf margins entire	10
b. leaf margins serrate, lobed, or 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. blade 2.5-5" long; leaf margins entire to sinuate, or toothed or 3-5 lobed; lower surface of leaf with white felty leaf hairs, 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 toothed 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 both top and bottom of leaf glabrous	**Texas Oak** *Quercus texana*
14a. leaf margins serrate to serrulate, apex acute or obtuse, dark green stiff , scabrous & rough to touch above , pubescent below; older 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 scabrous above, paler 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. most leaves opposite; only a few whorled, if any	18
b. most leaves whorled or clumped	33
18a. leaves 1-3"long, light green and pubescent above and below; base rounded or truncate	**Japanese Honeysuckle** *Lonicera japonica*
b. leaves dark, dull green and leathery, glabrous above and below	29
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 2-2.5" long; entire; stem square in cross-section	**Winter Jasmine** *Jasminum nudiflorum*
b. not as above	32
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 bi -or tri- pinnately compound	30
b. single pinnately compound leaves	24
24a. compound leaves 10-15" long; 7-13leaflets, each to 3" long	

and 2” wide, leaflets ovate to elliptical, coarsely serrate margins and grooved petioles	**Trumpet Creeper** *Bignonia radicans*
b. leaves not as above	25
25a. compound leaves 4-8” long; , 5-13 leaflets per leaf, leaflets elliptical to oblong or oval; 1-2.5” long and 1” wide margins entire, short or no petiole on leaflets	**Mountain Laurel** *Sophora secundiflora*
b. leaves not as above	26
26a. compound leaves 9-20” long; with 9-17 leaflets, leaflets 4-8” long, with doubly serrate margins, with little or no petioles, leaves aromatic when crushed; orange/brown lenticels on twig	**Pecan** *Carya illinoiensis*
b. compound leaves 8-16”long with 25-30 leaflets, and small (<1/3”); twigs green	**Paloverde** *Parkinsonia aculeata*
29a. leaves 2-4.5”long, >1” wide	**Japanese Privet** *Ligustrum japonicum*
b. leaves 4-6”long, <1”wide, with conspicuous yellowish main vein, most leaves opposite, some whorled	**Common Oleander** *Nerium oleander*
30a. leaves bipinnately compound most with only 2 branches; each with 12-20 leaflets, each leaflet ~2” long and 1/4” wide; twig with stout spines up to 2” long	**Mesquite** *Prosopis juliflora*
b. leaves not as above	31
31a. compound leaves bi or tri pinnately compound, 3-8” long; leaflets 1/2-1.5” long, ovate with margins coarsly toothed, incised or lobed	**Pepper Vine** *Ampelopsis arborea*
b. compound leaves 12-20” long; evergreen; leaflets ~2” long, elliptical, entire with bulbous swelling at base of petiole; new foliage often red	**Heavenly Bamboo** *Nandina domestica*
32a. 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*
33a. most leaves oblanceolate or obovate, >1.5” long, bright green and glabrous above & below; blades wavy or curled inward at margins, petioles reddish at base	**Pomegranate** *Punica granatum*
b. most leaves oblanceolate, <1.5” long, dark green and shiny above, much paler and glabrous below; shorter branches terminate in spines	**Pyracantha** *Pyracantha angustifolia*

Name:_____

Leaf Identification Exercise

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

IV. Plant Diversity

The plant kingdom contains over a dozen distinct phyla. In this class we will group all plants into four major kinds based on their strucrture and life cycles.

A. Mosses & Allies

The mosses represent the simplest members of the plant kingdom. Besides "true" mosses this group also includes liverworts & hornworts. 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 cells** 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 the asexual **spores** are released.

Lab Activities: Mosses (Atlas: 5th fig 6.23-40; 6th figh 6.27)

2 pts. Extra Credit: Bring in a live example of Mosses, liverworts or hornworts.**Check in with the instructor before the beginning of class**

1. Observe several examples of living and preserved mosses & allies.

   Living & Preserved Specimens & Illustrations of mosses, liverworts, hornworts
   (Atlas: 6th fig 6.1, 6.2, 6.17, 6.30; 7th fig 6.22 &ff)

2. On the true mosses you should be able to find: "leaves", "stems", and rhizoids

   Living and Preserved mosses
   (Atlas: 5th fig 6.28; 6th 6.27 & 6.31)

3. Observe the slides below to find the sexual reproductive organs of mosses:

   antheridia: Slide: Moss Antheridial Head, *Polytrichium* ls
   (Atlas: 4th fig 6.17 & 6.21; 5th fig 6.36; 6th fig 6.35; 7th fig 6.36-7)

   archegonia: Slide: Moss Archegonial Head, *Mnium* ls
   (Atlas 6.17 & 6.19; 5th fig 6.35; 6th 6.34; 7th fig 6.35)

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. The sporophyte consists of a spore producing **capsule** which may or may not be on a long **stalk**. Observe the slide below to see the **capsules** and the asexually produced **spores**, compare what you see on the slides to the illustrations in your Atlas?

Slide: Moss capsule, *Polytrichium*, ls
(Atlas: 4th fig 6.17 & 6.22; 5th fig 6.37; 6th fig 6.38; 7th fig 6.39)

B. Ferns & Allies (Seedless Vascular Plants)

The ferns and their allies represent the simplest kinds of **vascular plants**. Besides "true" ferns this group includes club mosses, horsetails and whiskferns. **Vascular Plants** have **vascular 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. This vascular tissue allows a much more efficient distribution of materials throughout the plant body and therefore allows the plant to grow considerably larger than mosses. Also, special cells 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 since the roots can grow into the soil and absorb water and minerals.

The ferns are the largest and most diverse phylum of **seedless vascular plants**. Most are tropical but many are used as house plants throughout the world. They have typical **roots**, **stems** and most have 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 is the dominant, most visible stage in the life cycle. Most people have seen a fern 'sporophyte', few have seen a fern 'gametophyte' The **sporophyte** asexually produces **spores** int a **sorus** or in groups of **sori** called an indusium found usually on the underside of the frond. **Sperm** and **egg** are produced in **antheridia** and **archegonia** on the small heart-shaped **gametophyte** plant. Like the mosses, the sperm of the **gametophyte** plant requires water to swim to the egg. The small gametophytes , therefore, are still tied to water even though the **sporophytes** can grow in drier areas.

Lab Activities: Ferns (Atlas: 5th fig 6.75-91; 6th fig 6.79-99)

2 pts. Extra Credit: Bring in a living example of a fern, horsetail, whisk fern, or club moss. **Check in with the instructor before the beginning of class.**

1. Observe and distinguish between the preserved and live specimens of ferns and their relatives that are available.

Living and Preserved Specimens & Illustrations of ferns and allies
(Atlas: 6th fig 6.42, 6.48, 6.56, 6.66-686.80-85; 7th fig 6.43&ff)

2. Observe the fern sporophytes and locate **the frond, fiddle heads, rhizome sori** and **roots**

Living & Preserved ferns and illustrations
(Atlas: 4th p71-73; 5th fig 6.75; 6th fig 6.79, 6.81, 6.90; 7th fig 6.82)

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
(Atlas: 5th fig 6.53; 6th fig 6.44, 6.46; 7th see fig 6.47)

4. The typical fern plant is the asexual **sporophyte** stage of the fern life cycle. Ferns produce **spores** from groups of special **sporangia** on the fern frond called **sori**. These groups of sporangia are covered by an umbrella-like **indusium**. Identify the **fern spores** on the slide below:

Slide: fern indusium sec
(Atlas: 4th fig 6.44-45; 5th fig 6.75,6.85; 6th fig 6.92; 7th fig 6.93)

5. Each spore that is released will grow into the tiny prothallium, the **gametophyte,** to complete the cycle. Ferns do not produce flowers, their sexual reproductive organs are simple and very small. In the fern life cycle the **gametophyte** is a tiny heart-shaped organism which is rarely seen because of its small size. On the gametophyte are the male and female reproductive organs; the **antheridium** and **archegonium**

Slide: fern prothallium male and female, wm
(Atlas: 5th 6.43, 6.51; 6th fig 6.79; 7th fig 6.95-8)
or **fern antheridia wm** and **fern prothallium wm archegonium**
(Atlas: 5th fig 6.87; 6th 6.79, 6.94, 6.95; 7th fig 6.95-8)

6. 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.** Find the **young sporophyte** growing from a fertilized egg in **archegonium** on the slides below:

Slide: fern young sporophyte wm
(Atlas: 4th fig 6.43; 5th fig 6.75; 6th fig 6.79; 7th fig 6.80)

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.

C. Conifers & Allies (Gymnosperms)

This group includes cedars, pines, spruce & fir trees as well as ginkgoes and mormon tea. In conifers the leaves are usually in the form of **needles** or small triangular **scales**. They generally have a thick layer of **cuticle** to protect them from water loss since most conifers tend to grow in relatively dry areas.

Almost all conifers (and many flowering plants) are **perennial** and have thick **woody trunks** with **bark** rather than herbaceous stems. The bark replaces the epidermis for protection of the stem in large woody plants.

Plants that live more than one year, ie. perennials, produce **secondary growth** each year. In woody plants there are layers of **meristem (embryonic) cells** called the **cambium**, that produces this secondary growth each year. This 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. Differences in the size of the cells produced throughout the growing season produce the familiar "**growth rings**" in the wood. Xylem grows much faster than phloem and virtually all of the "**wood**" of a tree is **xylem** cells with the oldest cells closer to the center of the trunk, these older cells are often darker and are called **heartwood**. The layers of **phloem**, on the "outer-side" of the cambium, along with the **cortex** and the **periderm** make up the **bark** of a tree.

Conifers are one of two major groups of vascular plants that produce **seeds** during their reproductive cycle. In ferns and mosses the fertilized egg (=zygote) developed directly into the sporophyte without forming a seed. In conifers the life cycle is considerably different. The main reproductive organs are **male** and **female cones**. The male cone produces **sperm cells** inside microscopic **pollen** grains. The female cone produces the **egg** inside groups of cells called **ovules**.

The tiny pollen grain is released from the male cone and travels by wind to the female cone to fertilize the egg. Conifers 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**. The embryo itself consists of an embryonic root and stem and embryonic leaves. 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: Conifers (Atlas: 5th fig 6.123 – 6.146; 6th fig 6.101-110, 6.124-125, 6.140, 6.149)

1 pt Extra Credit: bring in a branch of any conifer other than a cedar tree. **Check in with the instructor before the beginning of class.**

2 pts Extra Credit: bring in a branch of a ginkgo tree or mormon tea shrub. **Check in with the instructor before the beginning of class.**

1. Observe examples of conifers and allies in the material provided

Living and Preserved and Illustrations of conifers and allies
(Atlas: 5th fig 6.123 – 6.146; 6th fig 6.101-110, 6.124-125, 6.140, 6.149)

2. Observe the examples of conifers and note the vegetative organs; the **roots**, **stems** and **leaves**, and the reproductive organs; the **male** and **female cones.**

Living and Preserved and Illustrations of conifers

3. **Perennial, woody stems** are found in most conifers and many flowering plants. Their basic anatomy is similar. Study the materials below to learn about the structure of woody stems:

   a. **Wood Sections:** Examine the pieces of logs and cut wood available. Can you see the growth rings? Use a magnifying glass or dissecting scope to examine the growth rings more closely.

Pieces of logs & cut wood

b. **Bark:** Bark consists of 2 kinds of plant tissues; periderm (including cork) and phloem. 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. Compare your slide to the illustration provided. Diagram and describe what you see on your lab sheet. What is the function of cork?

Pieces of logs, bark and cork

c. **Woody Stem at the end of the third year:** Examine the slide below and find the structures indicated. Understand the relationship between each **growth ring** and the layers of **xylem** and **phloem** and **periderm**

Slides*:* *Tilia*, Basswood, third year stem cs *or*
Basswood three year stem, *Tilia* cs
(see handout)

d. **Pine Stem**. Examine the slide below and be able to identify which is the younger and which is the older and how old each stem is.

Slide: Pine Stems younger & older cs

4. Observe the slide of a cross section of a pine leaf and find the following structures: **epidermis**, **vascular tissue** and **ground tissue, resin ducts**, **stomata**

Slide: pine leaf – 3 needle , cs
(Atlas: 4th p79, 6.78; 5th fig 6.132; 6th fig 6.147; 7th fig 6.148)

5. Study the **life cycle** of a typical conifer on the attached illustrations (Atlas: 4th p 76 '5th fig 6.123; 6th fig 6.137; 7th fig 6.137)

6. Observe examples of the **cones**; be able to recognize and distinguish between **male (staminate)** and **female (ovulate) cones**.Use a magnifying glass to determine whether any of the male cones still contain **pollen**. Do any of the female cones contain **seeds**?

Preserved: male and female cones
(Atlas: 5th fig 6.79, 6.81, 6.,135, 6.136, 6.140; 6th 6.137; 7th fig 6.150)

7. Observe the slide below and note the structure of the **male cone** and identify the **pollen grains** (=microsporangia of your atlas)

Slide: Pine, staminate cone, ls
(Atlas: 4th fig 6.81; 5th fig 6.141,6.142; 6th fig 6.157-158; 7th fig 6.158-9)

8. Observe the slide below and compare to the illustrations attached to lab exercise; note the '**wings**' on each grain.

Slide: Pine mature pollen wm
(see handout; 7th fig 6.160)

9. Observe the slide below and again, note the structure of the **female cone** and identify the **ovule** and **scales**

Slide: Pine young ovulate cone
(Atlas: 4th fig 6.80; 5th fig 6.135-8; 6th fig 6.153-4; 7th fig 6.155)

10. Observe a section of a **seed** on the slide below and identify the **embryo**, **endosperm**, **seed coat**.

Slide: pine mature embryo, ls
(Atlas: 4th fig 6.84; 5th fig 6.123; 6th fig 6.166; 7th fig 6.167)

D. Flowering Plants

Flowering Plant species are the dominant members of the Plant Kingdom in the world today. 90% of all living plants are in this group. 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.

Like the conifers, asexual spores are not produced by flowering plants (remember that the sporophytes in the other two major plant groups *did* produce spores). The main sexual reproductive organ in flowering plants is the **flower.**

Most angiosperms are monoecious (hermaphrodites); flowers are a combination of both male and female reproductive parts. General flower structures include the **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 fertilized egg (=zygote) begins to divide to form the **embryo**. At the end of this short spurt of development the embryo along with a small food supply are encased within a tough **seed coat** to produce the **seed**. The embryo is a miniature version of the future plant and contains an embryonic root, an embryonic stem, and the embryonic leaves.

The **fruit** is an adaptation of flowering plants that helps to protect the seed while enhancing its 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.

Some of the slides you will use in this section mention **monocots** and **dicots**. These are two major kinds of flowering plants. Monocots include onions, orchids, lilies, grasses, corn, wheat, etc. Dicots include all the other kinds of flowering plants such as beans, tomatoes, peppers, roses, bluebonnets, apples, peaches, roses, pecans etc. You do not need to be able to distinguish between monocots and dicots on these slides. Both will have the same basic tissues, they are just arranged differently.

Lab Activities: Flowering Plants (Atlas: 5th fig 6.147-244; 6th fig 6.167, 6,203, 6.218)

1. General Flowering Plant Anatomy: Vegetative Organs

Refresh your memory of the anatomy of roots, stems and leaves by viewing the slides below.

a. Roots:

i. Examine the **root model** and and identify the **root cap**, **root hairs** and the **epidermis, cortex, xylem, phloem**

ii. Examine the slide of a root cross sections and identify the internal structures and tissues of the plant root including **epidermis, cortex, xylem, phloem:**

Slide: Typical monocot and dicot roots, cs
(Atlas: 4th fig fig 6.93-94; 5th fig 6.151-152, 6.157-158; 6th fig 6.170 & 6.181; 7th fig 6.182)

b. Stems:

i. Look at the **stem section model** and refresh your memory of the location of the three tissue types and the additional terms here:

dermal tissue: epidermis, guard cells, stomata
vascular tissue: vascular bundles, xylem, phloem
ground tissue: cortex, pith

Model: stem section

ii. Examine the slides of stem cross sections and identify the internal structures and tissues including **epidermis, vascular bundles (xylem and phloem)**, ground tissue

Slide: Typical monocot and dicot stems, cs
(Atlas: 4th fig 6.102 & 6.106; 45th fig 6.170 & 6.173; 6th fig 6.189 & 6.192; 7th fig 6.191&6.194)

c. Leaves:

i. Look at the **leaf model** and refresh your memory of the location of the three tissue types and the additional terms here:

dermal tissue: epidermis, guard cells, stomata
vascular tissue: leaf veins, vascular bundles, xylem, phloem
ground tissue: mesophyll

Model: leaf section

ii. Observe the slide below and be able to recognize: cells of the **epidermis, stomata, guard cells, leaf hairs** (trichomes)

Slide: monocot & dicot leaf epidermis wm
(Atlas: 5th fig 6.196; 6th fig 6.216; 7th fig 6.219-20)

iii. Examine the slide of the leaf cross sections below. Identify the internal structures and tissues including, **cuticle**, **epidermis, ground tissue (=mesophyll), xylem, phloem, stomata, guard cells.** 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 **stoma** (pleural = stomata) are small **guard cells** that can open and close the pore. On this same slide note the **leaf hairs** (or trichomes).

Slides: Typical monocot and dicot leaves, cs
(Atlas: 4th fig 6.115 & 6.116; 5th fig 6.191; 6th fig 6.211; 7th fig 6.214-4)

2. Modified Vegetative Organs of Flowering Plants

1 pt extra credit: bring in an example of a modified root, stem or leaf on this day of this lab. **Check in with the instructor before the beginning of class.**

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 those in the other plant groups. You will investigate some of these modifications in this lab exercise.

There are several "fresh" and preserved examples of various modified roots, modified stems and modified leaves available in the lab. In your lab report place the number or name of each item in the column of the table that best describes which vegetative plant organ has been modified *and* list the **major** function of each. **Make sure you include at least one example each of an organ modified for: support, gas exchange, food gathering, food or water storage, protection, and asexual reproduction.**

a. **Modified Roots**. 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 provided. Then note the modifications of roots in the specimens provided (Atlas: 4th pp84-92; 5th fig 6.149, 6.150, 6.153; 6th 6.168). These modified organs usually enhance one or more of the organ's major functions, or give that organ a completely new function.

Recognize & know functions of : **prop roots, pneumatophores, tuberous roots, aerial roots**

b. **Modified Stems**. 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 provided. Then note the modifications of stems in the specimens provided (Atlas: 4th pp84-92; 5th fig 6.164-165; 6th fig 6.183). These modified organs enhance one or more of the organ's major functions, or the modification can give that organ a completely new function.

Recognize & know functions of : **tubers, rhizomes, runners, spines, prickles. vining stems**

c. **Modified Leaves**. 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 provided. Then note the modifications of leaves in the specimens provided. These modified organs usually enhance one or more of the organ's major functions, or give that organ a completely new function.

Recognize & know functions of : **tendrils, bulbs, spines, pitcher plant leaves**

3. Flowering Plants: Reproductive Organs

1 pt Extra Credit. Bring in 2 examples of flowers. **Check in with the instructor before the beginning of class**

a. Flower

i. Examine the flower model to identify the following structures: **receptacle, sepals**, **petals**, **stamen**, **anther**, **filament**, **pistil**, **stigma, style, ovary** with **ovules**.

Model: flower

(Atlas: 4th fig 6.119; 5th fig 6.197 – 6.215; 6th fig 6.217 & 6.251)

ii. Examine the fresh lilies and identify as many of the same structures as you can. Note that the sepals and petals look very similar

Live: fresh lilies

iii. Remove the **pistil** from the open flower you dissected above (ii.) and use a scalpel to make a **cross section** of the very bottom of the **ovary**. Make a **longitudinal section** of the remainder of the ovary. Use your dissecting scope to note the location of the **ovules** with **eggs** in your two sections. Make a labeled sketch of your sections in the space provided in your lab report.

iv. touch a small piece of CLEAR scotch tape to the anther and tape it onto a clean slide. View the slide under low power and draw the pollen grains that you see in the space provided in your lab report.

v. After studying the flower structure of the Lily, dissect 5 of the other kinds of fresh flowers available to find the basic flower parts. *You may need a dissecting scope for the smaller flowers*. Note the many variations in shape and numbers of the four basic flower parts; eg sometimes sepals or petals are fused together into a tubelike structure. In some cases the pistils or stamens are missing completely (=incomplete flowers). Record this information in the table provided on your lab report.

Live: fresh flowers

vi. Examine the slide of a lily flower bud cross section and identify the sepals, petals, anthers and pistil. Also note the **ovary** with **ovules** & **eggs**:

Slide: Lily flower bud cs
(Atlas: 5th fig 6.228; 6th 6.252 & 6.258; 7th fig 6.263)

vii. Take a live lily flower bud that has not yet opened and with a scalpel cut off the top half inch of the bud. Then peel back and identify, in order, the sepals, petals, stamens and pistil.

b. Pollen

i. compare the slide below to the illustration in your atlas to be able to recognize what pollen grains look like

Slide: mixed pollen grains
(Atlas: 4th fig 6.134-5; 5th fig 6.219-23; 6th fig 6.246-50; 7th fig 6.257-61)

ii. View the slide below and note the growing **pollen tube** as it would appear after it lands on the stigma of a pistil:

Slide: Lily pollen tubes, wm
(Atlas: 6th fig 6.251; 7th fig 6.261)

c. Seed Development

View the slide below and identify the **embryo**, **endosperm** and **seed coat**

Slides: Shepherd's Purse Mature embryo, *Capsella*, ls
(Atlas: 5th fig 6.225-6; 6th 6.262-5; 7th fig 6.275-6)

d. Fruit Development

i. 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, and others attached to locate the **seed** in each kind of fruit.

Slides: Tomato Fruit *Lycopersicum* cs
Apple Fruit *Malus* cs
(Atlas: 4th beginning on p97; 5th fig 6.218; 6th 6.243-5; 7th fig 6.277)

ii. 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 using the illustrations provided. Select four different fruits, use the knife provided to make a section down the fruit beginning at its "stalk". Then make a simple sketch of each in the appropriate boxes on the lab report. Then indicate where, on each, the parts of the flower (sepals, petals, pistil (stigma, style, ovary), stamen) are, or once were, before it became a fruit.

Living & Preserved: examples of fresh fruits

(Atlas: 5th fig 6.232-44; 6th fig 6.266-78; 7th fig 6.277-90)

V. Plant Symbioses

A. Root Nodules

Some roots have a symbiotic relationship with nitrogen fixing bacteria. The bacteria creates a swelling on root called **root nodules**. Each nodule contains millions of bacteria. The bacteria convert nitrogen gas into useable nitrogen 'fertilizer' for the plant. Only bacteria are able to use the abundant nitrogen gas in the atmosphere as a nutrient in this way. Plants with root nodules are freed from a strong dependence on nitrogen fertilizers and tend to grow in poor soil where other plants are unable to thrive. Review the slide and preserved material below related to this symbiotic association.

Slide: Legume Nodule cs
(see handout)

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

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. Review the slide below to distinguish between the plant cells and fungal cells in this symbiosis.

Slide: endotrophic mycorrhizae, cs
(see handout)

C. Plant Galls

Plant **Galls** are any deviation from the normal pattern of plant growth on a particular organ or part due to the presence of another organism. Many galls superficially resemble plant parts such as berries, nuts and other types of fruit. Some galls look like fungi and for years some were even misidentified as fungal species. Other galls resemble strange animal forms like sea urchins and coral polyps. Plant galls can be produced by a variety of organisms; viruses, bacteria, fungi, protozoa, mites, insects and nematodes. A gall appears to be a **parasitic** relationship. Most galls are a physiological response or defensive reaction by plants to certain insects that feed or deposit eggs on or within plant tissues.Virtually all plant organs are attacked: roots, stems, leaves, flowers and fruits, but leaves are the most common organ attacked.

Living and Preserved: plant galls & illustrations
(see handout)

D. Parasitic Plants

A few plants are parasitic on other plants or on soil fungi. Some plants, such as mistletoe still have green leaves that do photosynthesis but their roots are able to also absorb sugars and other organic

molecues from their hosts. Some plants have completely lost the ability to do photosynthesis and are heterotrophic, feeding completely on the organic foods produced by their hosts.

VI. Other Plant Interactions

A. Root Grafts

As perennial plant roots grow they encounter roots of other plants growing nearby. The roots of these different plants may grow together to such a point that the vascular tissues of both are interconnected. Root grafts can occur between members of the same species and sometimes even between two different species. Such root grafts have been found in over 160 species of trees and shrubs. Nutrients and water are shared enhancing the survival of individuals that cannot absorb adequate amounts of nutrients and water from their own roots. But pathogens can also more easily spread from tree to tree.

Preserved: root graft & illustrations

B. Insectivorous Plants

100's of plants are carnivorous. They generally grow in nitrogen poor soil and use insects as a source of nitrogen.

C. Plant Movements

While plants are nonmotile, many of them can move in some way; from leaves or flowers bending toward light, petals opening and closing during the day or night, insectivorous plants that can capture a fly by closing their leaves, etc.

Lab Activities:

2 pts Extra Credit: Bring in an example of any of the kinds of plant symbioses mentioned above for the appropriate lab period. **Check in with the instructor before the beginning of class**

1. Look at the examples of plant symbioses & interactions on display (**illustrations, slides, preserved and live materials**) and be able to recognize each example of sympiosis and to describe the nature of the relationship.

Name:_____

Date:_____

The Plant Kingdom

Lab Report

I. The Anatomy of Plants

1. Draw and label a typical **plant cell** as seen in the *Elodea* wet mount and the plant cell model.

2. List each of the major **plant cell organelles & structures** mentioned in the lab and that you found on the plant cell model, and in a phrase describe the general function of each.

3. Name three structures that you *actually saw* on your wet mount. Name two structures that you found in the plant cell *model* but could NOT find in real plant cells.

4. Name the major **vegetative plant organs** and list the specific **function** of each.

5. Select one plant **organ** and sketch a section from one of the slides you used and label each of the three major kinds of plant **tissues** within that organ; show both kinds of vascular tissue

6. What are **leaf hairs**, **stomata**, and **root hairs**. What is the function of each, and in what **tissue** is each found

7. Name & describe the difference in structure and in function between **xylem** and **phloem**.

8. After looking at all 4 major plant groups; how much overall variation (size, shape functions, etc) did you find in each type of **vegetative organ**; for example are there more different kinds of leaves than roots or stems in the 4 main kinds of plants? Explain

II. Plant Life Cycle

9. Define **sporophyte** & **gametophyte**. What would be the advantage to having these two separate stages in the life cycles of mosses and ferns?

IV. Plant Diversity

10. Sketch a moss **sporophyte** and a moss **gametophyte** from the sample slides that you viewed. Which stage are you most likely to find hiking in the woods? Why?

11. Sketch a fern **sporophyte** and a fern **gametophyte** from the slides that you viewed. Which stage are you most likely to find hiking in the woods? Why?

12. Looking at the examples of ferns on the counter, are the leaves of most ferns **simple** or **compound**?

13. Sketch the **vascular bundle** of a fern, a conifer and a flowering plant from the slides you viewed in lab and label the **xylem** and **phloem** of each:

Fern vascular tissue **Conifer vascular tissue** **Flowering plant vascular tissue**

14. Draw what you see on your slide of cork tissue. Robert Hooke was the first to illustrate cork tissue in 1665. What was the significance of his description of cork?

cork

15. Name the **tissues** found in **wood** and the tissues found in **bark** of perennial plants.

16. How can you tell the difference between a male cone and a female cone in conifers?

17. The first three plant groups; **mosses**, **ferns** and **conifers**, actually each consist of several related but distinct plant **phyla** (see lecture notes and handouts).

a. Name a plant that ***we included*** with **mosses** but technically is not a moss and describe one way in which it differs from true mosses

b. Name a plant that ***we included*** with **ferns** but technically is not a fern and describe one way in which it differs from true ferns

c. Name a plant that ***we included*** with **conifers** but technically is not a conifer and describe one way in which it differs from true conifers

18. On the table below name the item that represents a **modified vegetative organ**, check the correct column to indicate which organ it is, then indicate its major function.

Item or #	**Modified Roots**	**Modified Stems**	**Modified Leaves**	**its New or Enhanced Function**
eg onion bulb			**x**	food storage

19. Record your drawings of the lily flowers below.

ovary cross section **ovary longitudinal section** **lily pollen grains**

20. For the 5 flowers that you dissect indicate how many of each flower part you found in each different kind of flowers

Flower	Sepals	Petals	Pistil	Stamen
eg. Lily	**3**	**3**	**1**	**6**

21. Record your labeled drawings of four different kinds of fruits in the boxes below:

22. What were the similarities and the differences that you saw in lab between the **conifer embryo** and the **flowering plant embryo** that you looked at in the lab?

23. Using lecture material, your textbook, or other reference sources, Name a **specific example** of a food or other commercial product made from each of the following specific plant parts:

Vegetative Plant Organs		
Roots	**fibrous root**	
	tap root	
Stems	**whole stem**	
	bark	
	sap	
	axillary buds	
Leaves	**whole leaf**	
	blade only	
	trichomes	

24. Using lecture material, your textbook, or other reference sources, name a **specific example** of a food or other commercial product that is made from the specific reproductive structures below:

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

V. Plant Symbioses

25. List each of the **symbioses** displayed in the lab. Label each as **mutualistic**, **commensal** or **parasitic** and explain why.

The Animal Kingdom

Biol 1409 Lab Exercises

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 **tissues**, **organs** and **organ systems**. Whereas plants had tissue and relatively simple vegetative and reproductive organs, animals have complex tissues forming 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**, **eukaryotic** organisms
2. cells with **no cell wal**l or chloroplasts and **many more mitochondria, many more ribosomes**
3. **heterotrophic** nutrition (herbivores, carnivores, saprobes)
4. **aerobic respiration**: require free oxygen for energy production
5. extra energy usually stored as **fats & oils**
6. cells differentiated into **tissues: epithelial, connective, muscular, nervous**
7. tissues differentiated into complex **organs** and **organ systems**.
8. most are **motile** at some point in their life cycle
9. most are **much more active** and have a **much higher metabolism** than members of any other kingdom
10. reproduce both **sexually** and **asexually**, animals show a great diversity in kinds of reproduction. some with well developed **alternation of generations**.
11. most have a relatively **complex developmental** stages including an embryonic or a larval stage as they progress from zygote to adult
12. most have fairly **elaborate behaviors** to enhance their survival within their habitat

There are more animal **phyla** than those in any other kingdom and new ones are still being described. There are about 34 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".

A simple way to categorize animals is as **invertebrates** (= animals without backbones) and **vertebrates** (=animals with backbones). The **vertebrates** are all members of the phylum Chordata and are the most familiar animals to most people. This is also the phylum to which we belong. But notice that, by far, most animal species are **invertebrates** while the vertebrates are found in only a single phylum of animal.

I. The Anatomy of Animals

A. Animal Cells:

Animal cells share the same basic features as other eukaryotic cell. What distinguishes them from plants is their lack of a cell wall and lack of chloroplasts. Also, since animals are much more active, animal cells have many more **mitochondria** (the energy factories). Finally, animal cells are

also much higher in protein and therefore have many more **ribosomes** (protein factories) than the cells of any of the other kingdoms that we have studied

Lab Activities:

A. Animal Cells:

1. Study the illustrations and find the following organelles on the animal cell model: **cell membrane, nucleus, ribosomes, mitochondria.** Compare and contrast the structure and organelles of plant cells and animal cells. Are there any organelles that animals have but are lacking in plants?

Model: animal cell
(Atlas: 4th fig 1.16-1.56; 5th fig 1.18; 6th fig 1.18; 7th fig 1.18)

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.

1. **Epithelial Tissues** –form the outer coverings of animals. It also lines the inner and outer surfaces of all body organs. It functions in : protection, secretion, absorption, filtration; secrete cuticles, exoskeletons, shells, etc.

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.

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.

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)

Lab Activities:

B. Animal Tissues:

1. **Epithelial Tissues**

Slide: epithelium simple squamous (oral smear)
(Atlas: 6th fig 1.29; see handout)

2. **Connective Tissues** Be able to distinguish between the four different examples of connective tissues below:

a. Areolar Connective Tissue

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

Slide: mammal areolar tissue spread

(Atlas: 4th fig. 1.42; 5th fig 1.44; 6th fig 1.44; 7th fig 1.44)

b. Adipose Connective Tissue

– large 'empty' looking cells for fat storage

Slide: adipose tissue sec [Wards]

(Atlas: 4th fig. 1.41; 5th fig 1.43; 6th fig 1.43; 7th fig 1.43)

c. Bone Connective Tissue

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

Slide: bone dry ground cs

(Atlas: 4th fig 1.50; 5th fig 1.52; 6th fig 1.52; 7th fig 1.52)

d. Blood (or vascular) **Connective Tissue**

- transport of nutrients, wastes, oxygen, hormones, etc

Slides: blood frog or **frog blood smear**

3. **Muscle Tissues**

slide: amphibian smooth muscle teased

4. **Nervous Tissues**

Slide: mammal neuron motor nerve cell sm

(Atlas: 4th fig 1.33; 5th fig 1.65; 6th fig 165; 7th fig 1.65)

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 tissues that extend continuously throughout relatively simple plant organs; animals instead developed a great variety of discrete **organs** and **organ systems** to perform life 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 them. The description of the major animal organ systems below focus on **vertebrates**, particularly humans, as an introduction to the major kinds of animal organ systems.

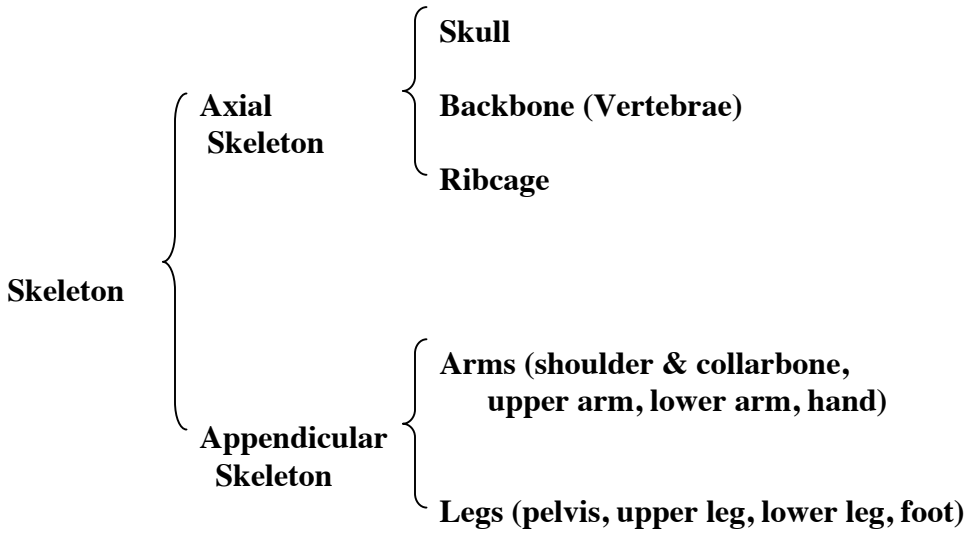
1. <u>The Skeletal System</u>

General Functions of the Skeletal System

1. Support (particularly on land)

2. Movement (along with muscular system)
3. Protection of certain vital organs (eg. brain, heart, reproductive organs, etc)
4. Mineral storage (eg. calcium & phosphorus)

The skeletal system serves several important functions the most obvious of which are structural support and protection of vital organs. The skeleton also serves as a reservoir for important minerals such as calcium and phosphorus.



Lab Activities:

C. Animal Organs and Organ Systems: 1. Skeletal system

a. Look at the skeletons available and be able to distinguish between the **axial** and **appendicular** skeletons

Model: human skeleton
(Atlas: 5th fig 9.10-11; 6th fig 9.10-11; 7th fig 9.10-1)

b. Identify the other subdivisions of the human skeleton as described in the introductory material above

2. The Muscular System

General Functions of the Muscular System:
1. movement
2. Posture & Stability
3. Communication (taking, body language, etc)
4. Control of Body Temperature (in warm blooded animals)

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 bones and joints. In humans there are over 600 different muscles that are attached by tendons to bones across a moveable joint. Most voluntary movements require the coordination of several muscles at the same time.

Lab Activities:

C. Animal Organs and Organ Systems: 2. The Muscular System

a. Observe the models of human muscles, find the '**lats'**(=latissimus dorsi), '**pecs'**(=pectoralis major & minor), '**biceps'**(=biceps brachii), '**triceps'**(=triceps brachii), '**quads'**(=quadriceps femoris (=rectus femoris and others)), '**glutes'**(=gluteus maximus), '**sixpac'**(=rectus abdominis)

Models: human muscular system
(Atlas: 5th fig 9.28-29; 6th fig 9.28-29; 7th fig 9.28)

b. Also be able to describe the general movement produced by each of these muscles

3. The Endocrine System

General Functions of the Endocrine:

1. Coordination and control of long term activities such as growth, metabolism, reproduction & development

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. Three of the major endocrine glands of vertebrates are:

pituitary gland → master gland of body; helps coordinate function of other endocrine glands

thyroid gland → regulates overall rate of metabolism or chemical processing by body cells. Some OTC "diet pills" contain extracts from animal thyroid glands to boost metabolism

pancreas → helps to maintain a constant level of sugar in the blood. Sugar is the main energy food that cells need to carry out their work. Diabetes is a malfunction of this gland causing blood sugar levels to drastically increase and resulting in many physiological malfunctions

Lab Activities:

C. Animal Organs and Organ Systems: 3. The Endocrine System

a. Locate and identify three of the major human endocrine glands listed below

pituitary gland → master gland of body; helps coordinate function of other endocrine glands
thyroid gland → regulates overall rate of metabolism or chemical processing by body cells. Some OTC "diet pills" contain extracts from animal thyroid glands to boost metabolism
pancreas → helps to maintain a constant level of sugar in the blood. Sugar is the main energy food that cells need to carry out their work. Diabetes is a malfunction of

this gland causing blood sugar levels to drastically increase and resulting in many physiological malfunctions

Model: human torso
(Atlas: 5th fig 9.40 & 9.42; 6th fig 9.57 & 9.49; 7th fig 9.57)

4. The Nervous System

General Functions of the Nervous System:

1. Coordination and control of all body activities
2. Rapid responses to emergency situations
3. Perception & interpretation of sensory information
4. (in humans) Higher level thought processes; planning, abstract thought, memory, learning, speech

Animals are more physically active than members of any other kingdom and therefore 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**.

In humans, the nervous system is subdivided into a **Central Nervous System** (the **brain** and the **spinal cord**) and the **Peripheral Nervous System** (the **nerves** branching from the brain and spinal cord). Nerve cells of the PNS that are bringing information to the brain are called sensory neurons. Nerve cells that are taking information away from the brain out to muscles and glands are called motor nerves.

Lab Activities:

C. Animal Organs and Organ Systems: 4. The Nervous System

a. Observe the display of the cat nervous system and Identify the **CNS** & **PNS**. Observe how the **spinal cord** connects to both the **brainstem** and the main **nerves** of the body to coordinate impulses going to and coming from the brain.

Preserved: cat nervous system

b. Find the following general regions on the model human brain;

Brain Stem → controls vital life functions such as heartbeat, breathing, consciousness
Cerebellum → helps coordinate and control voluntary muscle movements and posture
Cerebrum → gives us conscious perception of our major senses; abstract thinking and planning; language and speech; learning & memory

Models: human brain

Preserved: human brain
(Atlas: 5th fig 9.55&58; 6th fig 9.47-9; 7th fig 9.47-9)

5. The Senses

General Functions of the Senses:

1. monitor the outside world and the internal environment to allow the body to respond quickly and effectively to any potential dangers or threats

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:

photoreceptors → convert light energy into nerve impulses
chemoreceptors → convert various chemicals in air or water into nerve impulses
mechanoreceptors → convert mechanical movements such as vibrations of air or water, pressure, and touch to nerve impulses
thermoreceptors → converts heat or cold into nerve imulses

Lab Activities:

C. Animal Organs and Organ Systems: 5. The Sense Organs

a. Name and describe the main functions of the major human sense organs: eye, ear, nose, taste buds

Models: **human torso**
ear (Atlas: 7th fig 9.65)
eye (Atlas: 5th fig 9.55 & 9.58; 6th fig 9.62 & 9.65; 7th fig 9.62)

b. Identify which type of the **receptors** mentioned in the introduction to this section that you would expect to be found in each of the sense organs for **vision**, **smell**, **taste**, **touch**, **hearing**, and **orientation**

6. The Circulatory System

General Functions:
1. Delivers food and oxygen to cells
2. Removes carbon dioxide and wastes from cells
3. transports hormones to target cells
4. protects body from pathogens

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.

The circulatory system consists of a muscular pump, the **heart,** and plumbing, **arteries, capillaries and veins**. In simple animals the heart is a simple pumping vessel, in birds and mammals the heart is a double pump with two distinct circuits of blood flow; the **pulmonary circuit** and the **systemic circuit**. The heart first pumps blood to the **lungs or gills** to pick up oxygen and release carbon dioxide. The oxygenated blood then returns to

the heart and is pumped into the **systemic circuit** which branches to every other organ in the body to deliver oxygen and nutrients. The **capillaries** are the microscopic vessels that are the actual sites of exchange of materials. Capillaries are found in virtually all organs of the body and are never more than a millimeter away from any body cell.

Lab Activities:

C. Animal Organs and Organ Systems: 6. The Circulatory System

a. Study the preserved cow heart and human heart models and note the following:
   i. the **4 pumping chambers**; **2 atria** and **2 ventricles**
   ii. the **1-way valves** that insure blood can circulate only in 1 direction
   iii. and the **4 major blood vessels** attached to the heart
   iv. **veins** bringing blood back to the **atria**
   v. **arteries** taking blood away from the v**entricles**

Preserved: cow heart
(Atlas: 5th fig 9.66; 6th fig 9.73; 7th fig 9.73)

Models: human heart
(Atlas: 5th fig 9.66; 6th fig 9.73; 7th fig 9.67-8)

b. In illustrations and using the circulatory system plaque, follow the **pulmonary circuit** from the **ventricle** of the heart through **arteries** to the **lungs** and back to the **atria** of the heart through **veins**. Also, Follow the **systemic circuit** from the **ventricle** of the heart through **arteries** to all other parts of the body, then back to the **atria** of the heart through **veins.**

Model & Illustrations: human circulatory system
(Atlas: 5th 9.60-1; 6th fig 9.67-8; 7th fig 9.67-8)

7. The Digestive System

General Functions:
1. physical and chemical digestion of large organic milecules into their smaller building blocks
2. absorption of water and digested nutrients
3. collection & elimination undigested and unabsorbed materials

The digestive system is essentially a long hollow tube which has been modified along its length to form organs responsible for processing and absorbing food. In addition, several accessory organs such as the liver, gall bladder and the pancreas are associated with the alimentary canal.

Lab Activities:

C. Animal Organs and Organ Systems: 7. The Digestive System

Locate the main digestive organs on the models available: **mouth, throat, esophagus,**

stomach, small intestine, large intestine, anus, liver, pancreas. Which of these organs are most important in the actual **digestion** of food? Which of these organs are most important in **absorption** of nutrients into the blood?

Model: human torso
(Atlas: 5th fig 9.75; 6th fig 9.82; 7th fig 9.82)

8. The Respiratory System

General Functions:

1. O_2 and CO_2 exchange between blood and air
2. speech and vocalization
3. sense of smell

Virtually all animals require free oxygen gas (O_2) for respiration. And since animals are considerably more active than members of other kingdoms they require a greater supply of oxygen to generate energy.

The respiratory system is a collection of continuously branching tubes, held open by bands of **cartilage** that allows air to move into and out of the lungs.

nose → throat → voice box (larynx)→ trachea → bronchial tree → alveoli (in lungs)

Inside the **lungs** the open tubes terminate at clusters of sacs called **alveoli**. These are the actual sites of gas exchange. they are surrounded by capillaries. and together provide a considerable surface are for gas exchange.

Also, just below the throat is an enlarged area called the **larynx**, or voice box. By forcing air over a thin sheet of muscles and adjusting the tension of the muscles we can produce various sounds including those related to emotions, crying, laughing, and speech.

Lab Activities:

C. Animal Organs and Organ Systems: 8. The Respiratory System

Locate the **nose, throat, voice box, trachea,** and **bronchial tree** on the torso model

Model: human torso & respiratory system
(Atlas: 7th fig 9.74)

9. The Excretory System

General Functions:

1. removal of metabolic wastes & toxins
2. elimination of excess nutrients & excess hormones
3. regulation of blood volume & pressure
4. regulation of electrolytes & body pH

Animals 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.

The metabolic wastes that our cells produce diffuse into the blood and are taken to the kidneys for disposal. The basic strategy is that wastes and other materials present in excess quantities must be removed from the blood. Kidneys selectively regulate concentrations of dissolved wastes and other substances in the blood. This regulation process is accomplished by filtering the dissolved substances out of the blood. Later, certain constituents are selectively reabsorbed back into the blood. the final filtrate, urine, passes out of the organism through ducts and an organ called the urinary bladder which temporarily stores the urine.

Kidneys ⟶ **ureters** ⟶ **bladder** ⟶ **urethra**

Filtering the blood and urine formation occurs in the kidneys. Each kidney is a collection of 1000's of tiny **neprhons**. Each nephron processes a small amount of blood to extract metabolic wastes and excess nutrients from the blood and sends it to the bladder for storage and later elimination.

Lab Activities:

C. Animal Organs and Organ Systems: 9. The Excretory System

Identify the **kidneys**, **ureters**, **bladder** and **urethra** on the models below

Models: **human torso**
excretory system
(Atlas: 5th fig 9.67; 6th fig 9.74; 7th fig 9.97)

10. The Reproductive System

General Function:

1. producing offspring
2. propagation of the species

Most animals reproduce both asexually and sexually. Humans and other mammals are somewhat unusual in that they only produce offspring by sexual reproduction. The main human reproductive organs are described in the table below.

Male Reproductive Organs		Female Reproductive Organs	
organ	**general function**	**organ**	**general function**
Testes	produce sperm and sex hormones	**ovaries**	produce eggs and sex hormones
Internal conducting passageways	direct semen to female reproductive system	**oviduct**	fertilization of the egg
Glands	produce semen to protect and nurture sperm cells	**uterus**	Development of child
urethra in penis	internal fertilization	**vagina**	internal fertilization

Lab Activities:

C. Animal Organs and Organ Systems: 10. The Reproductive System

Identify the main reproductive organs on the models available; know the functions of each:

male: **penis, testes, glands, urethra;**

female: **ovaries, oviducts, uterus, vagina**

Models: **human torso**
male reproductive system
female reproductive system
(Atlas: 5th fig 9.90-1; 6th fig 9.97-8; 7th fig 9.101-2)

Human Organ Systems Overview

Skeletal System

the skeleton is subdivided into Axial and Appendicular portions. each individual bone is a separate organ of the skeletal system (eg. humerus, radius, femur, etc.)

Muscular System

each individual muscle is a separate organ of the muscular system
(eg. biceps, triceps, gastrocnemius. etc.)

Nervous System

Central Nervous System vs Peripheral Nervous System, brain, cerebrum, cerebellum, brainstem, spinal cord, cranial nerves, spinal nerves

Sense Organs

eyes, ears, taste buds, smell, touch, balance organs

Endocrine System

pituitary gland, thyroid gland, pancreas

Circulatory System

heart, arteries, capillaries, veins

Respiratory System

nose, throat , voice box (=larynx), trachea, bronchi, lungs, diaphragm

Digestive System

mouth, throat , esophagus, stomach, small intestine, large intestine, liver, gall bladder, pancreas

Urinary System

kidneys, ureter, urinary bladder, urethra

Reproductive System

male: penis, testes, glands
female: ovaries, oviducts, uterus, vagina

II. Animal Reproduction, Development & Life Cycles

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

A. 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.

In animals, sexual reproduction includes:

1. the development and maturation of the **gametes**; the egg and sperm
2. fertilization to produce the **zygote** or fertilized egg
3. **embryonic development** from single celled to multicellular form
4. and one or more post embryonic stages such as **larvae**, **nymphs**, **fetuses**, etc

Lab Activities:

1. Review the exercise we did earlier in the course on the **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
4. Fragmentation
5. Polyembryony (twinning):

a. Protandry
b. Sexual Dimorphism
c. Parthenogenesis (Virgin Birth)

B. Embryonic Development

After fertilization, the **zygote** typically goes through various developmental (or immature) stages as the life cycle progresses from the zygote to adult.

1. **Fertilization & Early Cleavage Divisions.** 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 The first identifiable period of development after the egg is fertilized are called **cleavage divisions**.

2. **Embryonic Development.** Embryos are immature stages of animals that are not able to feed and move independently.

   a. **Blastula:** If the embryo is spherical it is called a blastula; At the blastula stage, the cells form a hollow sphere..

   b. **Gastrula:** 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 new cavity formed will eventually develop into the digestive system. The opening of this cavity to the outside will become the mouth or the anus of the adult animal.

Lab Activities:

1. Fertilization & Early Cleavage Divisions. identify **fertilized eggs** and eggs undergoing **cleavage divisions** in the slide below:

   Slide: starfish early cleavage, *Asterias* eggs
   (Atlas: 5th fig 2.13; 6th fig 2.13; 7th fig 2.13)

2. Embryonic Development**.** Identify the **blastula** and the **gastrula** of starfish embryology as illustrated in the lab manual and as seen on the following slides.

   Slide: starfish blastula; starfish development
   (Atlas: 5th fig 2.13; 6th fig 2.13; 7th fig 2.13)

   Slide: starfish gastrula, starfish development
   (Atlas: 5th fig 2.13; 6th fig 2.13; 7th fig 2.13)

C. Later Developmental Stages.

Further development varies considerably in different animal groups. Various additional developmental stages may occur before maturity is reached. Such terms as **larva**, **pupa**, **fetus, nymph**, etc are used to describe some of these immature stages. Sometimes, the immature stage even 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.

1. **Larva:** In some animals, especially marine animals, the embryo soon becomes a free living **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.

2. **Pupa:** A transformational stage in some insects between the larval and adult stage during which metamorphosis occurs in which the larvae acquire their adult characteristics

3. **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.

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

Lab Activities:

1. Review the exercise we did earlier in the course on the **developmental stages.** Be able to define the following stages that are common in the animal kingdom.

2. Take a closer look at some of the specific kinds of animal larvae and be able to distinguish between them. The larvae listed below are evolutionarily significant. You do not need to know to which group each belongs:

   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.

Slides: *Aurelia* planula, wm
(Atlas: 5th fig 7.23; 6th fig 7.23; 7th fig 7.27)

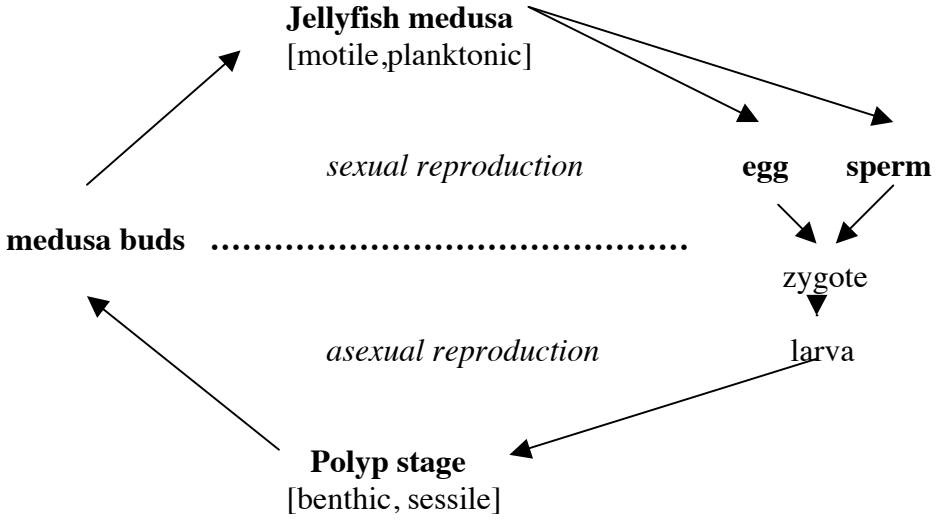
***Patella* trochophore larvae, wm**

Nauplius, barnacle, wm

D. 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 life cycles. 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 life cycle of these beasts is illustrated below.



Name:_____

III. Identifying Common Freshwater Invertebrates

Lab Activity:

2 pts Extra Credit: bring in a water sample that contains visible aquatic organisms**. Notify your instructor before the beginning of class.**

1. Examine the water samples available in the lab room.
    a. collect a drop of water or sediment from the bottom of the container and make a wet mount to examine on your compound microscope
    b. Also, carefully examine any small stones, leaves etc for signs of larger organisms. Then use forceps to pick them up and place them in the small dish provided. Now use the dissecting scope or magnifying glass to investigate these larger critters
    c. If a speciman is moving too quickly place a drop of 'Detain' on your wet mount.

2. Now use the key provided to identify 5 different organisms that you collected. You will usually be trying to identify the animal to **Phylum** or **Class** (review the categories used by taxonomists to categorize living organisms) Use the same technique that you used to identify the leaf specimens several weeks ago and follow the dichotomous key as far as you can go. Then complete the table below. Generally, the common name is given in parentheses and the formal name is in bold face.

Animal	**Sequence used to identify it**	**Common Name**	**Formal Name of Animal Group**
Sample	1a→2b→3a→4b	water mites	Order Acari (a kind of arthropod)

Identification of Some Common Freshwater Invertebrates

1a.	Animal with obvious jointed legs or antennae (Phylum Arthropoda)	22
b.	Animal without obvious jointed legs (may have stubby unjointed "legs")	5
2a.	With 3 pairs of legs	**Class Insecta** (adults and nymphs)
b.	Clearly with more than 3 pairs of legs	3
3a.	With 4 pairs of legs, no antennae; Class Arachnida (spiders, mites)	4
b.	Usually with 5 or more pairs of legs and 2 pairs of antennae	25
4a.	Body divided into 2 distinct sections	**Order Aranea** (spiders)
b.	Body not obviously divided into 2 distinct sections	**Order Acari** (mites)
5a.	Microscopic, with segmented body with 4 pairs of knoblike legs bearing claws at their tips	**Phylum Tardigrada** (water bears)
b.	Not as above	6
6a.	Body covered by a shell	7
b.	Body without a shell	8
7a.	Body covered by 1 shell, usually coiled or spiral	**Class Gastropoda** (snails)
b.	Body covered by 2 distinct, hinged shells	20
8a.	Individuals growing in colonies or spongelike masses growing on rocks and twigs	9
b,	Individuals not growing in colonies	10
9a.	Colonies with pores, often green, irregular shapes	**Phylum Porifera** (sponges)
b.	Not as above; individuals of colony distinct, flowerlike with numerous tentacles; or gelatinous mass; some can be quite large	**Phylum Bryozoa** (moss animals)
10a.	Body soft, umbrella-like and translucent, free swimming by rhythmic contractions; Phylum Cnidaria;	**Class Hydrozoa** (jellyfish)
b.	Not a jellyfish	11
11a.	Most of body with distinct segments	12
b.	Body not segmented	16
12a.	With distinct head with eyes, antennae and jaws; legs present or absent; Phylum Arthropoda;	**Class Insecta** (insect larvae)
b.	Without a distinct head	13
13a.	Body often flattened, with a sucker at one end Phylum Annelida;	**Class Hirudinea** (leeches)
b.	Not as above, without a sucker	14
14a.	Microscopic, front of body with two wheellike corona that appear to spin as the animal feeds; back of body appears as a segmented, telescoping leg with 2 "toes" that are used for attachment	**Phylum Rotifera** (wheel animals)
b.	Larger animals, not microscopic; easily visible to the unaided eye; features not as above	15
15a.	Body very elongated and worm-like, without distinct	

head or legs; Phylum Annelida;	**Class Oligochaeta** (earthworms)
b. Body not as above; *may* have wartlike "legs", hooklike jaws and/or siphonlike tail Phylum Arthropoda; Class Insecta;	**Order Diptera** (fly larvae)
16a. With tentacles at one end (around mouth) Phylum Cnidaria;	**Class Hydrozoa** (hydras)
b. Without tentacles	17
17a. With elongated whiplike proboscis (tongue) extending from mouth	**Phylum Nemertinea** (proboscis worms)
b. Body elongated and wormlike	18
18a. Microscopic; not easily visible without magnification	21
b. Much larger and easily visible to unaided eye	19
19a. Body elongated, soft and delicate, flattened, often with eyespots, tends to ball up when disturbed; Phylum Platyhelminthes;	**Class Turbellaria** (planarians)
b. Body extremely long, thin, and wire-like, often tangled into a knot	**Phylum Nematomorpha** (horsehair worms)
20a. Microscopic; with jointed legs and/or antennae protruding from shells as it swims Phylum Arthropoda; Class Crustacea;	**Class Crustacea-Ostracods** (seed shrimp)
b. Larger animals with 2 hard shells usually tightly closed; often with brown barklike periostracum covering outer surface of shell and pearly layer on the inside; Phylum Mollusca;	**Class Bivalvia** (clams)
21a. Microscopic; flattened body, usually with spines on its surface, and with a forked tail end; gliding movement	**Phylum Gastrotricha**
b. thin wormlike body that tapers at both ends, no distinct head, makes whiplike, side to side movements	**Phylum Nematoda** (roundworms)
22a. Body appears to be enclosed in a shell, with no distinct head	**Class Crustacea-Ostracods** (seed shrimp)
b. Not as above	23
23a. Usually with a large pair of antennae, often branched, extending from front of body, large eye clearly visible	**Class Crustacea-Cladocera** (water fleas)
b. Not as above	24
24a. Entire body clearly segmented, pair of long antennae usually extending at right angles to the body	**Class Crustacea-Copepoda** (copepods)
b. Not as above	2
25a. Small, arching segmented body with many paired jointed appendages	**Class Crustacea-Amphipoda** (amphipods)
b. Large animals, at least several inches long, pair of prominent "pinchers toward front end, two distinct pairs of antennae	**Class Crustacea-Decapoda** (crayfish)

IV. Animal Diversity

The Invertebrates

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). Animal groups are very roughly divided into two main categories; the **invertebrates** and the **vertebrates**.

Invertebrates are usually small animals. Most are lacking an internal skeleton or a backbone. The great majority of animal species are invertebrates. We will look at examples of the following groups of **invertebrates**:

A. Simple Animals
B. Worms
C. Parasites
D. Shelled Animals (Molluscs)
E. Arthropods
F. Echinoderms

Vertebrates are the animals we are most familiar with; fish, frogs, lizards, snakes, birds, mammals, etc. Their defining characteristic is the presence of an internal skeleton of bone and/or cartilage, usually including a backbone. We will look at examples of the following kinds of **vertebrates**:

G. Fishes
H. Amphibians
I. Reptiles
J. Birds
K. Mammals

A. Some Simple Animals

1. Sponges (Atlas: 5th fig 7.1 – 7.7; 6th 7.1-7)

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:

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

2. Now, look a a slide of a section of this organism

   Slide: *Scypha* mls
   (Atlas: 5th fig 7.4; 6th fig 7.4; 7th fig 7.6)

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

3. Where in the sponge body would you expect to find **collar cells?**

4. Look at the slide of **spicules** and draw a few of them

   Slide: *Scypha* spicule strew
   (Atlas: 5th fig 7.6; 6th fig 7.6; handout)

5. 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.

6. Note the symbiotic crabs trapped within the venus flower basket (*Euplectella*) on display. How did they get there and why are they there?

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

2. Hydras and Corals (Atlas: 5th fig 7.8-44; 6th fig 7.8-45; 7th fig 7.11-51)

The **Hydras and Corals** have two **true tissues** and a few simple organs. Their body structure takes the form of a simple sac with **tentacles** around a mouth like opening pointed upward (called a **polyp**).

While hydras lack true organs the mouth does open into a sac-like **digestive cavity** in which digestion takes place. They also have a very simple type of nervous system called a **nerve net**. Some corals secrete an **exoskeleton** of calcium carbonate which, over thousands or millions of years produces large coral reefs and limestone rocks.

Hydras & Corals are **predators**. The most unusual kind of cell in the group is a **stinging cell** (or cnidoocyte) which contains a poisonous harpoon-like nematocyst that they use to spear their prey and "reel" it into their mouth.

Lab Activities:

1. **Living Hydra.** Hydra are common freshwater animals in ponds and streams in our area. 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. (Atlas: 5th 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?

   d. Take a hydra and place it on a regular microscope slide. Place the slide on the microscope and cover with a cover slip. Add a drop of methylene blue to the right edge of the coverslip. While watching through the scope touch a small piece of paper towel to the left edge of the cover slip – this will draw the methylene blue under the coverslip toward the hydra. What happens? 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 slide below of a Hydra, one of the simplest Cnidarian animals. Locate and identify the **tentacles** used for capturing food**,** the **mouth** in the center of the tentacles**, and** the **basal disc** which it uses to attach to hard surfaces. Note any asexual **buds**.

Slide: Hydra budding wm
(Atlas: 5th fig 7.10; 6th 7.10; 7th fig 7.14)

3. Jellyfish (Atlas: 5th fig 7.8-44; 6th fig 7.8-45; 7th fig 7.26-37)

Jellyfish are closely related to hydras and corals but their main form consists of an "umbrella-shaped" body called a **medusa** in which the mouth and tentacles are pointed downward. Also their body wall usually has a thick layer of jelly like material between their tissue layers giving them their common name, jellyfish. Most jellyfish have a complex life cycle where they alternate between two different body 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.

Lab Activities:

1. Observed the preserved jellyfish on display and locate the **mouth**, **arms**, **tentacles** and **gonads**

   preserved: *Aurelia* jellyfish

2. *Obelia* is a very small jellyfish that produces a colony of polyps that are all interconnected. Also, there are **two different kinds of polyps** in the colony. The **feeding polyps** have tentacles and somewhat resemble the hydra that you looked at earlier. The **reproductive polyps** lack tentacles and look more like clubs. The reproductive polyps bud off medusa which float free and, when mature, will reproduce sexually to complete the life cycle.

   Observe the slides of *Obelia* below and distinguish between the **medusa** and the **polyp** (=hydroid) forms. How many individual polyps 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?

   Slides: *Obelia* hydroid colony wm
   (Atlas: 5th fig 7.17-19; 6th fig 7.17-19; 7th fig 7.22-3)

   ***Obelia* medusae wm**
   (Atlas: 5th fig 7.20-21; 6th fig 7.20-21; 7th fig 7.24-5)

3. Review "Animal Life Cycles" where it reviews the life cycle of a jellyfish and make sure you understand the concept of "**alternation of generations**'; be able to distinguish between the polyp, the medusa, the asexual stage and the sexual stage of its life cycle.

   a. Observe the **preserved jellyfish** – this is the medusa stage (sexual) of the life cycle

      Preserved: adult jellyfish

   b. 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.

Slide: planula larva

c. 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.

Slides: scyphistoma
strobila

d. The strobila are budding (asexual reproduction) tiny jellyfish. The young medusae are called the ephyra. They will grow into the adult jellyfish

Slide: ephyra
(Atlas: 5th fig 7.17, 7.23-27; 6th fig 7.23-28; 7th fig 7.27-30)

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?

4. Planarians (Atlas: 5th fig 7.45-8; 6th fig 7.46-9; 7th fig 7.53-7)

Planarians are some of the simplest animals that have true organs and organ systems. They are common animals in creeks and ponds around central Texas. 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 a simple **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 detect chemicals in the water. 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:

2 pts Extra Credit: Bring in a live freshwater or land planarian on the day "simple animals" are studied in lab. **Be sure to check in your sample before the beginning of the lab**

1. **Live Planaria**. 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. Look at the slide of the planarian and 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** near the center of the animal.

Slide: *Planaria*, injected, wm
(Atlas: 4th p107; 45th fig 7.46; 6th fig 7.46-7; 7th fig 7.55)

3. Compare other planaria on display to the planarian you just studied; what are the similarities and differences

B. "Worms"

Worm-like animals typically have elongated, usually **cylindrical** bodies usually 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 animals differ from each other?

1. 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 pt Extra Credit: Bring in a piece of rotting fruit that has fallen to the ground from a fruit tree (NOT from the grocery store) on the day "worm' are studied in lab. After lab begins, make a wet mount of a small piece of the fruit and look for roundworms in your sample. **Be sure to check in your sample before the beginning of the lab**

1. **Live Vinegar Eels**: *Anguillula aceti*

   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 how they move among the grains.

   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**.

2. 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.

Lab Activities:

1. Locate and identify the following external structures on the preserved worm below: **mouth, jaws, tentacles, eyes, pharynx, parapodia, segments**

Preserved: sandworm, *Nereis*
(Atlas: 4th fig 7.63-4; 5th fig 7.81-4; 6th 7.83-6; 7th fig 7.103-4)

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

3. Earthworms (Atlas: 4th p116-118; 5th fig 7.85-94; 6th fig 7.83-94)

Earthworms are probably the most familiar of worms. They have elongated, wormlike bodies with repeating **segments**. They have a more efficient digestive tract than the hydra or planarian since it has two openings, a mouth and an anus; food travels only one way as it is digested and absorbed. Segmented worms also have a **circulatory system** with beating **hearts** to help to distribute food and oxygen. they also have an 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 much larger, as long as 10 feet.

Lab Activities:

1 pt Extra Credit: Bring in a live earthworm. **Be sure to check in your sample before the beginning of the lab**

Preserved: earthworm
(Atlas: 5th fig 7.85-91; 6th fig 7.87-92; 7th fig 7.107-112)

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.

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. Notice that the clitellum does not extend completely around the animal, it is thickest on the top and absent on the bottom of the animal. 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:**

Place the earthworm "clitellum-side up" in a dissecting tray and pin the very front and back of the worm to the tray. 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.

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. Look at the **slide** 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

Slide: earthworm nervous system wm

4. Demonstration: Other Worm-like Animals

The "worm" body plan is a very common and successful form for many different kinds of animals. Not only for the familiar earthworms and sand worms but a variety of more specialized and more cryptic animal phyla. The elongated body allows the animal to burrow in soft sediments or hide in the rocky crevasses of rocks and reefs. With only the head protruding to feed, most of the body is hidden and well protected from would-be predators. The front ends of some worms are often modified into elaborate feeding organs for filtering the water or engulfing sediment. A few specialized worms however are voracious predators of the plankton or lack a gut all together and receive nutrients from symbiotic bacteria.

Look at the **slides**, **preserved materials** and **illustrations** of some of the different kinds of worms below to see the diversity of the worm body plan. What are their similarities? What are their differences?

peanut worms (Sipuncula) - marine worms with tentacles for feeding on one end, live in burrows in sandy sediment

spoon worms (Echiura) - sausage shaped marine worms in shallow water sediments or rocky crevasses

beard worms (Pogonophora) - usually found in deep waters, very common at hydrothermal vents, have long tentacles that give them a beard-like appearance, have no mouth or digestive tract and get their nutrients from symbiotic bacteria living in their tissues

velvet worms (Onycophora) - brightly colored cylindrical body with up to two dozen pairs of legs, jaws and antennae at front end

arrow worms(Chaetognatha) - voracious planktonic predator in shallow waters with large jaws

acorn worms (Hemichordata) - chordates closest relatives, in tubes in soft sediment feed like earthworms, eating the sediment and letting the gut sort out the nutrients

horsehair worms (Nematomorpha) - also called gordion worms for their ability to tie themselves into knots, often found in yards and sidewalks after summer rains, juveniles parasitic in insects

C. The Molluscs - Shelled Animals

Many animals including clams, snails and their relatives secrete and live inside some kind of shell. This shell is usually a type of **exoskeleton** that is used for support and sometimes for protection from predators. In some animals the "shell" consists of a group of interconnected plates underneath a thin epidermis.

2 pts Extra Credit: bring in a LIVE mollusc on the lab day that we study Shelled Animals. **Be sure to check your sample in before lab begins.**

1. Clams (Atlas: 5th fig 7.70-3; 6th fig 7.70-3; 7th fig 7.80-8)

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. Study the **shell** of a clam:

Preserved: whole shells and pieces of shells

Find 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. Clam Dissection:

Preserved: clam
(Atlas: 5th fig 7.70-3; 6th fig 7.70-3; 7th fig 7.84-8)

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.

2. Snails

Snails are relatives of clams and have only a single shell that is usually **coiled**. Snails are able to retract into their shell for protection. Some can even close the opening with an **operculum**. Some snails have completely lost their shell and are called **slugs**

Lab Activities:

1. **Live Snails**

If live snails are available observe their external features, particularly eyes, tentacles and mouth. Note how they move by gliding on a mucus trail. Note their reactions to sudden movements or noises.

2. **External Anatomy**

Preserved: snail
(Atlas: 6th fig 7.69; 7th fig 7.76-9)

Study the **shell** of the preserved snail. note the kind of coiling and find the growth lines. Is there an **operculum** present. locate the **head** with **tentacles**. The **eyes** of a snail are on the tips of the largest pair of tentacles. Find the **mouth**, can you see the **radula** inside the mouth? Note the **foot** on which the snail glides. Most of the internal organs of the snail are inside the shell and will not be dissected here.

2. **Radula**

Slide: radula
(Atlas: 6th fig 7.68; 7th fig 7.78)

The **radula** is the main feeding organ of snails. It consists of rows of file-like teeth. Most use it to scrape algae off of rocks and sediment. Others use it as a drill to penetrate the shells of other molluscs on which they feed

3. Cephalopods

Cephalopods include octopus, squid and cuttlefish. Unlike other molluscs, the **shell** in this group has been greatly reduced or completely lost. The **mantle** becomes the protective outer covering and the **foot** has been modified into **arms** and **tentacles**.

Lab Activities:

1. **External Anatomy**

Preserved: squid
(Atlas: 6th fig 7.80; 7th fig 7.94)

Using your atlas, find the **mantle, fins, funnel, eyes, arms,** and **tentacles.** The long tentacles can shoot out to quickly catch unsuspecting prey. Note the **suckers** on arms and tentacles. Also, observe specimens that show **chromatophores** or pigment cells. Some cephalopods are noted for their ability to quickly change colors and to even put on a "light show" as part of their mating displays.

2. **Internal Anatomy**

Preserved: squid

(Atlas: 6th fig 7.79-82; 7th fig 7.93-6)

place the squid so that the **funnel** is on the top then use scissors to cut from the edge of the mantle to the tip (as in the illustration in your atlas). Pin the mantle open. If you have a female, remove a pair of large whitish nidamental glands to view the organs below. Now locate the following organs: **gills**, , **rectum**, **ink sac**, **stomach**, **cecum**, **ovaries** or **testis**.

3. **Other Cephalopods**

Look at examples of other kinds of cephalopods and note especially the different kinds of shells found in the group.

D. Some Parasitic Animals

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 outside of their hosts, **endoparasites** live completely inside the host, often in the digestive, respiratory or urinary system.

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 **final** (or definitive) **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. **Structures for penetration and attachment to host**
   eg. hooks, suckers, teeth, enzymes

2. **Reduced superfluous structures**
   such as nervous system, sense organs, muscles, digestive tract, etc

3. **Usually have a resistant stage in life cycle**
   for getting from one host to another

4. **Tendency toward being Hermaphrodite**
   only need any two, not male and female
   some can even self fertilize if necessary→ but usually don't

5. **Enhancement of reproductive capacity**
   reproductive organs are often the largest, most apparent organ systems present
   often able to produce of large #'s of eggs

6. **Complex Life Cycle usually with intermediate larval stages in intermediate hosts**
   to enhance chances of getting to final host

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.

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 **final 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.

Lab Activities:

1. *Clonorchis*, commonly called the Chinese liver fluke, is a relative of the sheep liver fluke above and has a similar anatomy and life cycle. Observe the slide below and find: **oral sucker, ventral sucker, intestine, testes, uterus with eggs**

   Slide: *Clonorchis sinensis*, wm
   (Atlas: 4th p 109; 5th fig 7.52-3; 6th fig 7.53-4; 7th fig 7.61-2)

2. *Fasciola*, the sheep liver fluke: is one of the largest flukes. Like most flukes, *Fasciola* is an hermaphrodite. Note the **reproductive organs** particularly the **ovaries, uterus** and **testes**. Note also the two suckers, the **oral sucker** around the mouth and the **ventral sucker** near the beginning of the uterus. Look at the slide below on the **Dissecting Scope**.

   Slide: *Fasciola hepatica* wm
   (Atlas: 5th fig 7.49, 7.51, 7.59; 6th fig 7.50; 7th fig 7.59)

3. The Blood Fluke, *Schistosoma*. is unusual for parasitic flukes since it is **dioecious**. Still the animal has adapted to facilitate sexual reproduction. Observe the slide below:

   Slides: *Schistosoma mansoni* male & female wm,
   ***Schistosoma mansoni* male wm,**
   ***Schistosoma mansoni* female wm**

   note how the female is smaller and carried by the male in a groove on the underside of the animal. This facilitates egg productionand dispersal of the young to other hosts.

4. Flukes are parasites characterized by a complex life cycle with **several larval stages** and one or more **intermediate hosts** along with the **final host**. Observe the slides below and identify the tadpole-like **cercariae** as one of these stages. The cercariae are usually the stage that enters the final host to become the adult parasite.

   Slides: Cercariae wm or ***Schistosoma* cercaria** or
   ***Fasciola hepatica* cercariae wm**
   (Atlas: 5th fig 7.54, 7.57; 6th 7.52, 7.55, 7.58; 7th fig 7.63)

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.

Lab Activities:

1. The adult of the tapeworm *Taenia* sp. is found in the human intestine, the larval stage is found in the muscles of cattle and pigs. Observe the slide below and identify the attachment organ, the **scolex**, and know: **hooks, suckers**

   Slide: *Taenia solium*, scolex, wm
   (Atlas: 4th fig 7.38a & 7.39; 5th fig 7.58-62; 6th fig 7.59a & 7.60; 7th fig 7.67-8)

2. On the slide below note the chain of reproductive sacs, the **proglottids**. Also know: **proglottid, uterus**

   Slide: *Taenia pisiformis* mature proglottid
   (Atlas: 4th fig 7.38b &7.41; 5th fig 7.58b & 7.61; 6th fig 7.59b & 7.62; 7th fig 7.70)

3. When the eggs are fertilized by sperm from another proglottid or another tapeworm the **uterus** expands to completely fill the proglottid; it becomes an egg sac with 1000's of fertilized eggs as in the slide below:

   Slide: *Taenia pisiformis* gravid (=ripe) proglottid, wm
   (Atlas: 4th fig 7.38c; 5th fig 7.58c & 7.62; 6th fig 7.59c & 7.63; 7th fig 7.71)

4. A tapeworm larva is called a **bladderworm** (or cysticercus); it usually embeds in muscle tissue of its intermediate host. When eaten by the final host it develops into the adult tapeworm. Recognize the **bladderworm** on the slide below:

   Slide: *Taenia pisiformis* Cysticercus wm
   (see handout)

3. Roundworms

Ascaris is a common parasite in the intestine of pigs, horses, and humans. It is the largest roundworm parasite.

Lab Activities:

1. Dissect a male and female roundworm as described below:

   Preserved: male & female *Ascaris*
   (Atlas: 4th fig 7.42-4; 5th fig 7.95-9; 6th fig 7.97-100; 7th fig 7.116-20)

   a. External Features:

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.

b. Internal Organs:

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 forward being careful not to injure any 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 thin **cuticle**. Beneath the epidermis is a thin layer of **muscle** that allows the animal to make the characteristic side to side whip-like movements that you saw in the vinegar eel (another roundworm). The digestive system is simple and consists of a **mouth**, a long, flat, very fragile, flattened **intestine** that runs down the length of the anmal, 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. The female reproductive system terminates in very thin, threadlike, highly tangled **ovaries** 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 largest tube, the **seminal vesicle** which stores sperm. The thinnest part of the tube is the **testis** where the sperm cells are made.

2. Look at the slides below of other parasitic roundworms & their larvae. Learn where they are found and how they are spread to their final hosts. Compare them to *Ascaris* in size and general structure.

Slide: ***Trichinella spiralis*** **encysted larva wm** (causes trichinosis)
(Atlas: 5th fig 7.103; 6th fig 7.105; 7th fig 7.124)

Slide: ***Enterobius vermicularis*** **wm** (pinworm)

Preserved & Biosmount: dog heartworm
(Atlas: 6th fig 7.104; 7th fig 7.123)

4. Some Examples of Ectoparasites

Some parasites live on the outside, rather than inside, their hosts. These **ectoparasites** generally feed on **blood**. Some **ectoparasites** are more or less permanent residents on their hosts, others only

attack while feeding then leave their host to digest their meal. Ectoparasites are found in a wide variety of animal phyla. Most of us are familiar with **mites**, **ticks, lice, leeches, fleas, mosquitoes,** etc., sometimes from direct experience with them. In this exercise you will learn to recognize a variety of the more common ectoparasites that affect our lives.

Lab Activities:

Look at the slides, preserved materials and illustrations of ectoparasites available. Recognize each general type. Know the main effects these parasites have on their hosts and explain how these effects differ from those of the **endoparasites** that you studied.

1. **Leeches** are members of the segmented worm (annelid) phylum. While most leeches are small aquatic predators, some are blood feeding parasites. Note the two **suckers** and the **mouth** of the leech.

   Slide: leech wm
   (see handout)

   Preserved: medicinal leech
   (Atlas: 4th fig 7.75-6; 5th fig 7.93-4; 6th fig 7.95-6; 7th fig 7.114)

2. **Mites & Ticks** are arthropods related to spiders and scorpions. Virtually all species of ticks and many mites are ectoparasites at some point in their life cycle. They are attracted to their hosts by chemical cues. Their greatest danger to humans is in the diseases they transmit while they feed

   Slide: Tick & mite, wm
   (see handout)
   Slide: Lone Star tick wm
   (Atlas: 4th fig 7.81; 5th fig 7.110; 6th fig 7.112; 7th fig 7.133-4)

3. **Lice** are arthropods in the insect group that live on hair and clothing when not feeding.

   Slide: *Pediculus humanus capitis* wm
   (see handout)

4. **Mosquitoes** are another common blood feeding insect. The larvae are aquatic and are found in any standing water. Many mosquitoes are vectors for devastating diseases such as malaria.

   Slide: Mosquito life cycle *or Culex* wm
   (see handout)

5. **Fleas** are insects that are common pests of domesticated animals and are noted for their jumping abilities. Most of the 1000 species lay eggs in their hosts nests or in their fur.

   Slide: flea (*Ctenocephalides*) male & female, wm
   (Atlas: 4th fig 7.95; 5th fig 7.136; 6th fig 7.145; 7th fig 7.167)

E. Arthropods

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.

All arthropods share the following characteristics:

→ a hardened jointed **exoskeleton** made of **chitin** that must be **molted** for growth
→ a **distinct head** with a variety of sense organs
→ a **segmented body**
→ paired **jointed appendages**

Four main kinds of living (not fossils) arthropods are the:

1. **Myriopods** (centipedes, millipedes)

2. **Chelicerates** (horseshoe crabs, spiders, scorpions, mites and ticks)

3. **Crustaceans** (crabs, crayfish, shrimp and barnacles)

4. **Insects** (dragonflies, butterflies, beetles, bugs, flies, etc)

The members of each group can be distinguished by a characteristic body plan and a few distinctive organs as described below.

2 pts Extra Credit: Bring in a live example of at least two of the 4 major kinds of arthropods on the day we cover them in lab. **Be sure to check in before class begins to get your points.**

1. The Myriopods

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. All members of this group have a distinct **head** rather than a cephalothorax. Members of this group also have **mandibles** as their main mouthparts. Most have a **single pair of antennae** and **compound eyes**. The rest of the body consists of **similar segments**, each with one or two pairs of l**egs**. You may need a hand lens or the dissecting scope to see all the structures below.

Lab Activities:

1. **Centipedes**

Preserved: centipedes
(Atlas: 5th fig 7.142; 6th fig 7.151-2; 7th fig 7.174)

Centipedes are generally predators. They typically have a flattened body and can be distinguished from millipedes in that they typically have **one pair of legs per body segment**. The first pair of appendages is modified into **poison claws** which, in some species, can cause extremely painful stings. Locate the **head**, **poison claw, antennae**, **mandibles** and **eyes**.

Do not discard centipede, return to jar when you complete your observations

2. **Millipedes**

Preserved: millipedes
(Atlas: 5th fig 7.143; 6th fig 7.153-4; 7th fig 7.175)

Millipedes 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**. Locate the **head**, **antennae**, **mandibles** and **eyes**.

Do not discard millipede, return to jar when you complete your observations

2. 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. The horseshoe crab: *Limulus* sp.

Preserved: horseshoe crab
(Atlas: 4th fig 7.78; 5th fig 7.107; 6th 7.109; 7th fig 7.131)

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.

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 horseshoe 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**.

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

2. The Garden Spider, *Argiope* sp.

Preserved: spiders
(Atlas: 4th fig 7.79; 5th fig 7.108, 7.111; 6th 7.113; 7th fig 7.135)

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. You may need a hand lens or the dissecting scope to see all the structures below.

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.

Do not discard spiders, return to jar when you complete your observations

3. The scorpion

Preserved: scorpions
(Atlas: 4th fig 7.835th fig 7.113; 6th 7.115; note: stinger, walking legs, pedipalp and abdomen are mislabeled in atlas; 7th fig 7.137)

Scorpions are also common in our area, Central Texas is home to two species of scorpions. You may need a hand lens or the dissecting scope to see all the structures below.

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 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.

Do not discard scorpions, return to jar when you complete your observations

4. Note other examples of chelicerates that are on display

3. 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. **The Crayfish: *Procambarus* sp.**

Preserved: crayfish
(Atlas: 4th fig 7.85-8; 5th fig 7.118-26; 6th fig 7.121-9; 7th fig 7.145-53)

i. **External Anatomy:** 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 **tail** (telson) used in swimming. How many different functions do the crayfish appendages perform?

ii. **Internal Anatomy:** 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 along the top 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.

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

4. The Insects

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. **Grasshopper**

Preserved: grasshoppers
(Atlas: 4th fig 7.96-7; 5th fig 7.138, 7.139-40; 6th fig 7.147-9; 7th fig 7.169-70)

Slide: spiracle & trachea insect larva, 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.

2. **Honeybee anatomy** (use a dissecting scope)

Slide: honeybee legs, wm
(Atlas: 7th fig 7.163)

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 hind legs
Pollen Brushes - stiff haired, on fore and middle legs
Antenna Cleaner - on forelegs
Pollen Comb - rows of stiff hairs in inner surface 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

(Atlas: 5th fig 7.132; 6th fig 7.140; 7th fig 7.162)

3. **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
(see handout)

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
(see handout)

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
(Atlas: 5th fig 7.1356th fig 7.143)

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 wm
(Atlas: 5th fig 7.137a; 6th fig 7.146a; 7th fig 7.168)

***Culex*, wm** (mosquito)
(see handout)

***Musca domestica* head wm** (housefly)
(Atlas: 6th fig 7.141; 7th fig 7.161)

grasshopper mouthparts wm
(Atlas: 7th fig 7.172)

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

The Echinoderms

This group consists of the starfish, brittle stars, basket stars, sea urchins and sea cucumbers. The name, echinoderms, means "spiny skinned" animals. Of all the invertebrate animals, the echinoderms are the most unusual in terms of their shape and their anatomy. They have an **endoskeleton** of **calcium plates** or **ossicles**; sometimes buried loosely in the skin, sometimes "welded together" to form a rigid "**test**". They have a unique **water vascular system** for feeding, movement, respiration and excretion, and tiny pincer-like **pedicellariae** for cleaning and protection. They are also the invertebrate group most closely related to us!

Lab Activities:

In this lab you will dissect a starfish as a representative of the group. But other members of the phylum will be on display.

1. Endoskeleton

Echinoderms have an internal skeleton of calcium plates. In seastars and brittle stars the plates are attached by moveable hinges making the arms of the animal very flexible. In sea urchins and sand dollars the calcium plates are fused together into a "test" or shell.

Miscellaneous dried and preserved echinoderms

Observe the skeletons of various kinds of echinoderms and observe the calcium skeletons.

2. Starfish - External Anatomy

Preserved: ***Asterias***
(Atlas: 6th fig 7.159; 7th fig 7.182)

Note the distinctive 5-part radial symmetry of this animals and most of its relatives and the complete absence of a head. The body of this animal consists of 5 **arms** radiating from a **central disc**. In the center of the disc on the oral surface is the **mouth** and 5 rows of **tube feet**.On the opposite side (the aboral surface) find a small whitish **sieve plate** (=**madreporite)** between two of the arms of the animal.

3. Starfish - Internal Anatomy

Preserved: ***Asterias***
(Atlas: 6th fig 7.159-65; 7th fig 7.183-6)

Take your small scissors to cut along the sides of two arms and gently lift the upper surface off of the arms and central disc as shown in your atlas. The **digestive glands** (=**pyloric caecae**) fill most of each arm. Beneath them are smaller **gonads**. By removing the gonads you can see the top of the **tube feet** along the ridge of the ambulacral groove. In the oral disc is a sac-like **stomach.**

4. Other Echinoderms

Look at the variety of other organisms that belong to this group; brittle stars, basket stars, sea urchins, sand dollars, and sea cucumbers. Be able to recognize them as being echinoderms; Try to find the skeleton, spines, & tube feet in each speciman.

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 closed circulatory system, 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
- -warm blooded; 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

Fishes

Some characteristic structures that you will seen in your dissections of fish:

fins: most fish have both **paired** and **unpaired** fins. The paired fins are part of the appendicular skeleton

nostril: contain chemical receptors to monitor their watery environment and to find food

lateral line: most fish have a lateral line system to detect vibrations in the water, this allows them to avoid predators or to locate prey

scales under skin layer: to help protect the animal and to enhance swimming ability

spiracle: cartilaginous fish have a spiracle that allows them to take in water to pass over the gills when their mouth is full

operculum: bony fish have a moveable cover called an operculum that allows them to pump water over their gills even if they are not moving

myotomes: in most fish the swimming muscles are in the form of segmented "W- shaped" bundles

spiral valve: this coiling structure found in the intestine of cartilage fish improves absorption after digesting its meal

swim bladder: most bony fish have a swim bladder to control their buoyancy in the water

A. The Lamprey

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.

Lab Activities:

1. External Anatomy

The lamprey has an eel-like body is covered with a scaleless, slimy skin. Lampreys have no paired fins, only two **dorsal fins** and a **caudal fin**. The **mouth** lacks a lower jaw and therefore cannot close its mouth. Its mouth is lined with horny (ie. not bony) **teeth**. A **tongue** is located near the center of the funnel. A single median **nostril,** for detecting chemicals in the water, is located behind the **eyes** on the dorsal surface of the head. Also, try to locate portions of the **lateral line system** near the eyes and mouth. External **gill slits** are located laterally behind the eyes.

Preserved & Plastimount: lampreys

(Atlas: 4th fig 7.117-22; 5th fig 7.167-74; 6th fig 7.182-8; some figures may be mislabeled; 7th fig 8.1-10)

2. Internal Anatomy

Look at the mounted sections of lampreys and identify the **teeth** made of **keratin** 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. The Dogfish Shark

Sharks have an internal axial & appendicular 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 appendages in the form of 2 pairs of fins. They also have **hinged jaws** that are packed with **teeth** making most sharks efficient **predators**.

Lab Activities:

1. External Anatomy

Locate and identify the following structures: **eyes, nostril, mouth, gill slits, spiracle, lateral line system, dorsal, caudal, pectoral and pelvic fins, claspers** (in male)

Preserved: dogfish shark

(Atlas: 4th fig 9.2-10; 5th fig 8.2 – 8.15; 6th fig 8.3-10; 7th fig 8.1-10)

2. Scales

Shark **scales** are bony and extend through the skin making it feel rough to the touch. Cut a small piece of the skin, place it on a slide and look at it under a dissecting microscope. Note how the tips of the scales pierce the skin.

3. Shark Skeleton

Look at the skeleton of the shark and be able to distinguish between the **axial** and **appendicular** skeleton.

Preserved: shark skeleton

4. Internal Anatomy

dissect as instructed and find: **gills, liver, stomach, intestine, spiral valve (=ileum), heart,** and **gonads (testis or ovaries)**

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

5. Other Cartilaginous Fish

Preserved: miscellaneous sharks & rays

Compare the external characteristics of the hammerhead and bonnet head sharks, the guitar fish and the rays. What characteristics do they have in common?

C. The 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

Lab Activities:

1. Fish Skeleton

Preserved: perch skeleton
(Atlas: 4th fig 9.17; 5th fig 8.16; 6th fig 8.21; note: pectoral & pelvic fins and the operculum are mislabeled in atlas; 7th fig 8.21)

view the fish skeleton and distinguish between the **axial** and **appendicular** skeletons. On the axial skeleton find; **skull**, **vertebrae**, **ribs**, **operculum**, **dorsal, ventral & caudal fins**. On the appendicular skeleton find: the bones of the **pectoral** and the **pelvic fins.**

2. Scales

Remove a scale or two from the skin of the perch. Make a wet mount and compare its structure to the scales of the shark.

3. Dissection of the perch

Preserved: perch
(Atlas: 4th fig 9.17-8; 5th fig 8.16-8; 6th fig 8.17-22; 7th fig 8.17-23)

i. External Anatomy

Note the single **dorsal**, **ventral** and **caudal fins** and the paired **pectoral** and **pelvic fins**. also find the **eyes**, **mouth**, **lateral lines**, 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 slide and look at on the dissecting scope. Compare it to the shark scale you looked at earlier. Note the growth rings – these rings can be used to determine the age of fish.

If live fish are available: identify the pectoral and pelvic fins and note their use in improving maneuverability.

ii. Internal Anatomy

Dissect the fish as described in lecture handout 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** (=myomeres) that contract to produce the "S–like" swimming motion characteristic of fish.

3. Other examples of bony fish

Look at the illustrations and preserved examples of other kinds of bony fish. Note the variety of shapes and forms. Can you tell anything about the fishes "lifestyle" by its general characteristics? Locate the paired pectoral and pelvic fins on the specimens available. Are any modified in any way?

Amphibians

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 since their eggs would easily dry out on land.

Some characteristic structures that you will see in your dissection of amphibians:

paired legs instead of fins: in some amphibians the hind legs have adapted to jumping

nostrils: that also help take in air as well as detect airborne chemicals

tongue: a moveable tongue that can be used to capture prey and move food to the stomach

eardrum: terrestrial amphibians have "traded" the lateral line system for ears that are better able to detect vibrations in air (=sound waves)

lungs: very simple sac-like lungs for respiration; some aquatic amphibians have retained gills, most terrestrial amphibians also get oxygen through their moist skin

Lab Activities:

1. The Necturus and the Frog Skeletons

The skeleton of Necturus shows the generalized design of an amphibian skeleton. Notice the long but sturdy axial skeleton and the relatively small appendicular skeleton. Abdominal organs are suspended from the **axial skeleton** which bears most of the body weight. Also the bones of the appendages are developed into jointed legs for support on land. They are divided into **upper** and **lower legs** and **feet**. This animal shows the "S-shaped' movement typical of a fish, but with legs instead of fins.

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. How do the frog's legs differ from the paired fins of fish? How has the frog skeleton been modified for jumping?

Notice also the **absence of a rib cage** in both skeletons. Amphibians have no "breathing" musckes and must gulp air into their lungs.

Preserved: frog skeleton
(Atlas: 4th fig 9.21-2; 5th fig 8.19-20; 6th fig 8.32-4; 7th fig 8.24-5)

2. Dissection of the frog

Preserved: bullfrogs
(Atlas: 4th fig 9.29-31; 5th fig 8.25-8; 6th fig 8.32-4; 7th fig 8.32-6)

i. External Anatomy

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.

ii. Internal Anatomy

Begin by locating the major internal organs in the **Frog Model** on display.

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.** 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.

3. Frog Life History

While amphibians were the first vertebrates to venture onto land, most still had to return to water for reproduction and early development. Most amphibians have an **aquatic embryonic stage** with **gills**, **fins** and fish-like movement followed by a **metamorphosis** in which the gills and fins are lost and **lungs** and **legs** emerge for live on land.

4. Demonstrations: Representative Amphibians

be able to recognize the variety of amphibians on display. Some amphibians remain aquatic as adults and retain the gills for respiration and fins for swimming. Many salamanders have become adapted to cave live and have lost their skin pigment and have lost their eyes.

Reptiles

Reptiles were the earliest group of vertebrates to make a a clean break from the water; not even having to return to it for reproduction. Their skin is much thicker, much more waterproof with dry scales, they have a more efficient respiratory system and circulatory system and produce a new kind of egg (the amniotic egg) that can be laid on land and protects the developing offspring until it is ready to live on its own.

Some characteristic structures that you will see in your observations of reptiles:

scales on the surface of skin: help to waterproof the skin and protect it from damage

shelled egg: the hard or leathery egg provides a watery environment for development so that reptiles no longer have to return to water even for reproduction

reptile teeth: reptile teeth, when present, are all generally conical like those in fish for capturing prey, however, the prey is swallowed whole and cannot be chewed

Lab Activities:

1. **Reptile Scales.** Living reptiles have thicker skin covered by dry waterproof scales for protection. The outer layer of skin and scales are shed periodically to renew this protective layer. The 'rattle' of a rattlesnake is made of modified scales and is used for warning.

   Preserved: shed snake skins

   Preserved: Rattlesnake rattle

2. **Lizard Skeleton.** Note the presence of **Ribs.** The muscles of the rib cage are used for breathing in Reptiles, they no longer have to 'gulp' air.

   Preserved: lizard skeleton

3. **Snake skeleton.** Note the absence of the appendicular skeleton.

   Preserved: snake skeleton
   (Atlas: 4th fig 9.40; 5th fig 8.37; 6th fig 8.48; 7th fig 8.48)

4. **Reptile teeth.** Most reptiles have conical teeth for capturing prey, they cannot chew their food and it must be swallowed whole. Venomous snakes have a pair of teeth modified into poison fangs for injecting poison into their prey to subdue them. Other reptiles (eg. turtles) have lost their teeth and have bird-like beaks instead better able to bite off pieces of plants or animals.

   Preserved: **rattlesnake skull**
   alligator skull
   turtle skeleton
   dinosaur teeth
   misc. preserved reptiles

5. **The Reptile Egg** - note the general structure of the **egg** on illustrations provided. What is the

advantage of this type of egg over the type of egg produced by fish and amphibians.

Preserved: **turtle eggs**
green anole eggs

Illustrations of reptile egg

6. **Representative Reptiles** - be able to recognize the variety of reptiles on display in pictures and preserved

Preserved & Illustrations: Miscellaneous reptiles

Birds

The overall design and anatomy of birds is related to its ability to fly. All birds (even flightless birds) have feathers (modified from the reptile scales of their ancestors), thin, light bones and much more efficient respiratory and circulatory systems than do most reptiles. Birds (along with mammals) are also warm blooded to maintain a constantly high metabolism required for their more active lifestyle.

Some characteristic structures that you will see in your dissection of birds:

feathers: today, only birds have feathers although in the distant past many reptiles were feathered as well. Feathers originated as scales (still found on the legs of birds)

beak: all birds today have a toothless beak with a very flexible neck. Their head and neck become their main "limb" for finding and collecting food

bird skeleton: The bird skeleton is extremely light for its size to enhance its flying ability

crop: bird have an enlarged sac in their neck for storing food, it allows them to fly long distances without stopping and to collect food to feed their young

gizzard: like reptiles, birds cannot chew their food, so have a strong muscular stomach, usually packed with small pebble (=gastroliths) to grind the food up.

Lab Activities:

1. Feathers

The **feather** is the most distinctive feature of birds. They form the **flight surface** and enhance the bird's flight efficiency. They also provide excellent **insulation** to maintain a high internal body temperature and reduce heat loss. The feather is essentially a modified reptile scale. A typical feather consists of the **shaft** (or **rachis)** and the **vane**.

Preserved: assorted feathers & study skins
(Atlas: 4th fig 7.134; 5th fig 7.190; 6th fig 8.52; 7th fig 8.52)

2. Bird Skeleton

The basic internal skeleton is similar in all groups of vertebrates. In birds, many of the bones are fused together and the overall size and mass are 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.** Note how the bones of the pectoral appendange has been modified for flight. Compare the arrangement of its bones to the bones of the human arm.

Compare the size and weight of the ostrich and the cow bone of similar size.

Preserved: **pigeon skeleton**
(Atlas: 4th fig 9.41; 5th fig 8.40; 6th fig 8.51; 7th fig 8.51)
ostrich leg bone

3. Dissection of Pigeon

Preserved: pigeon

(Atlas: 4th fig 9.43-4; 5th fig 8.42-3; 6th fig 8.54-7; 7th fig 8.54-7)

a. External Anatomy

Using the illustration provided find the following structures: **eyes, bill, nostrils, throat, flight feathers, thigh, tibia** (=tibiotarsus, "drumstick")**, scales, toes, claws, vent, tail.**

b. Internal Anatomy

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 **crop**, which is used for food storage. This allows birds to quickly ingest large amounts of food and then move to a safer area to complete digestion. Beneath the heart and lungs 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.

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

4. Variations in bird anatomy and nest structure

Observe the variety of bird and nest specimens in the hallway display cases.

Mammals

Mammals have developed a covering of insulating fur in place of scales. This fur can also be used for protection (porcupines), communication (fur coloration) and waterproofing. Rather than lay eggs like reptiles and birds, most mammals bear live young and nurture them with milk (mammary) glands. The evolution of mammals has resulted in a great diversity of teeth depending on their diet and unusual skeletal features such as antlers and horns that may be used for a variety of purposes. Their limbs have been modified for a variety of purposes; running, flying, digging, swimming etc that are reflected in changes to the skeleton.

Of all the vertebrates, the brain and nervous system is most elaborately developed in mammals, allowing them greater degrees of coordination and learning and more complex behaviors to enhance their survival.

Some characteristic structures that you will see in your dissection of mammals:

fur: today only mammals have fur, in the past many reptiles also had feathers and/or fur. Fur originated from the scales of reptiles to provide greater insulation from cold

versatile skeletons: the mammal skeleton is more massive yet the joints more agile than in any other vertebrate with a wide variation in sizes and shapes to adapt to a particular mammals lifestyle

mammal teeth: the 4 main kinds of mammal teeth (**incisors**, **canines**, **premolars** & **molars**) have been adapted in numerous ways to suit the diet of each species. Mammals can bite off pieces of food and chew them before swallowing thus improving the efficiency of d digestion

lungs: mammal lungs are very efficient at taking in oxygen for their warm blooded lifestyle. Gas is exchanged in tiny sacs called alveoli

Lab Activities:

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.

   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.

   Preserved: Misc. horns & antlers

ii. Armor

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

Preserved: armadillo

iii. Defensive hairs

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.

Preserved: porcupine quills

2. Mammal Skeletons

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**.

Model: human skeleton

(Atlas: 4th fig 8.10-11; 5th fig 9.10-11; 6th fig 9.10-11; 7th fig 9.10-11)

ii. Bat Wing

Compare the skeletal structure of the bat wing with that of the bird.

Preserved: bat skeleton

iii. Mole Skeleton

Note how the bones of the hand have been modified for digging.

iv. Sectioned cow skull

Note the large size of the nasal cavity compared to other classes of vertebrates. The sense of smell is much more important in mammals.

v. Feeding Adaptations

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).

Preserved: miscellaneous mammal skulls & teeth

3. Dissection of the Fetal Pig

Preserved: fetal pig

(Atlas: 4th fig 9.72-3, 9.81-90; 5th fig 8.59-60, 8.68-72; 6th fig 8.73-4, 8.82-6; 7th fig 8.73-4, 8.82-6)

i. External Anatomy

Identify the following structures**: eyes, nose, mouth, teeth, tongue, ears, umbilical cord, tail, anus, hoof**

ii. Internal Anatomy

Identify the following structures: **larynx, trachea, heart, lungs, diaphragm, liver, pancreas, stomach, small intestine, large intestine, spleen, kidney, ovaries/testes**

4. Mammal Nervous system

Preserved: cat nervous system, human brain

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?

5. Human Evolution

Four skulls are displayed representing 4 of the major stages in the evolution of modern humans. Study the skulls and read the information provided.

Name:_____

The Animal Kingdom

Biol 1409 Lab Report

I. Animal Cells, Tissues, Organs & Organ Systems

1. List the major **organelles** of animal cells discussed in this exercise and give the function of each

2. **Describe** how a typical animal cell differs from a typical plant cell; fungus cell; protist cell; bacterial cell:

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

4. name the animal **tissue** or **organ** used to make any 5 of the following food products:

chitlins	**filet mignon**
cracklins	**rocky mountain oysters**
sweet bread	**blood sausage**
menudo	**tamales(traditional)**
caviar	**escargo**

II. Animal Reproduction, Development & Life Cycles

4a. Describe a **specific** example of asexual reproduction in an animal.

b. Describe a **specific** example of sexual reproduction in an animal.

5. What is the difference between an **embryo** and a **larva**? Between a **nymph** and a **fetus**?

6. Describe some of the advantages of having a complex developmental cycle with several different stages before adulthood?

III. Animal Diversity

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

A. Invertebrates:

8: **Sponges**

a. Where exactly would you expect to find **collar cells?**

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

c. Draw a few spicules. What is their function?

9: **Hydras & Corals & Jellyfish**

a. Draw and describe a stinging cell (=nematocyst or cnidoblast). What is it used for?

b. Why, specifically, are some jellyfish and corals so dangerous?

10. **Planarians**

a. How is the digestive system of the planarian similar, and how is it different from that of the hydra

b. Describe the movement of the planarian and compare it to that of the vinegar eel.

11. **Worms**

a. List 4 similarities and 4 differences between the worms you studied in the lab.

12. **Shelled Animals (Molluscs)**

What are the advantages of a shell for these animals?

13. **Parasites**

a. Why do parasites usually produce so many eggs?

b. Name a major organ system that some parasites completely lack.

14. **Arthropods**

a. List at least two characteristics of each of the 4 groups of arthropods that would allow you to distinguish them from each other. Then list **two ways** that they are all **similar.**

b. Describe some of the ways that the honeybee is adapted to collecting pollen and nectar?

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

15. **Echinoderms**

How, specifically, are echinoderms different from every other invertebrate group?

General Invertebrates

16. Name and describe a specific example of:

a. an animal with no true organs or tissues

b. an animal with true tissues but only very simple, if any, organs

c. an invertebrate with all organ systems listed in the lab packet

d. an example of a colonial animal

B. Vertebrates

Fill in the appropriate cells in the tables below with all the organs & structures you identified during your dissections of each of the vertebrate classes. (not all cells will be used)

Organ System	Jawless Fish	Sharks & Rays	Bony Fish
skin			
skeleton			
muscles			
buoyancy			
respiration			
digestive			
circulation			

Nervous & Sense organs			
urinary			
reproductive			

Organ System	Amphibians	Reptiles	Birds	Mammals
skin				
skeleton				
respiration				
digestive				
circulation				
Nervous sys & sense organs				
urinary				
reproductive				

17. name a vertebrate with the most primitive organ systems listed in the lab packet

18. name a vertebrate with the most advanced organ systems listed in the lab packet

19. Name three different organ systems that are found in **all** the vertebrates you studied and dissected in the lab. Is the function of these organ systems the same in each group? Explain.

20. Which organ or organ system shows the greatest amount of change from the simplest vertebrates to the mammals?

21. How do organ systems of aquatic vertebrates differ from those of land vertebrates; describe as many major differences as you can.

22. a. How do birds resemble reptiles?

b. How do birds resemble mammals?

c. How do some mammals resemble reptiles