LAB MANUAL

BIOLOGY 10

LANEY COLLEGE BIOLOGY DEPARTMENT

FALL 2012

Laney College Biology 10 Lab Manual

This lab manual was created by Laney faculty to help you see how Biology can be applied to your everyday life. Each lab has tips on how to help you retain all the information by applying what you know. Being prepared for lab is the best way to retain more information, so make sure you read the lab ahead of time.

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What Makes Science Important?

Science can be described in two ways: one, it's a body of knowledge. This means there are scientific references that people can use, compare, research and ask questions. Two, it's a way of learning. Science provides for a step-wise process to ask questions and provide information about those questions. Not necessarily 'Truths', but information about the natural world. Anywhere you go, any language you speak, the scientific method is pretty much the same. This way, researchers half a world apart can read about each other's work, talk to each other about the process or even try to replicate it. This process provides a way we can be more connected to each other and everything around us, no matter how far away things may be seem. You are going to work in groups based on where you sit. Introduce yourself to the other people at your table.

Scenario: Say you and a friend decide to walk Lake Merritt every Saturday morning over the summer, as a way to get heart healthy. By the third week, you notice that the water level seems to be different each week. As you finish your way around the lake, you and your friend decide to try to figure out why.

Step One: What do you see?

Here, *Observation is Key.* Any good study starts with observing things and asking questions about what you see. From that you can limit some things that may not be worth looking into and things that may help you find answers. Now, talk to your lab group about possible reasons why the lake water level might be different. This will help us narrow our study and ask questions that will help us formulate a more specific question, so let's think about what we know already from the walks.

- Think about what you already know. Think about the details concerning what you saw, when you saw it, things like that. Be as specific as you can.

Think about what you are asking: "what causes the water to change?" Here is a good place to look up reference material that is fairly well established and can give us more background about the lake in general. This is where we would look in places like textbooks and current encyclopedias as opposed to journal articles and newspapers. It's important to be able to distinguish between information that's been time tested (**reference material**) and information that's on the cutting edge (**research material**). Both are important and useful in helping us ask questions, but one is more reliable than the other. Either way, we should verify that information in multiple places.

Go to STATION ONE as see what type of information you can glean about the history of Lake Merritt.

- What type of information was available? Choose reference material or research material and explain why.

Step Two: Making a Hypothesis

A hypothesis is a statement not a question. Yet, our questions can help us to formulate a hypothesis. Think about your questions, your background information and what you think the reason for the changing water level.

- Write out your hypothesis as to why the water level changes:

Did you make sure it's a sentence with a clear reason why the lake changes height?

Step Three: Designing an Experiment and Collecting Data

A good question to ask here is, "What are some factors that might change the water level, but are out of our control?"

Variables are things that change over the course of the study and are not predetermined. The more variables you have, the more possible explanations you may have as a result. If we can limit the number of variables we have, it can help us come to a stronger conclusion. A lot of biological research happens in labs because it is easier to limit variables. Our study is outside, so there are a lot of variables, but we can control some of it. The date is predetermined and isn't under our control, however, the day and time we go to the lake is a variable that we can control.

- Which are things that might change while we are there, or are variables?

- What are the things that you can control?

✓ Did you think about things like, the day of the week? Time of day? Presence or absence of rain? Great! Now, that we know what type of variables we are dealing with, let's take about what type of data we would like to collect and how to record it.

Let's look at what type of measurements we are going to make and what units we will use.

The Metric System

In this class we use the metric system which is the system of measure used by the majority of the world and is an actually easier system than the one we have. The metric system is based on 10's and the prefix tells you how many multiples of 10 of the base value you have. Those base values relate to the type of measure you need. If you are measuring the distance or height of something, you use **meters**. If you are measuring how much of a space you have (volume), you use **liter**. If you want to know the weight of something, you use **grams**.

Here is a chart to help you understand the metric system. We gave you an example, now you can fill in the blanks as you go.

Prefix	Ratio	Distance (meter)	Volume (liter)	Weight (gram)
Micro (*u*)	1/1,000,000	1m = 1,000,000 *u*m	1L= 1,000,000 *u*L	1g = 1,000,000 *u*g
Milli (m)	1/1000	1m =	1L=	1g =
Centi (c)	1/100	1m =	1L=	1g =
Kilo (k)	1000	1m =	1L=	1g =

When we look at numbers, we can label their position like this:

Let's take this number 123.456

The 1 represents the hundreds place, the 2 is in the tens place, the 3 is in the ones place

After the decimal, the 4 is in the tenths ($1/10^{th}$) place, the 5 is in the hundredths ($1/100^{th}$) place and the 6 is in the thousandths ($1/1000^{th}$).

- So how many orders of 10 are there between the 4 and the 5?

Notice that the difference between milli and centi is 10x. That means you can always move between milli and centi by moving the decimal one place. Which way would you move the decimal if you were moving from milli to centi?

Hint – look at the ruler, which one notates a larger number?

Let's practice collecting data using the metric system. Go to the lab materials table to get the equipment you need for each section. Make sure you put the equipment back in the same place and in the same condition you found it.

Distance – you will need a plastic ruler and meter stick.

Using the plastic ruler, draw a line that is 5 inches long

- Now, measure that line using the other side of the ruler.

  How many mm is it? _____

  How many cm is it? _____

  So how many mm are there in 1 cm? _____

Next, take out the meter stick. Notice that it has meters on one side and inches on the other. Let's see how these different units compare, or, **how many inches are in one meter**?

You can solve this problem two ways:

1) You can estimate by just looking at the ruler and follow it to the other side or

2) You can find it mathematically. You know how many centimeters there are in 5 inches and you know how many centimeters there are in 1 meter, so you can solve for meters using this type of method. First fill in how many cm there are in 5 inches and how many cm there are in 1 meter.

$$\frac{5 \text{ inches}}{\text{cm}} \times \frac{\text{cm}}{1 \text{ meter}} =$$

Now, fill in the blanks and do the math. Notice that the 'cm' units will cancel leaving your answer as inches per meter. Labeling units is extremely important in science.

- Name something you would use meters to measure in your experiment?

Weight – scale, salt, a piece of weigh paper.

We will be using a triple beam scale in this class. Looking at the scale:

- What type of units do you see?

- Are all the numbers the same?

The right end has a line on the beam and a line on the stationary part. When you weigh something you want those lines to, well, line up! Let's try it out:

People should eat somewhere below 2.7 grams of salt a day, yet the average American eats 11.6 grams. Let's see what that looks like. Get some salt in a weigh boat, a piece of weigh paper and a scale. Make sure your scale reads '0' to start out. Weigh the first value, now move the weights on the scale to represent the second. Keep adding salt until you find a balance. If you go too far, just a take some off.

- What do you think this means about people's salt intake?

- What types of health concerns are you familiar with that relate to high salt?

- Do you think there is salt in Lake Merritt? How does that affect your study?

Volume – do this at the sink, so you don't need to bring it back to your table.

To measure the amount of space something takes up (or volume), we use graduated cylinders and usually we are talking about liquids. There are three cylinders of varying sizes in the sink that should be kept all together. Looking at the tools in front of you, notice they are all different sizes.

- How much of a liquid can each of the cylinders hold?

By the cylinders, there is a glass container that can hold a quart. Now, pour the water from the quart container into the graduated cylinder that can best estimate the amount of water.

- How many mL are there in a quart?

- If there are 4 quarts in a gallon and if gas in Sweden is the equivalent to $1.50 dollars a liter, approximately how much would you pay for 1 gallon of gas in Sweden? In other words, **how many liters are there in 1 gallon?** (hint: write down the values you know already)

    - Now, do you think our gas is expensive compared to other countries?

Temperature – Using Celsius

When we measure how hot or cold something is, we are finding its temperature. The fancy definition of temperature is the measurement of the kinetic energy in a sample of matter expressed in units. To the scientific world, and most of the rest of the world, those units are degrees Celsius. This scale is based on the temperature at which water becomes solid (turns into ice) and the temperature at which water becomes a gas (or boils).

Using the reference material at the front, answer the following questions:

- What is the temperature at which water becomes solid using the Celsius (^{0}C) scale? _____
- What is the temperature at which water becomes a gas using ^{0}C? _____

Now, if you were going to create a scale, wouldn't it make sense to use '0' and '100' for your extreme ends of the scale? Well, Daniel Fahrenheit didn't think so, he preferred to use the temperature of brine (a mixture of salt, water and ice) for '0' and his wife's temperature for 100 (really 96). This is the basis of the scale we use.

Using the reference material, answer the following questions:

- What is the temperature at which water becomes solid using the Fahrenheit (^{0}F) scale? _____
- What is the temperature at which water becomes a gas using ^{0}F? _____
- How many degrees Fahrenheit are there in 1 degree Celsius?
  (write out what you know and see if you can figure it out?)

Considering our research on Lake Merritt,

- What other information might be helpful that you won't have to measure yourself?

Go to the front of the room, we've provided you with some information about the lake. Here is a blank table for you to record that information. Decide how many days of data collection you will use. Decide which tide level you're going to record and be consistent. Are you going to need the full table?

Name of table _____

DATE/TIDE	HIGH TIDE 1	LOW TIDE 1	HIGH TIDE 2	LOW TIDE 2

Notes: (is there anything you want to make sure you remember about your data collection?)

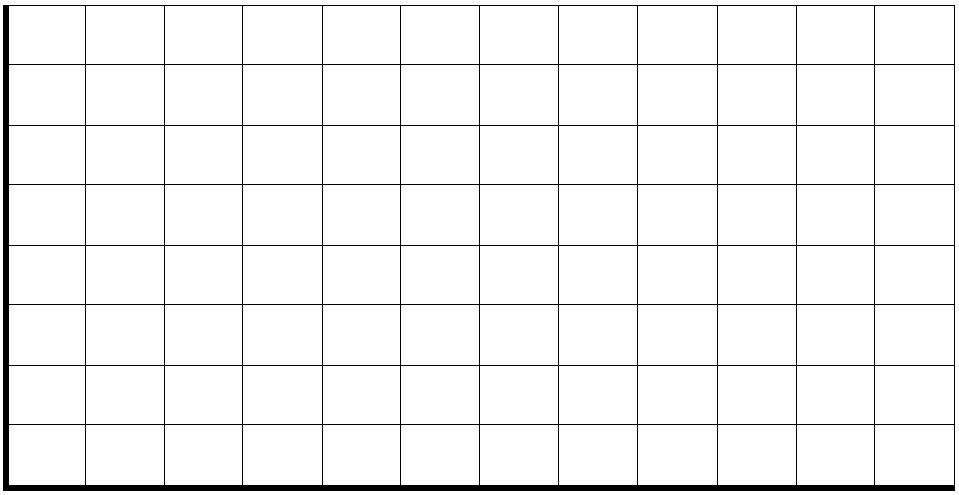
Step Four: Reporting Your Results

Reporting Data: Data is a word that is actually the plural of datum, so in here we say things like "These data suggest…" but it is hard to remember, even for scientists, but we'll try.
Since those data were provided by someone else, those values will go along the X-axis of our graph. Now, which data were observed by someone and recorded? Those values changed dependent upon which day you were out there, so they will go on the Y-axis.

Think of it this way: the water level was dependant on the date you were at the lake, but the date is not dependent upon the water level. That makes the date the independent variable (X axis) and the water level the dependent variable (Y axis). When you are presenting information about a graph to a group, make sure to explain the axes before you start talking about the graph.

Label the graph and the axes: Let's start with the date. This is a weekly interval, so putting a date that corresponds to each line is okay. Now, look at the tide height. We don't want to just put the heights recorded on each line because that will not give us equal distances between each line. What we want to do is see the range of heights from 0 to the highest tide level. Then, count the number of lines we have on the graph. Divide the highest tide height by the number of lines and that is the interval you want to use, but try not to use fractions. Once you have all your data points, so ahead and connect the dots. Sometimes we will draw a line to show a trend, or a best fit line, but not today.

Name of Graph _____



DATE

Step Five: Application of Data or What does it all mean?

When we look at graphs it's important to remember that *Correlation is not Causality*. Just because there are two axes and a line between them that doesn't mean one caused the other, it just means one may have an impact on the other. This is crucial to remember, especially when you see science reported in the news.

The other thing to remember the simplest answer is probably the best one, which is known as *The Law of Parsimony*. Don't try to explain too much with too little and don't try to apply answers to things unless you have the evidence to support your idea. Sherlock Holmes used this idea a lot and would say, "Elementary my dear Watson." Granted, when Bart Simpson saw that all the parents in town were staying inside all night, his simple answer was that they were all reverse vampires, but he had no evidence to back that up. It's good to discuss your results with others, maybe talk to other people about what you think is the simple answer before you decide. But, not everyone has to agree. That's the other great thing about science, debate is encouraged as long as it's respectful!

- What does it tell you about why the water level in Lake Merritt changes?

- Looking at the map of Lake Merritt, does that provide further evidence for your conclusion?

Lastly: Why do we care?

Now that you have completed your experiment, developed some conclusions and discussed those with other students, we can talk about the big picture questions. Make sure everything is put away and the stations are back they way they looked when you came in. Let's talk about why we did this!

- What difference does it make if the lake and the estuary are connected? Why does it matter to us? What are some of your thoughts about why this may be important?

Go to the front of the room and look at some of the other data provided. Look at the chart that shows you the amount of trash picked up from the lake each month.

- If people like us don't go clean the lake, where would that trash go?

What about the wildlife of the lake?

- What type of water do you find in the bay? _____
- What type of water do you usually think of when you think of a lake? _____
- Given what you now know about the lake, is Lake Merritt freshwater or saltwater? (circle one)

- Therefore, should we release freshwater turtles into Lake Merritt?

- How can we increase awareness to prevent people from putting turtles in the lake? Remember, people may just not know that it isn't freshwater, so we should be educational without being rude.

In this class, you'll be ask questions like that a lot. At the end of each lab, you'll be asked to reflect on what you just did and talk about it. To make these exercises useful to you, it's important that you take the time to answer them completely and concisely. This is not just because some of these questions may appear on your exams, but it will helpful you understand why this class is important to take. With that said,

- What did you learn about science that you may not have known before?

- Why is it important that we don't assume things may be related when there is no evidence?

- Give an example of when you witnessed that in your own life

We as humans have a tendency to jump to conclusions without all the information. Think about what would happen if everyone used this process before coming to conclusions about the world, about the daily situations, about themselves? What if every time you had a problem, or something happened that was upsetting to you, you took the time to stop, ask some questions, collect some data and draw your conclusions with the most information you could find?

- What were some of your preconceived notions about this class before lab?

Let's take the semester to collect the data about those notions, then draw results and then make our conclusions about this class.

Chemistry in Practice

Chemistry is a vast field of study in and of itself. In Biology, we use Chemistry as a tool to help us understand how things relate to each other on a smaller level. In this lab, we are going to take the aspects of Chemistry that relate to our studies so we can better understand the basics.

Unique Properties of Water: Hydrogen Bonds

As we have learned or will learn in class, water has some very unique properties. Much of this uniqueness stems from the fact that water, although covalent, has polarity. What does it mean to have polarity?

- Write out the definition of a **polar covalent bond**:

On the letters below, draw lines to show which elements are bonded together on these water molecules. Do you remember how many electrons both elements have in their valence shells?

O H H

H H O

Add the polarity to both water molecules. Which side is positive and which side is negative?

- What does this mean for how the molecules relate to each other? Label that too

The fact that water molecules are attracted to each other is due to the cohesive properties of water. ***Cohesion*** is the molecular force between particles within a body or substance that acts to unite them. Water molecules are equally attracted to each other in all directions, if they are surrounded by other water molecules. What about the surface of the water?

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Draw water molecules in this beaker. Show attraction between the water molecules. How is this attraction different at the top?

What do you call that type of tension?

Because water is polar, it also has adhesive properties. ***Adhesion*** is the molecular force of attraction in the area of contact between unlike bodies that acts to hold them together. Let's see what this means.
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Go to the materials table. Grab two slides and a dropper of water and bring them back to your table. Put the two slides together.

- Do they stick? Is it easy to separate the slides?

- Now, drop water on the slides and put them together. Is it still easy to separate them? Why?

Since water is attracted to itself and to other things, it can do cool stuff like climb walls. *Go to the materials table* and get a small beaker and a capillary tube. Fill the beaker with a small amount of water. Now, place the tube into the beaker, holding it so it just touches the top of the water.

- Draw what happened to the water

- How can you explain what happened? What force do you think leads to this phenomena?

The combination of cohesive and adhesive properties leads to something called ***capillarity*.** Can you find a definition for capillarity in the reference materials? If so, what did you find?

- What is the definition of capillarity?

Think about what this might mean for organisms like plants and animals. When you water a plant, where do you put the water? You probably know that water has to move up to the leaves, so what action do you think helps the water move up to the leaves?

- What properties of water help move water against gravity?

Density of Water

Now let's think about the fact that water is attracted to itself. Think about food items in your freezer and in your refrigerator. If you had a small, frozen fish in your freezer, you could probably break it in half with some effort. However, if the same fish were just refrigerated (and not frozen), would it be as easy to snap?

- What do you think it means about the bonds if a frozen fish is easier to break?

- Do you think the water molecules in the frozen fish are as attracted to each other as in the refrigerated fish? Why or why not?

- If water molecules are like magnets, why do you think frozen water molecules don't pull toward each other? Do you think it has anything to do with how close together the molecules are?

- What is the word we use to describe how many of something is in one place (or mass per unit volume)?

- Use the above concepts to explain why ice floats (feel free to draw if that helps).

- What do you think will happen to global water levels when icebergs melt?

Water and Energy Storage

We've heard that there is energy in the bonds between atoms. That energy holds them together, so when those bonds break, that energy is released. We just considered that there is a difference in the attraction of water molecules when water is frozen. Let's now consider what happens when water goes from a liquid to a gaseous state instead.

At some point, you've probably heard that the steam coming off a pot of boiling water is hotter than the water in the pot. You may have even experienced this (steam burns really hurt!) When water boils, liquid is converted into a gas, which is the steam.

- In order for water to turn into steam, what must happen to the bonds of the water molecule?

- What do you think happens to the energy that holds those bonds together?

Think about a rainy, calm day around here in the winter. Now, compare this temperature to that of a day when it isn't raining. You might have experienced that rainy days are actually much warmer. What do you think happens to water droplets as they fall and eventually evaporate from the ground?

- Rainy days are warmer because which bonds are broken?

This means that water has a **high specific heat**, or it can hold a lot of energy before changing. It also means that water can help regulate temperature in everything, including you. Water has what's called **thermostatic properties,** meaning it can keep climates moderate.

- Why do you think the temperature in Livermore is more drastic than in Oakland?

Mountains also affect climate because they influence air flow over land. When moist, warm air moves from the water toward a mountain, the air rises, releasing the moisture as it moves. On the other side, the cool, dry air falls on the other creating what's called a rain shadow.

- Why do you think there is more fog west of the hills of San Francisco?

- Why do we get more rain than Pleasanton?

Importance of pH

Measuring the amount of H+ something may gave off can also tell us about how it will react to other things. The measurement of the amount of H+ something can donate is called pH or potential Hydrogen. If a solution has a lot of H+ to donate it's called an acid. If it is more likely to accept the H+ it's a base. If there are equal amounts of donators and acceptors, it's a neutral solution.

The scale we use is a logarithmic scale meaning a pH of 1 is really 10^{-1} or 0.1. Therefore a pH of 4 is really 10^{-4} or 0.0001. That means something with a pH of 1 has 1000x more H+ to donate than something with a pH of 4.

1 ACIDIC 7 BASIC 14

Let's make sure this makes sense by using real things. Go to the reference library and find examples of acids and bases. Write those things on the chart above with their pH. Make sure they are in the right place.

Testing pH – *Go to the materials table*. Take a dry slide and place it on the towel. Now, place the pH paper on the slide. Lightly touch the pipette to the paper and note the color change.

Using the key on the tube, record the pH of each solution on the data table below:

SOLUTION	COLOR	pH	ACID/BASE/NEUTRAL
A			
B			
C			

What was the pH of solution A? _____

What was the pH of solution B? _____

What has more H+ to donate? _____

How much more H+ does it have? _____ Why?

Some solutions can resist changes in pH. These are called **buffers**. You can test if a solution has a buffer by adding an acid to the solution and testing its pH. Instead of using a lot of pH paper, we can use a solution called Phenol Red to test for the presence of an acid. Phenol Red will turn yellow of there is an acid present. We'll use this again to test for photosynthesis, so you may want to mark this page for later.

Go to the Testing Table for this part:

1) Measure out 20 ml of Solution X in a small beaker
2) Measure out 20 ml of Solution Y in a small beaker
3) Don't forget to label your beakers!
4) Add 5 drops of phenol red into each beaker and swirl
5) Now add 5 drops of the acid to each and swirl

Did you observe a change color in both beakers? If not, keep adding to the one that didn't until it changes to yellow. Don't forget to swirl the beaker to ensure even distribution.

How many drops did it take to change the other solution? _____

Given these results, which one can you conclude had the buffer? _____

- Do you think your body would have uses for buffers? If so, what might those uses be?

- Why do you think understanding pH important?

- Why do you think buffers are important?

Summary Questions

1. Explain how hydrogen bonds influence at least 2 unique qualities of water

2. How do these qualities affect climate?

3. What does pH stand for?

4. Why is pH important?

5. How do you think your body uses buffers?

Go through the lab and notice the words in bold. Rewrite them and their definitions in your own words here:

Using a Microscope

Frequently in science, we would like to see something that is too small to see with the naked eye. Luckily, we can use lenses to bend light, and make things appear bigger than they are in real life. Microscopes use lenses to gather up light from a tiny thing you are trying to see on a slide and then bends the gathered light again so that the image is focused on your eye. Let's look more closely at how to use and care for our microscopes.

Care and Use of Microscope

When we have labs that involve looking at small things, you will need to get a microscope from the cabinet where they are stored. There are correct and incorrect ways for caring for this expensive piece of equipment. These rules are posted on the microscope cabinet if you forget! *(Read the rules below and fill in the blanks)*

When you go to get a microscope from the cabinet…

ALWAYS	NEVER
Check the number of the microscope and shelf	
Check the head to make sure it's secure	Pull out a microscope with one hand
	Carry other things with a microscope

Before you turn on/off the microscope…

ALWAYS	NEVER
Start and end with the light meter on lowest setting and power off	

Before you put the microscope away…

ALWAYS	NEVER
	Loosen head
Check that smallest objective lens is in place	Leave the highest objective lens down
Stage down and centered	

Parts of Microscope

Once your group has been assigned a microscope, carefully bring it back to the table. Always carry your scope with two hands, one under the base and one holding the arm. Notice that our compound scopes have a nice handle.

Let's find the other parts of the microscope by looking at their functions. Starting with the light movement:

Direction and Angle of Light

Remember that before you turn on the microscope you need to check that the **light meter** is on low or 1. Find the light meter and see what number it's on. Is it on 1? If it is, go ahead and turn on the light power switch.

- This type of microscope is used for histology, or the study of *tissues*. Tissues are collections of *cells*, working together to perform a common function. Cells are tiny!

  Notice the source of the light. What parts of the microscope does the light have to pass through to reach your eye?

- The place where you put slides is called the **stage**. What would happen if you put a solid object, such as an eraser, on the stage and tried to view it under the microscope?

This means that the samples we look at have to be thin! Now we are ready to start looking at stuff!

Go ahead and look into the **eyepieces**. The eyepiece sits atop the **ocular lens**. This lens will magnify the object 10x and is not changeable. Light travels up through a lens on the revolving microscope head, called the **objective lens**. On our microscopes, there are three objective lenses, with different magnifications, so the magnification of the object depends on which objective lens you have in place ("down"). The smallest objective lens (4x) should always be in the down position **when you start and when you finish**.

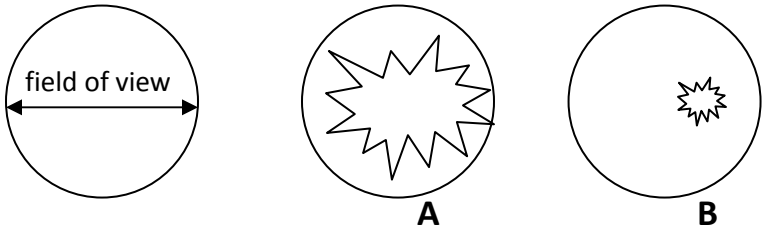
The **total magnification** of what you are seeing is equal to the strength of the ocular lens times the strength of the objective lens. Record this information on your **Microscope Reference Chart** on page 27.

Having the lowest objective lens in place, the stage completely lowered, and the light meter on low will from now on be referred to as the **Start Position**.

How to Start Looking at Samples

If you were looking for a friend in a crowd, would it better to stand in the crowd or stand on something that puts you above the crowd allowing you to scan the crowd from a distance? When looking for something on a slide, it's better to start with a broad view, then move to smaller sections. The width of the circle of light you can see when you look into the microscope (the **field of view**) is determined by the objective lens. The larger the objective lens, the smaller the field of view. Therefore, *as you increase magnification, you decrease the field of view*, and you can see less of your sample.

- Do you think it's better to start with a high magnification or a low one?



- Which field of view above is larger, A or B?

Let's determine the **field of view** for our lens by first measuring the diameter using the 4x lens.

Lay the ruler down across the stage on your microscope. Notice there are two sets of knobs, one set on either side of the scope. These are the focusing knobs. The larger knob is called the **Coarse Focus Knob** and when you move it, you can see the stage move. *You should only use this knob with the 4x lens.* Focus on the ruler to a point where you can clearly see the lines, then use the smaller knob, or the **Fine Focus Knob** to make the lines of the ruler more defined. Now you are increasing the **resolution** or clarity of the image. This is a good knob to use to focus things when you switch from one lens to another, but *always be sure to move the fine focus knob slowly so you don't miss anything.*

Count the lines (mm) across your field of view (diameter) and record this information on your **Microscope Reference Chart** on page 27.

Now that we've measured the size of the field of view for the lowest objective lens, we can calculate the rest. We know that the size of the field of view will *decrease* in the same ratio as the magnification of the objective lens *increases*. For example, if you increase the magnification of the objective lens you use by 10, you will decrease the field you see by 10 (multiply by 1/10)

Here is a formula that can help you calculate the diameter of your field of view:

(diameter of field A)(total magnification of field A) = (diameter of field B)(total magnification of field B)

Let's calculate the rest of our field of view sizes and record them. Here is some room to do the math.

Now write the values you obtain in the Microscope Reference Chart on page 27

Finding Your Object

For this you will need a slide of the letter "e." Before you start, make sure the microscope is back in **start** position.

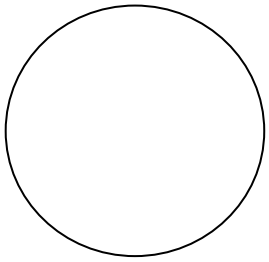
- If you have turned your microscope off, what should you check before you turn it back on?

Place the slide on the stage so you can read the letter "e"

- Looking through the eyepiece, what do you notice about the "e"?

- Why do you think the "e" appears the way it does?

Once you find the "e" using the 4x lens, make sure the "e" is in the center of the slide, then switch to the 10x lens and refocus. Only use the fine focus knobs to focus the "e", or you may hit the slide by accident! Once you decide which view is best, draw your "e" the way you see it, trying to draw it to scale. Label your drawing with total magnification. Given what you know now about field size, how big is the "e"?



Title your slide _____

Total magnification _____

- Let's work it out:
  How large is the field of view in which you drew the "e" above (see reference chart)?

  Estimate the % of the field the "e" takes up.

  Now, take that % of the diameter and that's the size of your "e"!

  So roughly what size "e" do you have?

Working Distance

Before you put the slide away and return the microscope to the start position, let's see how far the lens really is from the slide. Having an idea of how close you are to the slide will help you get started more quickly and show you why we should only use the fine focus with the higher magnification lenses.

While you are using the 4x lens, take the clear, bendable ruler and measure the distance from the slide to the bottom of the objective lens and record this as the "working distance" on the Microscope Reference Chart. Find the "e" with the other lenses and record those distances as well.

Looking at Layers

Have you ever gone to a birthday party and wanted a piece of cake, but wanted to know what type of cake it was first? When you look at a cake that's been frosted, you can't see the layers inside because only the top one is visible! The same is true for objects on slides. You can't always see all the layers at once, so you have to learn how use the microscope to find the layer you want. For this, you will need a *slide of crossed threads.* From the Start Position, focus on one of the threads. Now using the Fine Focus Knob, try to get the other threads into focus one at a time. Have everyone in your group do it with the 4x, then the 10x, then 40x lens.

- Which lens made it easier to see all three threads *at once*?

- Which lens made it easier to see the *detail* of threads?

- Was there a lens that wasn't good for looking at all layers at once?

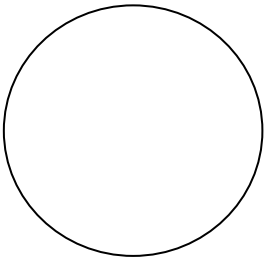
- So, if the highest objective lens wasn't that great for seeing the threads, why do new microscope users always try to find things using that lens?

  I don't know either! It's not really a good idea, is it?!

- With that knowledge, which lens should you always start with?

How to Record Data about Slides

Now that we have learned about the parts of the microscope, let's look at a real histological (tissue) sample. Remember to make sure you are in the Start Position. Check the light before you turn on the scope and make sure you are using the lowest objective lens. Label your drawing with the total magnification and interesting aspects of your sample. What is the size of your sample?

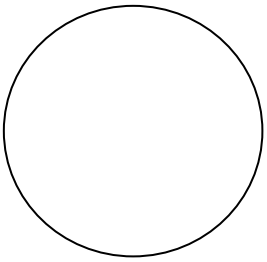


Label the things that are interesting

Total magnification _____

Title of Drawing _____

Diameter of Field _____ How big is the sample? _____



Label the things that are interesting

Total magnification _____

Title of Drawing _____

Diameter of Field _____ How big is the sample? _____

Microscope Reference Chart

Lens	Total magnification	Diameter of field	Working distance	Light Setting
4x				
10x				
40x				

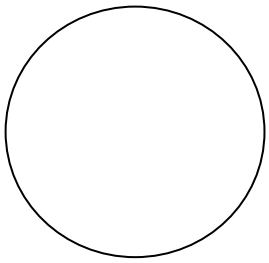
Compare to the Dissecting Microscope

What if you wanted to look more closely at something solid and examine its exterior features, like the frosting on a piece of cake? Can you use the microscope you currently have out? No! We instead need a microscope that won't shine light through the object. Go to the shelf where you got the light microscope and get a **dissecting scope**. When you get back to your table, compare the parts of the two scopes.

- What are some of the differences between them?

- What types of biological things would you look at with the dissecting scope?

Try looking at something solid like a pencil or your finger with the dissecting scope.
Draw it and don't forget your labels!



Total magnification _____

Title of Drawing _____

Diameter of Field _____ How big is the sample? _____

Dissecting microscopes are often used by scientists *dissecting* things because these scopes are more straightforward to use and manipulate than light microscopes. Move the object you are sketching side-to-side and up-and-down, and view it through the lens.

- **Which direction does the object appear to move? Is this the actual direction you are moving the object?**

Summary Questions name:

1) You are explaining a light microscope to a friend who has never used one. How would you describe how light is used in the microscope to see an object more clearly?

2) How do you determine total magnification?

3) How do you carry the microscope?

4) What is the **start** position?

5) Why was it important to record data concerning the microscope?

6) What steps do you take to determine the size of an object?

You Are What You Eat?

Now that we have reviewed how atoms come together to make molecules, let's take a closer look at the primary molecules our bodies make and utilize. Today, if you are sitting at tables 1,3 or 5, you will start with Activity 1. If you are sitting at 2,4 or 6, you will start with Activity 2. Let start!

Activity 1 – Biological Molecules

There are certain structures that are a combination of atoms. Once they bond together, they make molecules that can function on their own, but can also be used to make bigger things like Proteins. The molecules that are used to build the bigger structures are called **Monomers**. Remember 'mono' means one, so it's one molecule. When those molecules join together to make the bigger structure, it's called a **Polymer** ('poly' means many). Those bigger structures do things like build cell membranes, help cells talk to each other, store energy and keep us warm.

Quick Check:
Do you remember what atoms share that help them bond together?

If they share electrons, what type of bond is it?

Let's look at the main types of *Biological Molecules* our bodies need. For each, we are going to look at their structure and function and run some experiments to test their presence. All the materials for the testing part of the lab are on the materials table, including the directions. You will be conducted experiments for one of the molecules, then sharing with others, so your instructor will explain how the class will be split into groups.

Carbohydrates

Structure

Glucose, Fructose and Galactose are the building blocks (monomers) for Carbohydrates. They are also called monosaccharides. Carbohydrates are built when you put two more glucose molecules together. If you put two of those together, it's a **disaccharide (**di- means two). If more than two of these building blocks are bonded together, it's called a **polysaccharide** (poly- means many). **Cellulose, Starch** and **Glycogen** are types of polysaccharides.
Examples

Use the reference material or your lecture notes to answer these questions as preparation for your experiment.

- What three letters do most of these have in common?

- What is the molecular formula for Glucose?

Notice that there are 2x as many H's as there are O's? Keep that in mind as we look at other structures.

- What is Lactose? What are the monomers involved?

- What is Sucrose? What are the monomers involved?

- Which of the polysaccharides listed above is digestible by humans?

Test for glucose

The procedure and materials of these tests are on the materials table at the front. Send two group members to get the directions and materials. Then, have the person read the directions out-loud before you start. Make sure everyone understands the whole experiment before you begin.

Experimental Procedures - Since you will not have the procedures to study from, it's important that you notated the important aspects of the study:

- What are you testing for in this experiment?

- What chemicals are you using to test? (list all of them and what they do)

- What are the basic steps of the experiment (keep in mind you might be sharing them with others)

- What is your hypothesis for your experiment?

- What are the variables? What are you going to watch for?

Results: Data Collection

Here's a table to record your information. You don't have to use all the rows and columns, so decide how you are going to label them before you start.

Test/Tube	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Benedict's							
Notes:							
Iodine							
Notes:							

Notes:

Conclusions – Remember your conclusion is where you summarize what you found. In general, what information did you gain from the experiment? How does it help your understanding of Carbohydrates? What does it all mean?

- Was your hypothesis supported or not? Why or why not?

What is Diabetes?

Diabetes mellitus is a disease that affects your body's ability to move glucose into the cell using a hormone called insulin. We need glucose to make energy in the cell, so without it, we get tired more quickly. Insulin is produced by your pancreas, so the problem can be your don't make insulin or your insulin doesn't work anymore.

According to the Mayo Clinic, the two different types of diabetes can be defined in this way:

Type 1 diabetes, once known as juvenile diabetes or insulin-dependent diabetes, is a chronic condition in which the pancreas produces little or no insulin. Various factors may contribute to type 1 diabetes, including genetics and exposure to certain viruses. Although type 1 diabetes typically appears during adolescence, it can develop at any age.

Type 2 diabetes, once known as adult-onset or noninsulin-dependent diabetes, where your body either resists the effects of insulin or it doesn't produce enough insulin to maintain a normal glucose level. Untreated, type 2 diabetes can be life-threatening.

There's no cure for either type 1 or type 2 diabetes, though both can be managed. With proper treatment, people who have type 1 diabetes can expect to live longer, healthier lives than in the past. Type 2 can be managed or even prevented by eating well, exercising and maintaining a healthy weight. If diet and exercise aren't enough to control your type 2 diabetes, you may need diabetes medications or insulin therapy to manage your blood sugar.

- What is insulin?

- What is the difference between type 1 and type 2 diabets?

- Are ways that you can prevent type 2 diabetes?

- Will eating a lot of fiber increase your blood sugar? Keep in mind your answer to the question before!

Proteins

Structure

Proteins are different from Carbohydrates in a few ways. One big difference is the presence of Nitrogen in their structure. Molecules with Nitrogen sometimes have amin- or ammo- in their name. Because of the presence of Nitrogen, the building blocks for proteins are called **amino acids** (aa). Some of these like the water (hydrophilic) and some don't (hydrophobic). This means that when they bond together, the order of the amino acids is crucial to the shape of the protein since the ones that are hydrophobic would rather be close together. The shape is really important to make sure the protein can do what it's supposed to. Have you ever tried to open a door with the wrong key? The same thing happens if the protein is the wrong shape.

Building a Protein

For proteins, how the amino acids come together to make really long chains (polypeptide chains). That order determines how they fold up and how they come together with other chains. Use the reference material to write out what happens at each of the four steps in building a protein.

Primary

Secondary

Tertiary

Quaternary

Now that we have seen how specific the structure of a protein has to be, think about the many ways the structure might change. We are going to test how important the environment is to making sure proteins like enzymes work correctly.

The procedure and materials of these tests are on the materials table at the front. Send two group members to get the directions and materials. Then, have the person read the directions out-loud before you start. Make sure everyone understands the whole experiment before you begin.

Experimental Procedures - Since you will not have the procedures to study from, it's important that you notated the important aspects of the study:

- What are you testing for in this experiment?

- What chemicals are you using to test? (list all of them and what they do)

- What are the basic steps of the experiment (keep in mind you might be sharing them with others)

- What is your hypothesis for your experiment?

- What are the variables? What are you going to watch for?

Results: Data Collection

Here's a table to record your information. You don't have to use all the rows and columns, so decide how you are going to label them before you start.

Test	Egg albumin	Honey	Glycine	Water	Protein
Biuret					
Notes:					

Make sure you know which are the controls before you test.

Conclusions – Remember your conclusion is where you summarize what you found. In general, what information did you gain from the experiment? How does it help your understanding of Proteins? What does it all mean?

- Was your hypothesis supported or not? Why or why not?

- Do you know what it's called when a protein unfolds?

- How does the Carbohydrate experiment relate to this one? If your group didn't do that experiment, be sure to talk to the students that did.
    - What type of molecule is Insulin?
    - How important are things like pH to making sure insulin works?
    - What might happen to your blood sugar level if your blood pH changes?

Lipids

Structure

Lipids are different from the other two because they don't have a monomer that's true for all types of lipids. Instead, the types of lipids have different monomers and act a little different too. In general, lipids have the same make up as Carbohydrates, but they don't have the same Hydrogen/Oxygen ratio. Steroids are a type of lipid that uses cholesterol as its base. Estrogen, Testosterone, Progesterone are all types of steroids. Phospholipids are a combination of a lipid structure and a phosphate. If you recall, this is what helps build our cell membrane. This structure helps keep the shape of a cell without it being too rigid.

The biggest group of lipids are Triglycerides. These have a Glycerol head and a fatty acid tail. Glycerol (3 Carbon chain) is half a Glucose molecule (6 Carbon chain). Any extra Glucose you take in will be stored as Glycerol if you don't use it. Triglycerides are grouped together based on what their fatty acid tail structure looks like. It all depends on if the carbons in the chain are sharing one or more electrons with each other. If they share two electrons, it's considered a double bond. That also means it can't bond with the same number of Hydrogen atoms as if they only shared one electron, or it's not saturated with Hydrogen. *So, what is the difference between saturated/unsaturated and transfats?*

Use the reference material to define the following terms. You might want to draw it out to help your understanding.

- *Saturated*

- *Unsaturated*

- *Transfat*

Lipid Testing

The procedure and materials of these tests are on the materials table at the front. Send two group members to get the directions and materials. Then, have the person read the directions out-loud before you start. Make sure everyone understands the whole experiment before you begin.

Experimental Procedures - Since you will not have the procedures to study from, it's important that you notated the important aspects of the study:

- What are you testing for in this experiment?

- What chemicals are you using to test? (list all of them and what they do)

- What are the basic steps of the experiment (keep in mind you might be sharing them with others)

- What is your hypothesis for your experiment?

- What are the variables? What are you going to watch for?

Results: Data Collection

Here's a table to record your information. You don't have to use all the rows and columns, so decide how you are going to label them before you start.

Test	1ml Salad Oil	1ml Salad Oil	2ml Honey	Water	Known lipid
Water					
Notes:					
Sudan IV					
Notes:					

Notes:

Conclusions – Remember your conclusion is where you summarize what you found. In general, what information did you gain from the experiment? How does it help your understanding of Lipds? What does it all mean?

- Was your hypothesis supported or not? Why or why not?

- How does the Carbohydrate experiment relate to this one? If your group didn't do that experiment, be sure to talk to the students that did.
    - What type of molecule does Insulin move into your cells?
    - What do you think happens to Glucose if your Insulin isn't or can't work correctly?
    - How does extra Glucose relate to lipids?
    - If you have a lot of Triglycerides in your blood stream, do you think it helps your blood vessels be more or less flexible? (ask your instructor for help if you need it, but try to work it out with your groups first)

Review of Biological Molecules – Chemistry Aspects

Now that you have learned about different aspects of each type of molecule, fill in this table. If you class spilt up the experiments, make sure you wrote out the information about all the experiments and can answer all the questions.

MOLECULE	MONOMER (if applicable)	POLYMER (groups)

*For the fourth row, which molecule did we discuss in class but not test today?

Summarize What You Did - Give a brief description of each test, it's result and what they means. Try to use your own words

Molecules	**Test**	**Result**	**Implication**
Carbohydrates			
Proteins			
Lipids			

Activity 2 – Dietary Analysis

It's important that we learn about biological molecules because we eat them! They are crucial to us being able to do things because they are sources of energy and we use these building blocks to build cells and tissues. Remember that for us to use any of the molecules they have to be broken into their monomer by our digestive tract. Only monomers are absorbed! The first activity will help you with those.

Food = Energy

One of the benefits of food is that it helps provide energy for us. We can determine how much energy food can provide by looking at how many calories the food contains.

1 calorie = the amount of energy it takes to heat 1ml of water 1^{o} Celsius

Notice that the word calorie is lower case but when you see calorie on labels, it's capitalized. That's because when we talk about how many calories a food has, we are actually talked about kilocalories or Calories.

- Do you remember what kilo- means?

- So is a Calorie one calorie?

All of the molecules we are going to look at can help us make energy or ATP (Adenosine Triphosphate). But Glucose is the more efficient at making us energy. The other two can do it too, but don't make as much ATP as efficiently as Glucose.

These activities will help us understand how these molecules are digested as food and that food helps us with activities. We're going to start by looking at the types of food we eat and see how efficient they are at getting us energy.

Product Analysis

Good to **Station 2** and pick one of the food labels posted.

What is the product you picked?

How many Calories are there per serving?

How many servings are there per package?

Now, **fill in the grams column** (first column) of this table. Then calculate the rest with the following directions:

*for 'calculate' columns – use the number in the column to the left and use that to fill in the blank. Put your answer in the column to the right.

	Grams/serving	calculate	Calories/serving	calculate	% of total
Carbs		**_____ x 4 =**		**_____/total cal * 100 =**	
Protein		**_____ x 4 =**		**_____/total cal * 100 =**	
Lipids		**_____ x 9 =**		**_____/total cal * 100 =**	
TOTAL	--------	---------		---------	

So, now that you know how many Calories per serving and the number of servings per package, how many Calories are there per package?

- Multiply the Calories by the number of servings to find the answer

- Do you look at the number of servings per package?

- Do you think you'll start now?

- What do you think about the proportion of Carbs/Protein/Lipids per serving? Is it what you expected? Why or why not?

- A good rule is that fat should be less than 30% of the calories you take in. Does your product meet that standard?

How many Calories do activities need?

Another reason we take in Calories is to make sure we can complete certain activities. Here we have information about how many Calories it takes to complete some activities

Activity	Cal/Hr/Kg
Sleeping	0.9
Reading	1.4
Cleaning	2.4
Walking	3.0

Activity	Cal/Hr/Kg
Bicycling	3.5
Moderate Exercise	4.1
Running	8.1
Swimming	8.9

.

What can you eat to help you gain the Calories to complete these activities?

Food	Calories
Apple	72
Orange	62
Piece of Bread	69
Pasta (1 cup)	220

Food	Calories
Tofu (1 cup)	151
Chicken (skinless)	143
Fish (fried)	292
Beans (1 cup)	305

One thing to consider is making sure you Calories are nutrient dense. That means the Calories you take in have lots of other good stuff like vitamins and minerals. It's important that we also take in things like Calcium, Iron and Zinc along with all the vitamins like A, B, C, D, and E.

- Which of those sources do you think are more nutrient rich?

Tools you can use to stay healthy

Using the laptops, look up the My Plate website (www.choosemyplate.gov)

This website can help you make sure you are getting all the nutrients you need and help you examine your diet. You can breakdown your daily dietary information and increase your overall health through food choices. Take some time to search around the site. Your instructor might have a take home assignment about this website.

- What are the different sections of the plate?

- What ratio of your diet should those different sections be?

- Do you think this is something you'd like to try out?

Summary Questions **name:** .

1. **What are the three biological molecules you reviewed today?**

2. **What are the monomers for those molecules?**

3. **Summarize the experiments you reviewed today in a few words**
   a. **Carbohydrate**

   b. **Protein**

   c. **Lipid**

4. **What is Insulin? How does it relate to Carbohydrates, Proteins and Lipids?**

   a. Carbohydrate

   b. Protein

   c. Lipid

5. **Can you calculate the caloric value of each of those molecules?**

6. **What proportion of your daily intake should be from fats%?**

7. **What is My Plate? How is it used?**

8. **Do you think you are meeting the daily requirements for a healthy diet?**

What Makes Something a Cell?

Cells are important to understand because they are the smallest of the things we consider living. If you remember from lecture, we have certain criteria for what we consider life. This lab will walk us through those characteristics and help us better understand what living things are.

- What are some of the characteristics we use to determine if something is alive?

It's also important to know a few things about cells that we refer to as the Cell Law:

1. All life consists of cells
2. Cells have to come from other cells
3. All life processes derive from cellular activities

- So do you think cells can be made in lab? Why or why not?

The first big distinction between cell types has to do with where it stores information and genetic material. Was passing on genetic material something you listed? We hope so
If a cell has a nucleus, we call it Eukaryotic because the prefix 'eu' relates to something within and 'kary' relates to nucleus.
Let's make a chart with the differences between cells with a nucleus and cells without.

- First, what do we call cells that don't have a membrane nucleus?

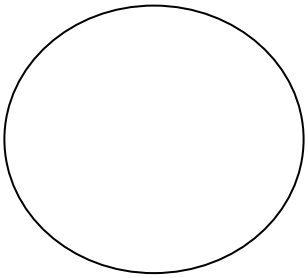
Now, fill in the rest of the table with information you learned in class or using the reference books in lab. Do you remember where those are?

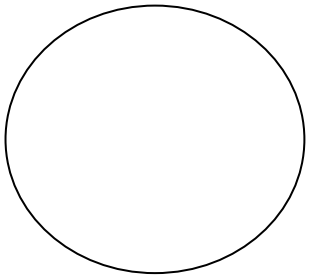
Cell Type	**Size (big/small)**	**Age (old/new)**	**Nucleus (yes/no)**	other
Prokaryotic				
Eukaryotic				

Okay, there is one more column on the chart, is there anything else you want to add?

If not, let's look at the differences between the two. With another group by yours, set up two microscopes. Hopefully you have your microscope reference chart from earlier. Have one group set up a slide of a prokaryotic group and another set up a slide from a eukaryotic group.

Prokaryotic versus Eukaryotic Cells





Title of slide _____ Title of slide _____

Total magnification _____ Total magnification _____

Quick Check: Do you remember how to find total magnification?

Label the important features that make them different. Be sure you start from the Start Position and move from there to help you see things better, don't just jump to the big lens!

- What are some differences you see between the two cell types?

- Is there anything you might have left off your chart?

- What do you think are some limits for each group?

Let's look more closely at Eukaryotic Cells

We know they have nuclei and membrane bound organelles, so let's look at those characteristics first. What a cell does all day has a lot to do with what's inside, so organelles are important.

- What is the definition of an organelle?

There are many cell models out for you to look at on the display table. Can you tell the difference between the plant cell and the animal cell? Are there different organelles?

- Based on your knowledge from lecture, why might they be different?

Let's make a chart of the basic organelles that Eukaryotic Cells have:

Organelle		**What does it do?**
Nucleus		
Rough ER		
Smooth ER		
Ribosomes		
Golgi Complex		
Mitochondria		
Lysosomes		

We left space for you to draw the organelle as it looks on the model. Make sure you go to the model and find them all.

There are two that use the initials ER.

- What does ER stand for?

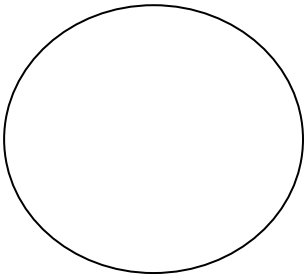
- What do both types of ER have in common?

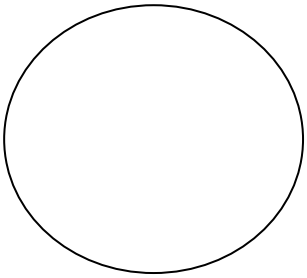
- How can you tell them apart on the model?

Not all Eukaryotic Cells are the same. What are some organelles that are specific to Animal cells? Let's make a chart of those: (there is a space to draw it next to it's name)

Organelle		**What does it do?**
Centrioles		
Cytoskeleton		

Now, Let's look at **Animal Cells**. Don't forget to label the important stuff like nuclei!





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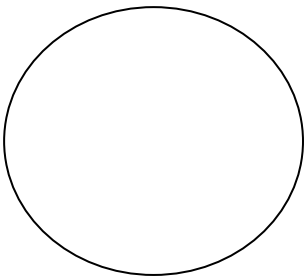
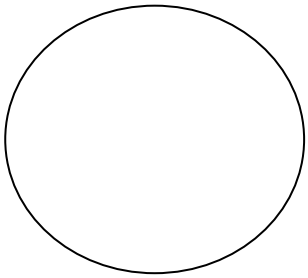




Title of slide _____

Total magnification _____

Title of slide _____

Total magnification _____

Compare your slides with the model. Can you find the organelles of the model on your slides? Make some notes about what you could find and what you couldn't:

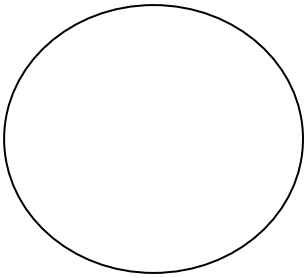
Let's make our own cheek cell slide

Everyone has a slightly different way of doing this, but in general there are a few steps to making what we call a wet mount slide:

1) Get a slide and a cover slip from the lab materials table
2) If need be, put a drop of water or dye on the slide
3) Cut a very thin sample to place on the slide (be careful with the sharp things)
    i. Sometimes you put dye after you put the sample down
4) Place the coverslip at an angle against the slide and drop it over the sample

Are there any notes you'd like to take considering the procedure?

Go to the front to make your cheek cell slide with your instructor's directions



Any notes on your slide?

Title of slide _____

Total magnification _____

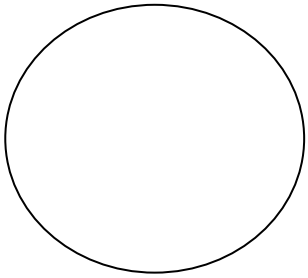
Can you find any of the important organelle's on these slides?

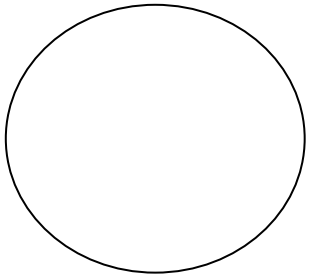
Let's look at some Plant Cells and their organelles?

What are the organelles that we only find in plant cells? Can you find these on the plant cell model? Can you find everything you have reviewed so far on both models? Let's make a chart that's plant specific:

Organelle		**What does it do?**
Chloroplast		
Cell Wall		
Central Vacuole		

Let's take a look at some plant cells:
Go to the materials table and get one prepared slide of plant cells and then make wet mount slides from the samples of onion using Lugol's Iodine to dye the nucleus.





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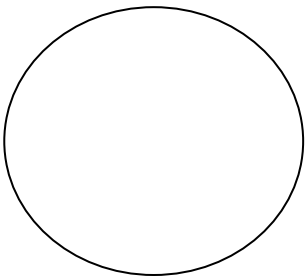
Looking at the onion cells:
* Do they have chloroplast?

* If they don't have chloroplast? Where do they photosynthesize? Where do onions make their food? (Food for the plant, not the food we eat)

Let’s look at more plants to get practice



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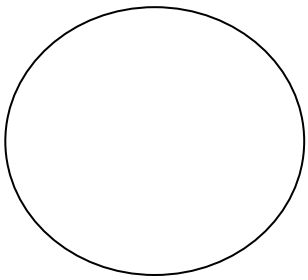

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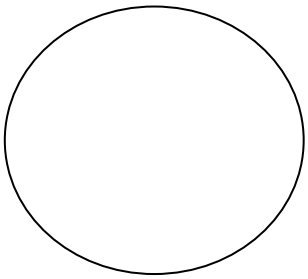
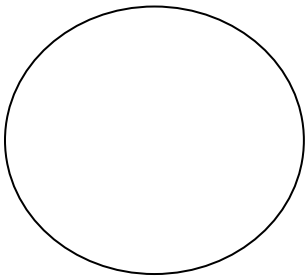
Let's take a closer look at plant cells and their colorations. First, make a wet mount slide of the red part of the onion and petals from a plant outside. Make sure the sample is very thin, you might want to tear the petal so you can only see one layer.





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- What do you notice about the color in red onion skin versus the petal?

- Why do you think there might be a difference in the reason for the color?
    - Think about where you find onions

- Where is there a big space in the plant cell that might be able to house all that color?

Summary Questions for Cell Lab **name:**

1. **What are the main differences between prokaryotes and eukaryotes?**

2. **What are the basic steps to making a wet mount slide?**

3. **What are the organelles you only find in plants versus animal cells?**

4. **Where are the two different places you might find color in plants? What does that difference look like on a slide?**

5. **Why might plants have color different places?**

6. **Find the organelles on the cell models and have another classmate sign off that you identified them all**

Why Do We Breathe Oxygen?

There are a lot of processes in Biology that seem difficult to understand and very complex. Sometimes it helps to break it down into parts and try to relate those processes to our everyday lives. Photosynthesis and Respiration are two of these processes, so we are going to work on understand how/why they are related and why it matters to us.

- Let's start by writing out the equation for Respiration:

Label the molecules with their names under their chemical formula

- How does it relate to the equation for Photosynthesis?

We sometimes refer to this type of reaction as an Oxidation/Reduction Reaction or **Redox Reaction**

- Can you find the definition of a Redox Reaction in the reference area of the lab?
    - If so, what is the official definition:

So, with that definition, what does that mean for the equation?

- Let's write out the equation again:

- Label what is being oxidized and what is being reduced
    - Remember it means reduced in charge, not in size. So it's the one being reduced gaining or losing electrons?

- Looking at the movement of electrons, which molecule is losing electrons on the left?

    - Where did that molecule come from in you?

Write where this comes from on the first equation you wrote down at the beginning of the lab

Rewrite the equation, just to remind you of what molecules are involved.

- What happens to that molecule once it enters your cell?

- Considering the electrons that are released when we break that glucose molecule apart, where will those electrons end up in the end? Or, which molecule accepts the electrons and what molecule does it end up making in the process?

    - How does this relate to why you breathe in Oxygen?

Label the equation from the beginning of the lab with where you get oxygen.

- Look at the equation again. What is on the right side of the equation that you exhale?

- Where did the carbon come from to make carbon dioxide?

Does the equation make more sense once you've looked at the molecules involved and how they break down? Let's label our equation on this page too.

But wait! Is that all there is to the answer? Then why do the rest of the lab? Oh, right we want to see how it relates to our lives and why it's so important for us to understand. So, let's play with plants and see what happens!

Activity 1 - Looking at Cells to Determine What They Do

One way to determine what type of activities some cells partake in is to look at their organelles. Go to the cell models and try to remember their names. Now, compare the Plant Cell and Animal Cell models, do they have different parts? This might be a good time to get out your Cell Lab and review the organelles.

Now, let's look at two in particular.

- Which organelle is the site of Cellular Respiration? (Put your answer in box A)
- What organelle is the site of Photosynthesis? (Put your answer in box B)

Now fill in the rest of the table with your definition of each organelle's job and if it exists in Plant Cells and/or in Animal Cells. What do you think that tells you about the activity of each? Let's test it!

Organelle	Job	Plant Cell	Animal Cell
A)			
B)			

Activity 2 - Experimenting With Cellular Activity and the Jobs of Organelles

First experiments can help us understand Photosynthesis. These take some time before we see results, so we suggest setting up the experiments and then skipping ahead to the Respiration section and answering those questions while you wait. Just don't forget about them!

Your instructor is going to demonstrate how to prep this experiment. Here's a place to take some notes before you start:

How Does the Equation for Photosynthesis Relate to Real Life?
Let's do some tests to see how the equation really works!

<u>Go to the materials table</u>

1. Grab a small test tube and a cork.
    - Use the tape to label your test tube with your group number. Be sure not to block the area where the plant will be.
2. Carefully pour Phenol Red into the test tube
3. Unless otherwise specified by your instructor, clip the top of a pipet and use that as a straw to blow into the test tube (you might want to do this over the sink, just in case)
4. Get a piece of Elodea out of the beaker and place it in the test tube
    - What are you adding to the test tube?

    - How did blowing into the test tube change the color of the Phenol Red?

- Why did the color change?

5. Put the cork in the test tube carefully. DO NOT shove the cork in, it can break the test tube
6. Now place the test tube outside on the rack (or by the UV lamp if you are here at night)

You'll be going out to check on the test tube every 20 minutes or so, don't forget about it!

Now that you have read through the directions, what is your hypothesis about what you think will happen? (Remember to make your hypothesis a directed statement, not a question)

What evidence will you look for to determine if your hypothesis is correct?

Now, we suggest that you skip ahead and set up the next experiment, then come back to answer these questions once you see results.

After about an hour, answer these questions:

- What color is the fluid now?

- What happened to the CO_2 you blew into the test tube?

- What does that tell you about the process that occurred in the plant cells?

- What organelle did the plant use to make the change?

- What other evidence do you have that there is gas production occurring? Think about how you might see gases in a liquid (like carbonated soda)

Activity 3 - How Do Plants Utilize Different Rays of Light?

Now that we were able to see that plants can convert CO2 into O_2, let's look more closely at how they do that. Go to the area with the models and check out the chloroplast model. Notice that there is what looks like stacks of pancakes in the organelle.

- Do you know what those are called?

- Do you know what makes them look green?
    - If not, don't forget that you have reference books to look stuff up

Let's conduct some more experiments to see if we can identify different types of chlorophyll in leaves.

Go to the materials table or the front table if your instructor prefers

Here, you are going to rub the leaf on chromatography paper and then expose the paper to a solvent that will separate the different chlorophylls in the leaf.

1. Get a large test tube and cork. Notice there is a pin in the cork.
2. Take a leave either from the table or from outside (pay attention to instructor directions)
3. Take a piece of chromatography and cut the end into a triangle.
4. Cut a notch in side of the paper where you are going to put the rubbing
5. Using a penny, place the leave on the paper at the notch and rub the penny on the leaf, transferring green pigment to the paper.
6. Place a small amount of solvent in the bottom of the test tube using a pipet.
7. Place the pin through the top of the paper and into the cork
8. Place the paper in the test tube so that the paper is just touching the solvent at the bottom
9. Place the cork on the top but don't force it into the test tube, it will get stuck!
10. Label your test tube with tape and place on the rack with everyone else
11. Wait for the solvent to move the chlorophyll up the paper

This too will take time, so don't forget to check on it every 10 minutes or so. If you don't, the color might move off the paper all together!

Once you can see different colors on the paper, take the paper out and dispose of the solvent in the appropriate container in the lab. Don't wash the test tube, just put it back on the rack with the cork and pin. Now you can answer these questions.

- What are the colors you see on the paper?

- Why do you think plants need different colors of chlorophyll?

Activity 4 - How does Respiration relate to metabolism?

In science, sometimes we can extrapolate information from other peoples work. Here, we are going to use data that will be provided to answer questions about **Respiration** rates in different types of animals. Let's analyze information about metabolic rates to better understand how our mitochondria work.

Some animals are frequently seen sitting out in the sun. Maybe you've seen pictures of Gila Monsters sitting on rocks with their arms around each other, just staring at the sun. It might seem like they are just sunbathing with friends, but they are really getting heat to 'jump start' their metabolism. Animals that need outside sources of heat are called **Exothermic**. Looking at the word, how does it relate to words you've seen before? (Think of moving things in and out of a cell)

- What does Exo mean?

Other animals (like us) use the process of making ATP to warm themselves up and all other mammals. That means their mitochondria are very active and they can make their own heat, so they are **Endothermic**.

- What does Endo mean?

Animal	Metabolic Rate in 5^o Celsius	Metabolic Rate in 20^o Celsius
Lizard	0.04 ml O_2/hr/gram	0.28 ml O_2/hr/gram
Mouse	7 ml O_2/hr/gram	2 ml O_2/hr/gram

Remember the units are very important for data collection.
Let's look at the units to figure out what it means:

ml O_2/hr/gram = intake of oxygen per hour per gram of body weight

- How does the amount of oxygen you take in relate to how much ATP you make?

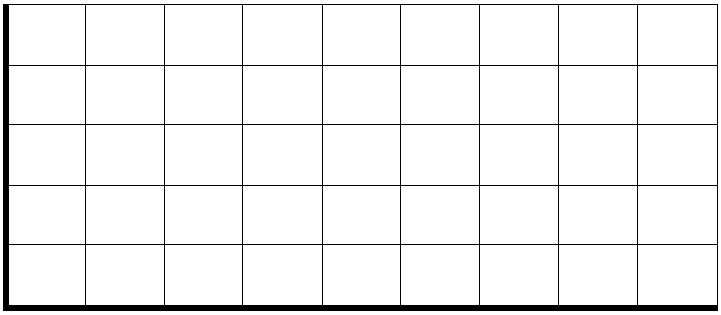
Now, let's graph these data so we can compare them.

- Looking at the range of values, would it be a good idea to use the same graph?
    - What are the data points for the lizard?
    - What are the data points for the mouse?

Maybe two is better, but let's look at them next to each other so we can compare.

On the graphs below, label the X and Y axis and place the data points on the graph. Then contact the dots and draw a line between the data points.

Lizard Metabolic Rate

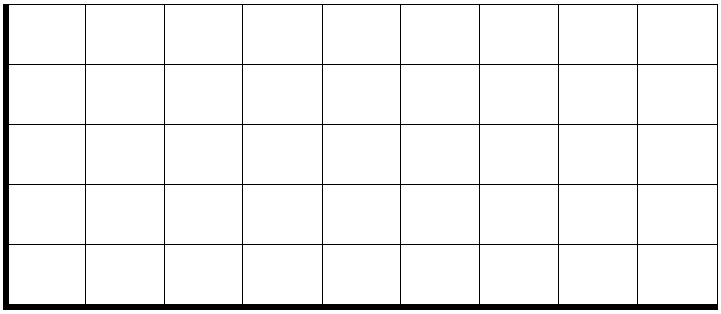


Environmental Temperature

- Which direction does the lizard graph go?

- What does that mean about the metabolic rate of a lizard?

Mouse Metabolic Rate



Environmental Temperature

- Which direction does the mouse graph go?

- What does that mean about the metabolic rate of a mouse?

Why Plants are Important to Us?

Now that we have looked at how both Respiration and Photosynthesis works, let's look at **how big a plant would have to be to keep you alive.**

How much oxygen do you need?

If the average person weighs 60 kg and during an hour of class you use about 0.4 L of O_2 per kg, how many ml of O_2 do you need per hour?

** Record this information on data table below

How much do plants produce?

Either your instructor will set up this experiment do watch as a group, or will provide data regarding this experiment to determine how much Oxygen plants produce over an hour. The experiment is designed to monitor oxygen production by recording how much gas is produced by the plant in a closed space. Go to the front and read the information about the experiment or take notes here if your instructor is explaining what is happening,

Then record your data here:

Data Source	Value
Need by you over an hour (from exercise above)	
Amount of O_2 produced by plant in 1 hour	
Light catching area in cm^2	
ml O_2 produced per cm^2 in 1 hour**	

* Don't forget your units when you record data

** You can find this answer by diving your answer for the second row by your answer for the third row

Activity 5 - How big of plant do you need?

Now that we have those data, let's use that information to calculate how big of plant you need to keep you alive. Keep in mind the units of the data points you have in the table on the previous page.

Here's the equation we are going to use:

$$\text{SIZE OF PLANT NEEDED TO KEEP YOU ALIVE} = \frac{\text{HUMAN OXYGEN DEMAND (in ml)}}{\text{PLANT } O_2 \text{ PRODUCTION (in ml) PER CM}^2 \text{ OF PLANT}}$$

Let's fill in our variables on the right using the table on the previous page:

- What is the size of plant required to keep you alive? _____cm^2

Let's change the units to m^2 to give us a better idea of the size of the plant. There are 10,000 cm^2 in one m^2:

To figure out how tall the plant is, we have to find our answer in meters. So take the square root of the answer above:

What about the fact that there is no sunlight at night? Is that going to change your estimated plant size?

- What is the new size of the plant?

Go outside with the meter stick and look at how big of a plant you need just to keep you alive!

Summary Questions name:

1. **What is the equation for Respiration/Photosynthesis?**

2. **Where do you get the molecules on the left?**

3. **What happens to the molecules on the right in animals?**

4. **Why do you breathe oxygen?**

5. **What organelle do plants have that we don't?**

6. **What does the answer to 5 make that we need?**

7. **What test did you conduct to prove that plants convert CO_2 to O_2?**
    a. **Write out the steps and what happened:**

How Do Cells Make More Cells?

We already mentioned that cells can only come from other cells, so how do they do that? If they come from other cells that means one cell will divide into two cells. This process is called **Mitosis**. We're going to look at how we ensure that the cells we make are the same as the original (or parent) cell. Once we look at how we make more of our own cells, we'll look at how we make cells like eggs (oocytes) and sperm that can be combined together to create new organisms. This process is called Meiosis and all **Eukaryotes** can do it, even plants!

We're also going to look at why we make more cells and how that is regulated? It's also important to understand how cells know when to make more and how many to make because if those regulatory systems aren't working, cells replicate unregulated. This is also known as cancer. In this lab we are going to work our way through cell division and then take a closer look at **cancer,** its causes and treatments.

Let's start with some terminology:
Using the reference materials, find the definition of these terms. It may seem easier to look in the glossary, but try looking for the word in the index and finding the word in a chapter to give it context. This will help your understanding.

Textbook definitions:

- Mitosis

- Chromosomes

- Sister Chromatids

- Meiosis

- Homologous pairs

- Sets of chromosomes

- Karyotype

Both types of cell division start with something called Interphase. There are three parts to interphase:

Phase	Activity
G_1 (gap or growth)	
S (Synthesis)	
G_2 (gap or growth)	

Go to the reference area and find definitions for these terms to fill in the table above.

Making it make sense!

Now, using those definitions as a starting place, let's work on defining these words in our own terms to help us understand them. This will also help you understand the differences between the phases listed above. Your instructor may have additional handouts to help your understanding.

Let's start with **Chromosomes** and **Sister Chromatids**:

We know chromosomes carry information (genes) that help make all your parts and chemicals that keep you going. That means that you have unique information on all the different chromosomes. If you miss class, you might ask a fellow classmate what happened, right? You might ask them to make a copy of the notes to make sure you have all the information that was covered. This is what happens to your chromosomes in Interphase.

- Which of the three phases on your chart above makes a copy of chromosomes?

- What do we call it when a chromosomes consists of itself and a copy?

- What is the difference in the shape of a chromosome during **G_1** and **G_2** of interphase?
  - Draw it to help solidify your answer

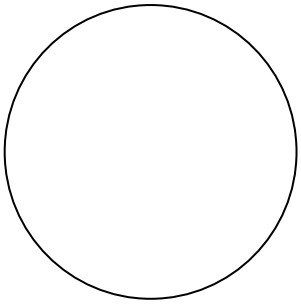
- Why do you think it's important to keep the sister chromatids together?
  (Hint, have you ever lost an earring? What do you do to prevent that?)

Now that we have copies of chromosomes, we need to separate them out and make sure each cell we create has the same information. This is the process of **Mitosis**. Let's do the same and start with reference material.

Activity 1 - Phases of Mitosis

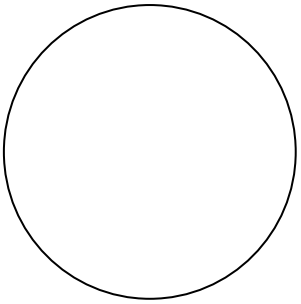
There are four phases of Mitosis: Prophase, Metaphase, Anaphase and Telophase. Then the cell will split into two or Cytokinesis. Let's use our reference material to define them first, then we'll find these phases on slides of actual cells. There are models, slides and posters out for you to compare the imagines and find things in common about the different phases. Using the circles below, label the defining characteristics and give a short definition of each phase underneath the circle.

PROPHASE



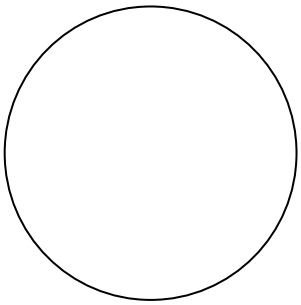
Characteristics:

METAPHASE



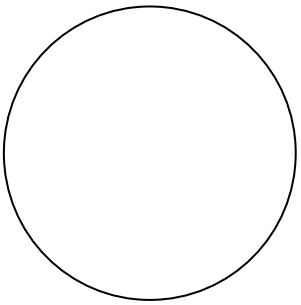
Characteristics:

ANAPHASE



Characteristics:

TELOPHASE



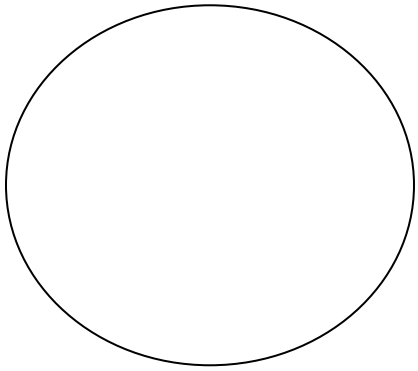
Characteristics:

Real Examples

With our background knowledge of phases, let's look at real life examples in both plants and animals. Remember, the slides you see will have multiple phases, so you'll be doing a lot of scanning before you find them. It might be a good idea to review your microscope procedures before you start.

Working with another group, have one group pick two animal slides and the other pick two plant slides. Scan the slide carefully to find all the phases of Mitosis on each slide. You may not find the phases in order, so think of the characteristics you defined previously to find them. On the board, you're instructor may draw where to start your search for onion root tip slides. But remember, take your time!

Try to find examples of all four phases in both animal and plant cells.



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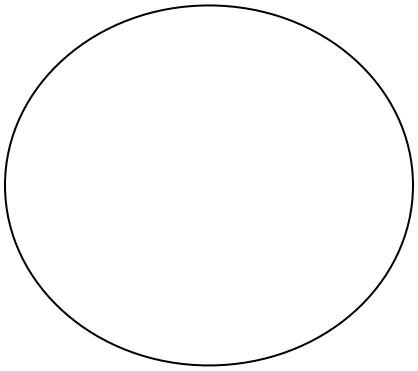

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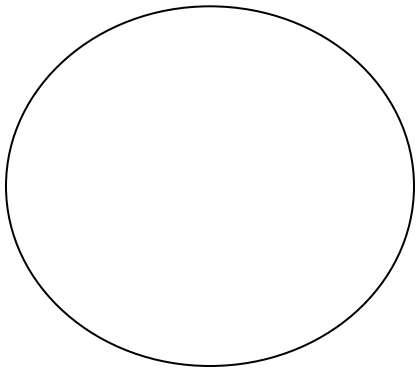

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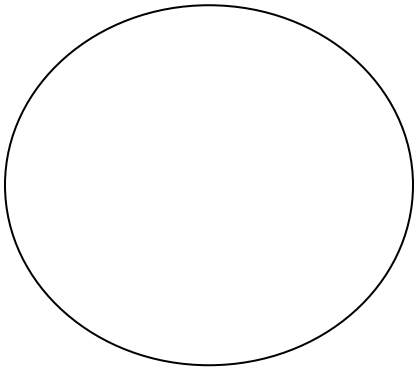

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Now, compare your slide drawings to the model and be sure you can identify the phases

What are some of the differences that you see between plant and animal cells? Keep in mind some of the differences between the structure of plant and animals.

With that knowledge, define some of these terms in your own words:

- Mitosis

- Chromosomes

- Sister Chromatids

There are some words we still have to define, so let's look at M**eiosis** to find those.

Let's start with Sets of Chromosomes and Homologous pairs:

We know chromosomes carry information (genes) that help make all your parts and chemicals that keep you going. That means that you have unique information on all the different chromosomes. If you have all the chromosomes that you need to make you, you have a set of chromosomes. Looking at your hand, notice that your fingers are all different. This means you have one set of fingers.

- How many different types of fingers do you have on one hand (**n**)?

- How many sets of fingers do you have on one hand (Xn, where X is the number of sets)?

Now, looking at both your hands:

- How many different types of fingers do you have looking at both hands?

- How many sets of fingers do you have with both hands? Use **n** in your answer

- Fingers that have a similar structure and function are homologous. Do you have any homologous fingers on each hand?

- Given your answer to the above question, what do you think **homologous chromosomes** are?

Now, applying that to humans:

- How many chromosomes do human cells have?
- Are they all different like your fingers on one hand?

- Are any of them homologous, as in they are the same size and have the same function?

If your answer was yes (which we hope it was), do you see that you have 23 pairs of chromosomes? Or 2 sets of 23 chromosomes? Or 2n where n=23

- Be sure you understand that before you move on!

How do you think those cells got two sets (2n)?
Can you think of where those sets might have come from? Where did you get each of your sets of chromosomes?

Activity 2 - Meiosis and the Production of Gametes

Let's consider what the resulting cells need to have before we look at the phases. These cells are called gametes, or eggs (oocytes) and sperm. Gametes have one set of chromosomes so that they can join together to create a zygote, which has two sets. So, the first thing we should do is cut the number of sets from two to one, ensuring we have the different types of chromosomes (all the different fingers on one hand). Remember that each of those chromosomes still have themselves and their copy, so we are going to have to go through the process twice!

Although both types of cell division start with Interphase, the steps that follow are very different.

Quick Check
What does a Chromosome look at the beginning of Interphase? (draw it)

What does it look like at the end of Interphase? (draw it and label the parts)

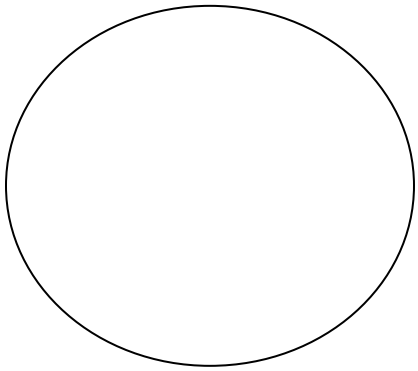
Phases of Meiosis

Meiosis I – Using the textbook or posters to start, draw what happens during the stages of Meiosis I. Name of the stage underneath your drawing. Notice that in Prophase I, **homologous chromosomes** are paired up. This action is called **synapsis** and structure is called a **tetrad**. Be sure you label these on your examples.

Now that we have separated the number of sets (pulled the hands apart). Let's separate the sister chromatids. This should look very familiar.

Meiosis II – Draw what happens and label the stage

Let's look at some slides to see Meiosis in real life. Remember, just like with Mitosis, you will find multiple stages on each slide so you have to scan the slide slowly!



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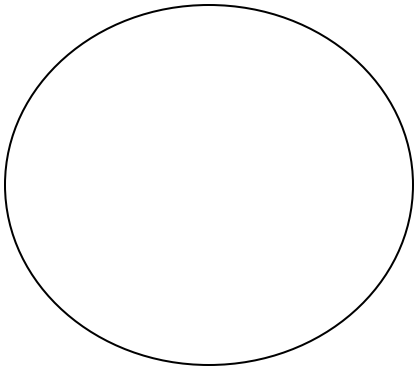

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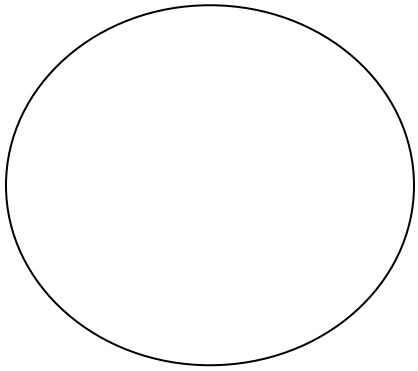

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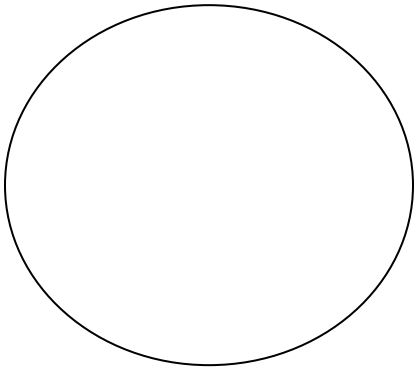

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<u>Make sure you can identify all the stages of both Mitosis and Meiosis on the models!</u>

Activity 3 - So, what is Cancer?

One way to explain Cancer is to say that these cells are going through Mitosis unregulated. They don't seem to know that they should stop dividing.

Types of Cancers

There are a lot of different types of cancer and most are classified by the types of cells that are affected. If cells are cancerous, they are often referred to as malignant. If the tumor has spread outside the area of origin, it has metastasized.

Stages of Cancer

Cancer stages are determined by the degree of growth seen in the cancerous cells ranging from 1 to 4. Stage 4 is often used if the cancer has metastasized.

What is Chemotherapy?

Chemotherapy drugs stop cell division in different stages or prevent DNA strands from sticking together.

- Why do you think this might make someone's hair fall out?

What are the causes of cancer? What are Carcinogens?

There are many causes of cancers, including:

- Genetic problems (not necessarily a carcinogen)
- Benzene and other chemicals
- Drinking excess alcohol
- Environmental toxins, such as certain poisonous mushrooms and a type of poison that can grow on peanut plants (aflatoxins)
- Excessive sunlight exposure
- Obesity
- Radiation
- Viruses

What can you do to protect your cells?

What if someone close to me has Cancer?

One of the best things you can do for someone with cancer is make sure they have someone that is going to the doctor with them. It's hard to take in all this information at once, so having an advocate will help. Also, make sure they know they can ask questions and they should!

Summary Questions name:

1. **What are the two types of cell division?**

2. **What is the difference in what they produce?**

3. **What are the differences in the phases of each?**

4. **What was a difference between the plant and animal cells going through mitosis?**

5. **Can you identify the phases of each on slides?**

6. **What are you looking for?**

7. **How does Cancer relate to this lab?**

What So Great About DNA?

This lab will help you understand what DNA is, how it was discovered and what it is used for in your cells. Today you have a combination of reading and answering questions, examining models and using manipulative kits. We'll also talk about why some sequences of DNA (genes) are expressed. Meaning the gene is ready to be interpreted by your nucleus, or the gene is turned on like a light.

DNA is something that we talk about lot in our culture. If you watch crime shows on TV, they may compare the DNA of a suspect to a crime scene. In the news, you may have heard people talk about how some people may have genes for different traits or genes for cancer. All of this can get confusing really quickly, so let's start with DNA itself.

Activity 1 - What is DNA?

Deoxyribonucleic Acid (DNA) consists of a series of **nucleotides** that are bonded together in a strand and also across to another strand (complementary strand). Because of the way the nucleotides bond, the whole structure looks like a double helix. There is a double helix in the lab room, so during the lab, go ahead and take a closer look so you can see it up close.

The first image of DNA was taken by a researcher named Rosalind Franklin, born July 25th, 1920. Her famous X-ray photograph (known as photo 51) gave support to the idea that DNA was helical in shape. She was the first to really see the molecule after finely tuning the X-ray camera to take a better picture. Maurice Wilkins showed the picture to James Watson in 1953 who, along with Francis Crick, won the Noble Prize for the discovery of DNA. Rosalind Franklin died from complications of ovarian cancer in 1958 at the age of 37. She died 4 years before Watson and Crick were awarded the Noble Prize for the discovery of DNA. If you are interested in controversy, this story is a good one. There are a number of books and a film (*The Race for the Double Helix*) that explains the situation quite well.

What makes up the helix? There are four nucleotides involved in the structure of DNA. They use a sugar and a phosphate to help build their structure and connect to each other in a row or strand. These can bond next to each other in any order. The order of the nucleotides in the strand is crucial to determining the order of amino acids in a protein. Therefore it is crucial to determining what kinds of proteins your cell makes.

Quick Check:

- Why is amino acid order so important to protein production?

- Why is protein shape important?

- What is the difference between hydrophilic versus hydrophobic molecules?

The nucleotides are very specific as to which bond together. The four nucleotides are:

Adenine (A)	**Thymine (T)**
Guanine (G)	**Cytosine (C)**

They are written out in this order because Adenine always bonds with Thymine and Cytosine always bonds with Guanine. Draw a line connecting those so you remember.

Let's practice making complementary strands.

DNA: T-A-C-T-T-A-C-A-C-G-T-C-A-A-C-G-T-G-C-C-T-T-A-G-C-C-A-T-T
DNA: A-T-G

Go ahead and write out the complementary strand to the strand above continuing where we left off.

Activity 2 - What is a gene or what do the letters mean?

The more formal definition of a **gene** is a unit of heredity in all living organisms or a particle of inheritance. **Genetics** is the study of inheritance. Remember that your chromosomes are made up DNA and your genes are made up of DNA. A genome is a map of all the different genes on a strand of DNA. In 2003, the Human Genome Project (HGP) was completed. This was a 13-year project coordinated by the U.S. Department of Energy and the National Institutes of Health along contributions from the United Kingdom, Japan, France, Germany, China, and others.

The HGP set out to *identify* all ~20,000-25,000 genes in humans, *determine* the sequences of the 3 billion chemical base pairs that make up human DNA, *store* this information in databases, *improve* tools for data analysis, *transfer* related technologies to the private sector, and *address* the ethical, legal, and social issues (ELSI) that may arise from the project.

This means we know where our genes start and stop, but it doesn't mean we know what they are all for or how many variations of those genes we have. Variations of a gene are sometimes referred to as **alleles**, which we'll get to later. One way to think of your genes is that a gene is the interpretation of our nucleotides (letters). Each group of three letters (called a **codon**) represents an amino acid (**AA**).

Quick Check:

- Do you remember what type of molecule amino acids make?

- Do you remember why the order of the amino acids is so important to the structure of those molecules?

You have genes for everything that is you. A gene to make your eyes, your hair, your liver, all of it! Your nucleus holds the information to make you and all your cells that have information. Most genes are like recipes for proteins. Let's look at how our cells read the recipe and make the protein.

Transcription and Translation

If you think of the nucleus of your cell as a big reference library, the books are only available for you to look at and they can't leave the library. So you can read and make a copy of the recipe, but you can't take the whole strand of DNA out of the cell. You can write the information now on something you can take out of the nucleus or *Transcribe* the information. Your cells transcribe the order of the nucleotides from your DNA onto something smaller that can leave the nucleus, bringing a message out. We refer to this molecule as **mRNA (messenger RNA)**.

Quick Check:

- Do you remember the difference between DNA and RNA from class? (explain)

One difference between DNA and RNA is the nucleotides that are used. RNA uses a nucleotide called Uracil instead of Thymine, so all your A's will bond with U's in this process.

Adenine (A) ---------- Uracil (U)
Guanine (G) ---------- Cytosine (C)

Let's practice making a strand of mRNA. Finish what we started:

DNA: T-A-C-T-T-A-C-A-C-G-T-C-A-A-C-G-T-G-C-C-T-T-A-G-C-C-A-T-T
mRNA: A-U-G

Go ahead and write out the complementary strand of mRNA above.

This first step is called **Transcription**, let's work through it

At the materials table, pick up the following materials:

2 strands of DNA	1 green strand of mRNA	5 blue tRNA molecules
1 yellow amino acid	A dry erase pen	

How to Fill Out This Chart:

- Write the number of the strand you are using in the first column, then write out the nucleotides from the strand of DNA you picked.
- Now, line up the first three nucleotides of the DNA strand with the first three spaces for mRNA> Write the matching nucleotide on the mRNA strand . Remember to use Uracil). Leave the short ones blank, that's just to show you codons.
- Once you have your mRNA completed, fill out the mRNA column.

You have now transcribed the strand of DNA to mRNA, which can now leave the nucleus. Remember a codon is a sequence of three nucleotides. On your chart, draw a box around all the codons (or three in a row). These are important for looking at how that information is *translated* into amino acids or **Translation.** Think of it as the language of nucleotides is being translated into the language of amino acids. This occurs once the mRNA leaves the nucleus and heads to the organelle that will help pull the amino acids together in the right order. Remember to transcribe mRNA codons, not tRNA!

Quick Check

- Which organelle is considered the 'work table' for protein synthesis?

These **amino acids** are brought to the Ribosome with the help of another type of RNA that transfers the amino acid to the mRNA strand also called tRNA. These molecules of tRNA also have 3 nucleotides exposed that are the opposite of the codon (or anti-codon) so they can bond together. Each tRNA molecule carries the appropriate amino acid.

Using the blue tRNA molecules, write out the anti-codon it would have to have to match up with your strand. On your chart, fill in the anti-codons in under the column tRNA.

Strand #:	mRNA codon	tRNA anti-codon	AA (short)	AA (full name)

Now we need to know which amino acid the tRNA is carrying. We can do this on paper using the **Genetic Dictionary** below. Starting with the 1st base in the codon, pick the row. Then use the 2nd to pick the column, the use the 3rd to pick the line. There you will find an abbreviation of the name of the **amino acid (AA).** Write that abbreviation in the **AA (short)** box next to the appropriate anti-codon. Use the list below to find the full name of the amino acid and list that in the **AA (full name)** box.

Notice that there is only one START codon and a few STOP codons. Go ahead and finish the strand even if it doesn't start with Met.

- Why do you think there is only one START?

- Why do you think there might be more than one STOP?

GENETIC DICTIONARY

2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe	Ser	Tyr	Cys	**U**
	Phe	Ser	Tyr	Cys	**C**
	Leu	Ser	STOP	STOP	**A**
	Leu	Ser	STOP	Trp	**G**
C	Leu	Pro	His	Arg	**U**
	Leu	Pro	His	Arg	**C**
	Leu	Pro	Gln	Arg	**A**
	Leu	Pro	Gln	Arg	**G**
A	Ile	Thr	Asn	Ser	**U**
	Ile	Thr	Asn	Ser	**C**
	Ile	Thr	Lys	Arg	**A**
	Met (START)	Thr	Lys	Arg	**G**
G	Val	Ala	Asp	Gly	**U**
	Val	Ala	Asp	Gly	**C**
	Val	Ala	Glu	Gly	**A**
	Val	Ala	Glu	Gly	**G**

Three Letter Abbreviations for the 20 Amino Acids

Ala: Alanine
Arg: Arginine
Asn: Asparagine
Asp: Aspartic acid
Cys: Cysteine
Glu: Glutamic acid
Gln: Glutamine
Gly: Glycine
His: Histidine
Ile: Isoleucine
Lys: Lysine
Leu: Leucine
Met: Methionine
Phe: Phenylalanine
Pro: Proline
Ser: Serine
Thr: Threonine
Trp: Tryptophane
Tyr: Tyrosisne
Val: Valine

Do a second strand the same way for practice:

Strand #:	mRNA codon	tRNA anti-codon	AA (short)	AA (full name)

So let's review what we just did with a few questions:

- What are the two main steps to protein synthesis and where to they take place?

- What are the different types of RNA used and what are their roles?

- How important is nucleotide order to the process?

- Looking at the Dictionary, why do you think there are more than one option for certain Amino Acids? (think of them like safeguards)

How Different Are Our Genes?

All of us have different strands of DNA. Granted the % that is different is quite small, but it's enough so we can use DNA to tell if you were in the room today. Since all of your cells carry all of your DNA, just touching the table left cells that can be tracked to you!

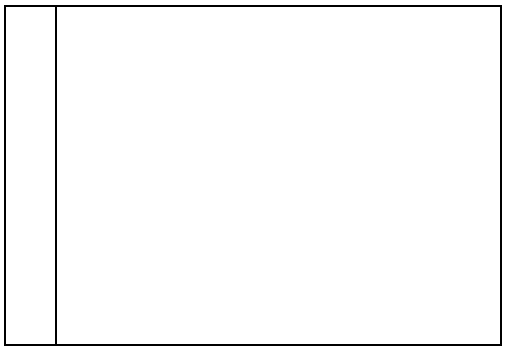
One way that the discovery of DNA has changed our lives is in the criminal justice system. Now that we have a better understand of genes and better techniques for sorting them out, we can compare DNA found at crime scenes and compare those to different people that are suspected of the crime.

To determine if our suspects are guilty, we can separate fragments of DNA out to compare to our crime scene DNA using a process called *Gel Electrophoresis.* In this process, we'll put DNA samples in the wells of an agarose gel. Then, we will send an electric charge through the gel to separate the fragments based on their size. Shorter fragments move faster and farther down the gel then the longer ones. This difference in size of fragments is unique to individuals, so we can compare the size of the fragments to the DNA found at the crime scene. If the fragments are the same size, they are the same person.

We are going to run an example at the front of the room to see if we can match the crime scene DNA to a suspect. There may be more specific directions at the front of the room, when you are ready, go over the directions with your instructor and record the results on the gel below.

Crime Scene Analysis

Mark the samples tested in the first column (crime scene DNA, suspect 1, suspect 2, etc. Then show where the fragments moved to.



- Do you see a match?
- What did you use to determine if the suspect is guilty?

DNA is not only used to convict criminals, it's also being used to clear people who were falsely convicted. **See how DNA testing is being used to right some wrongs at this website: www.innocenceproject.org**

The Innocence Project is a national litigation and public policy organization dedicated to exonerating wrongfully convicted individuals through DNA testing and reforming the criminal justice system to prevent future injustice.

Genetics as a Field of Study

Notice that the process of **Transcription and Translation** takes genetic information and turns it into something tangible like a protein. In what's considered classical **Mendelian Genetics,** genetic information is known as you **Genotype** and how that information manifests (or what you look like) is your **Phenotype**. So, Transcription and Translation is the process that turns a genotype into a phenotype. Remember that earlier we mentioned that there are variant forms of a **gene**, or **alleles**. This allows for things like a gene for eye color with are a lot of different colors of eyes.

Let's look Eye Color to see what we mean: You have genes that determine your eye color with the use of a protein called **melanin**. Two things determine your eye color, where the color is on your iris and how much melanin your eyes have.

If you have light colored eyes, your eye color is not in the front of your iris. This makes you more susceptible to going blind due to UV and makes your eye color lighter. The melanin in the back of your iris looks blue or gray. If you have a little bit of color in the front of your iris, your eyes will look greenish. The more color you have in the front, the darker your eye color. There are lots of variations of the gene for eye color, or lots of different **alleles**.

Let's look more closely at **Mendelian Genetics** to understand how genetic information is passed down:

Remember from the cell division lab that you have 2 sets of chromosomes (2n). That means that you have two alleles for every gene. In Mendelian Genetics, these alleles are shown as letters. Each gene is assigned a different letter (which is up to whoever is doing to study) and then the letter is capitalized or lower case depending on how likely the that version of the gene is to be expressed! If both alleles are the same, we say they are **homozygous** (for instance AA or aa) and there is only one choice.

Dominant Traits
If a gene is expressed when there are two different alleles, that gene is considered **dominant** and the combination of those alleles is called **heterozygous**. These alleles are often notated by a capital letter (for example: A). Dominant genes are not necessarily more common, they are just the version of the trait that is expressed in a heterozygous condition (or when the alleles are different – Aa).

Recessive Traits
If a gene is likely to be hidden, or not expressed when there are two different alleles (heterozygous), then that gene is considered **recessive**. These alleles are notated by a lower case letter like 'a'. Recessive traits are not less common. In fact, having 5 fingers is a recessive trait.

- How many fingers do you have?

When you assign letters to represent alleles, it is your choice. Just keep in mind that letters like C and S are hard to use because they look alike as capital and lower case letters.

Let's do an example to see what this all means:

Eye Color is a trait that involves a number of genes. In general, we can break down the trait into two phenotypes: dark color and light color eyes. Dark coloration is considered dominant, or is expressed in a heterozygous condition (when the alleles are different).

Q: If you have one light eyed parent and one parent that is homozygous for dark eye color, what are the potential eye colors of their offspring (young)? To start, what do the parent's alleles look like? Of what is their Genotype? (Remember, you pick which letter you want to use)

Light eye colored parent:

Dark eye colored parent:

One of the things Mendel designed was a way to provide information about how the genes pass on from parent to offspring. He designed something called a Punnett Square. This square places the parent's alleles outside the box, then uses those alleles to fill in the squares.

Let's start with a reminder of what we know about the parents:

Parent	Phenotype (appearance)	Genotype (alleles)
1		
2		

Put the genotypes of Parent 1 above the columns, one letter over each column. Then, put the alleles of Parent 2 on the left side of the rows, one letter for each row.

Parents: **Offspring:**

Genotypes: **BB, bb**

Phenotypes: **Dark, Light**

Write the allele from the top of the column in the boxes below each. Then, write the allele from the side of the rows in the boxes next to them. We made one of each pair bold so you can see how it was distributed in the square.
Your Punnett Square should look something like this:

	B	B
b	**Bb**	B**b**
b	**B**b	Bb

If it does, move on to the next part.
If not, try to figure out why.

Each box represents a potential offspring. Notice that genotypically speaking, they are all the same. They are all heterozygous (genotype) which means their phenotype is dark coloration. So, there is 100% change of producing a dark eyed, heterozygous offspring. What if that offspring mated with a light eyed individual? Can you make a Punnett Square for that?

Write the Genotypes and Phenotypes of the parents on the left of square. Complete the square, then write the potential offspring's genotypes and phenotypes on the right of the square.

Parents:

Genotypes:

Phenotypes:

Offspring:

- What are the genotypes of the resulting offspring?

- What are the phenotypes of the resulting offspring?

Not all Genes are the Same!

That's a pretty straightforward example with one trait being dominant over the other. That isn't true of a lot of other genes. Many genes are more of a blend between the two traits or even express both versions of the trait. These cases are referred as **Incomplete Dominance** and **Co-Dominance** respectively. Let's look at an example where the heterozygous (different alleles) condition is a blend.

Let's look at hair texture. Some people have curly hair, some have straight hair and some express a trait that is in-between (**Incomplete Dominance**), or wavy hair. Therefore curly and straight are both homozygous and wavy is the expression of the heterozygous condition. Instead of using capital and lower case letters, we'll add a prime (`) to the letter. This is because one is not dominant over the other, they will both contribute to the phenotype. We can use H to indicate curly hair and H` to indicate straight hair.

Given this information, complete the square:

Parent	Phenotype (appearance)	Genotype (alleles)
1	**Curly hair**	**HH**
2	**Straight hair**	**H`H`**

Do you remember where the alleles of each parent go?

Parents: **Offspring:**

Genotypes:

Phenotypes:

- What are the potential phenotypes and genotypes of the offspring?

Do you notice that in both cases, two homozygous parents produced offspring with a heterozygous genotype? This will always be true for genotypes. But remember, the phenotypes are different for the first and second example, the second example was a blend between the two parents phenotypically.

Make sure everyone in your group understands. Complete another Punnett Square if that will help. Remember, you can assign the alleles, so you can do as many as you need to before you more on. Double check your answers with another group.

A good example of **Co-Dominance** is blood types. You may go over this in lecture or your instructor may give you a take home assignment that includes this example. For now, let's just go over the last type of alleles.

What about our 23rd Chromosome?

The other difference in alleles stems from the fact that our 23 chromosome pair is unique. This pair is referred to as our sex determining chromosome. Your sex is a genetic condition where you have two Xs (XX for female) or an X and a Y (XY for male). We don't use the terms woman and man in here because those are sociological archetypes and although some of those traits related to your chromosomes, they aren't defined by them.

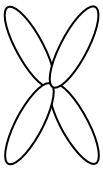
Again, the X from the male is in bold so you can see that female offspring have two XXs, one from the father and one from the mother. Males get their X from their mother.

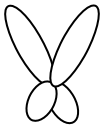
	X	X
X	**X**X	**X**X
Y	XY	XY

- What chromosome does a father give a male offspring?

The X chromosome has a lot of traits for things besides the traits we consider female. It carries traits for things like the ability of your blood to clot correctly and the ability to see differences in the colors red and green. If you blood doesn't clot correctly, it's called Hemophilia. If you can't see the difference between red and green, you are colorblind.

Notice that those are on the X chromosome only. That means they are missing from the Y. In fact, the Y is called Y because it is physically missing a section at the end.

X chromosome - 

Y chromosome - 

See how the Y is missing part of the chromosome?

This means the Y chromosome is missing genes that the X chromosome has. If you are XY, you only have one copy of the gene, or one allele.

- Given what we just said above, can a male pass a X-Linked Trait to his son?

- Can a female pass a X-Linked Trait to her son?

- What do you think that means about the frequency of X-Linked Traits in males?

The part that is missing is where the traits for things like colorblindness and hemophilia exist. This means that if you have XY chromosomes, you are missing alleles on one of chromosomes. So whatever allele is on your X is expressed regardless of if being dominant or recessive. These traits are considered **X-Linked Traits** and have a special way to note the alleles.

X-Linked alleles use X and Y as their base and then the allele that notates the trait is in the top, right corner. For instance:

Phenotype (appearance)	Genotype (alleles)
Male with Hemophilia	$X^h Y$
Female without Hemophilia	$X^H X^h$

Notice that the female has two X's so 2 alleles. She is not a hemophiliac, but is carrying the trait. That means she can pass the trait to her offspring.

Why don't you cross those two parents here and find the outcome:

Parents: **Offspring:**

Genotypes:

Phenotypes:

- Is there a chance of producing a male with hemophilia? Explain your answer

- Will any of the female offspring carry the trait?

- Will any of the male offspring carry the trait?

- Do you think you can complete a Punnett Square with a Sex-Linked Trait?

Why do some genes express and some don't?

The study of heritable changes in gene expression over time is known as **Epigenetics**. It seems the old debate of Nature vs. Nurture is not that simple. It's too simple to say that your phenotypes are determined by either the genes you have or the environment in which you were raised, in fact the environment in which you are raised seems to affect your gene expression!

In our next lab, we are going to look at gene expression more closely. We'll be looking more closely at Epigenetics as a process of changing gene expressions in a population too!

Summary Questions **name:**

1. **What does DNA stand for? How does it differ from RNA?**

2. **What are some of the safeguards of the process that help your cells make sure you are making the right protein? (think about the dictionary)**

3. **Explain the following terms in your own words**
    a. **Genotype**

    b. **Phenotype**

    c. **Allele**

    d. **Dominant**

    e. **Recessive**

    f. **Heterozygous**

    g. **Homozygous**

4. **How do your cells turn Genotypes into Phenotypes (be sure your answer includes explanations of Transcription and Translation)**

5. **Who was Gregor Mendel? What did he contribute to the understanding of genes?**

6. **What is a Sex-Linked Trait? Why are they different?**

How Do Things Change?

In the last lab, we looked at how genetic information is passed on from one cell to another or pass from parent to offspring. But why would some traits be more common than others? And how do traits change? Why would traits become more or less common in a population? A number of people have theories about why the frequency of certain traits would change. This is one way to define Evolution. When we talk about Evolution, what we are really talking about is change of the frequency of certain alleles in a population.

Genes in a Population

Let's review some concepts before we start:

- What is a Genotype?

- How does it relate to a Phenotype?

- How does a Genotype become a Phenotype? (Do you remember Transcription/Translation?)

- If a genotype is the gene and a phenotype is expression of that gene, can you think of things besides external features that are phenotypes?

- What about enzymes you produce? Are those phenotypes?

- What about Insulin? Do you remember the types of Diabetes?

    - So, is that a phenotype?

Quick Check:

- What type of molecule is an enzyme?

- What is the name of the process that makes proteins:

It seems like a lot of things are phenotypes and it seems like Transcription and Translation play a big role in making a genotype a phenotype. But what are the reasons a phenotype would be more common in a population then another? How can you tell if some of it is internal?

Variation of Allelic Distribution

Mendelian Genetics used **alleles** as a way to notated variations of certain traits. We can determine how many individuals have those alleles through genetic screening, or by following generations of individuals (making a pedigree). Then, we can track changes in **allelic frequency** or how many individuals carry that allele and how many express that trait.

Remember, dominant traits are not always most common, there are other reasons why an allele expressed (or turned on) more often than another.

One of Gregor Mendel's studies determined that yellow was the dominant version of the trait for pea pod color and green was the recessive trait.

- How many yellow peas do you see?

This is an example of a situation where the recessive trait is more common.

- Why do you think it might be more advantageous for a pea pod to be green?

- If you are trying not to get eaten by predators, would it be better to be yellow or green?

Here, it is better for the success of the pea pod to be green and blend in to the plant. It's more likely that the pea pod won't be eaten and can grow into a new plant. So the recessive trait is more common because it helps the plant be reproductively successful. Reproductive success is also called **fitness**. The fitness of an individual is determined by that individuals ability to reproduce offspring and how likely those offspring are to reproduce more offspring. Simply put it's the likelihood that you can pass on your genes and keep them in the population.

When we say "survival of the fittest" what we mean is "survival of the most fit" or the individual with traits that make them better suited for their environment is more likely to produce successful offspring. Just like the plant with green pea pods has a trait that makes them better suited (green pea pods), so that plant is more likely to produce offspring that will be successful too.

This is the concept of **Natural Selection** and part of Charles Darwin's Theory of Evolution. The other part of the theory has to do with us all having a common ancestor.

Quick Check:

- What is the definition of a theory?

Let's look at another example:

- Do you remember if having 5 fingers is a dominant or recessive trait?

- Can you think of why that trait might be more common?

We can say that the 5 finger trait was selected for because it gave us some type of advantage over the individuals who have 6 fingers. It might not be as obvious as green pea pods, but it is another example of a recessive trait that is more common. All mammals have 5 fingers (even your dog and cat), so it was trait that was selected for a long time ago.

Natural Selection in Practice

Case Study:

You are a member of a very diverse species of bird that inhabits a wide range. This species has a variety of beak phenotypes due to a wide variety of food sources in the past. Unfortunately, urban development has reduced the habitat area and the variety of food has been limited. Now, there is only one food type and that food is limited. As the species exists now, the varieties of beak phenotypes include the following shapes: skewer, clothespin, tweezer, chopsticks, and spoon. Some of these beak shapes maybe not be the best for this type of food. That means they will likely die or be too weak to produce offspring and those genes will be lost.

Experiment:

1. The class will be divided into 5 groups with each group representing a different beak phenotype. Each member will need a beak (same for each group member) and a mouth (plastic tube)

2. Each group will try to get food using your "beak" during 5 generations of foraging. You will be competing with the other groups to capture the food.

3. The food will be tossed by the instructor, cover your eyes or turn around while the food is distributed.

4. When the instructor gives the signal, you will try to capture as much food as you can before time is called.

5. <u>Rules to Foraging</u>
   a. Food must be lifted only with the beak and placed in the mouth held in the opposite hand; you can't shove food into the mouth along the ground.
   b. You can steal food from another bird if the food is <u>not</u> in their mouth.

6. After time is called:
   a. Count the number of pieces your group collected
   b. Report that number to the data keeper who will add up the total for the class

c. The amount of food collected by your group will determine whether your beak phenotype produces offspring or if members have died. To calculate the number of birds in your group for the next round, we will use this formula:

total number of birds in your group in the next generation:

$$\frac{\text{total pieces collected by group}}{\text{total pieces collected by class}} \times \text{total \# of students collecting}$$

d. If your group gathered very little food and one or more members have "died", your group will be reduced in the next generation. Although you may have died, you may be reborn as another beak type if another group has offspring. You can fake your death or rebirth will some dramatic license.

7. Repeat the foraging rounds four more times, stopping to recalculate the number of birds in each group.

Before we start, consider the types of beak phenotypes and make a hypothesis as to how your group will do during the change in habitat.

Hypothesis:

Results:

Table 1 - Survival Rate of Groups

	Generation 1		Generation 2		Generation 3		Generation 4		Generation 5	
Group	# of birds	Pieces of food	# of birds	Pieces of food	# of birds	Pieces of food	# of birds	Pieces of food	# of birds	Pieces of food
1										
2										
3										
4										
5										
Total										

Notes:

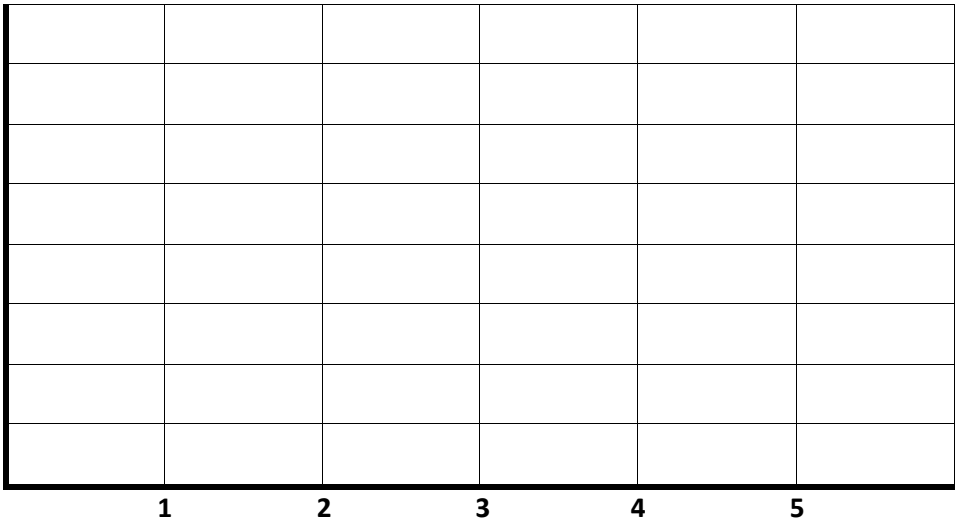
Once we are back in the classroom, make sure your Table 1 is completed, and then use those data to complete Table 2. Calculate the percentages of each bird phenotype in the total population (# of birds in each group/#of total birds) over the five generations.

Table 2 - Percentage of Total Population Represented by Groups

	Generation 1		Generation 2		Generation 3		Generation 4		Generation 5	
Group	# of birds	% of population	# of birds	% of population	# of birds	% of population	# of birds	% of population	# of birds	% of population
1										
2										
3										
4										
5										
Total										

Graph of your results:

Remember, a graph suggests that the values on the Y-axis are dependent upon the values on the X-axis. Label the Y-axis yourself.



Conclusions:

Gene Flow and Genetic Drift

There are other reasons that allelic frequency might change. Things like individuals moving in or out of a population (immigration and emigration) involve genes flowing between populations, so we call it **Gene Flow**. When a small group leaves a big group, or a big group's population is drastically decreased due to natural disasters or over-hunting by humans, the individuals left are more susceptible to changes in allelic frequency. **Genetic Drift** is a term used to describe changes in a population's allelic frequency due to changes that seem random. Smaller populations are more affected by genetic drift then large ones.

So, if individuals leave one group, their genes flow out with them. Then, that small group is more susceptible to random changes (or genetic drift). Make sense?

- Can you think of examples where these options might happen?

Other ways DNA changes – Mutation

Many scientists study the frequency of mutation in populations. Some believe that some of the changes we have seen over time are because of mutations and not just natural selection. A great man explained mutation as the key to our evolution. He went on to say that It has enabled us to evolve from a single-celled organism into the dominant species on the planet. And that this process is slow, and normally taking thousands and thousands of years, but every few hundred millennia, evolution leaps forward. Charles Xavier may only run a school of the gifted in comic books and in movies, but his point is well taken and mutations are real. They might not give us super-healing abilities of the ability to read minds, but they do happen. Mutation may have a bigger impact on our genes then we think.

It's likely that mutation affects Prokaryotes more than Eukaryotes.

- Can you think of why that might be?

- Do Prokaryotes have sets of chromosomes like we do?
    - If you're not sure, use the reference material to look it up!

Mutations can happen in **Transcription**, which might only affect the protein you are making, or during the S phase of **Interphase** which will affect all the cells you make. If it's Interphase for Meiosis, it will affect those gametes.

Quick check:

- Do you remember what happens in the S phase of Interphase? (explain)

Mutations can occur in a few different ways:

1) A **point mutation** is where one nucleotide is copied incorrectly.

2) A **frame-shift** occurs when one or more nucleotides are removed or added from the sequence and therefore the whole things changes!

Let's see some examples of each to see what would happen if it changes. Refer to the stand you used in the last lab.

- What would happen if we take out a nucleotide (frameshift)?

Strand 1: C-G-T-A-T-C-T-C-A-T-A-G-C-T
Strand 2 : A-A-A-G-A-T-A-T-C-A-C-C-C-A
Strand 3 : T-A-G-C-C-C-T-G-G-T-C-T-T-T
Strand 4 : A-C-C-G-G-C-T-C-G-A-C-T-T-C

Strand #:	mRNA codon	tRNA anti-codon	AA (short)	AA (full name)

- Did you end up with the same chain of Amino Acids?

Let's do another one:

- What would happen if we change one nucleotide (point mutation)?

Strand 1: C-G-T-T-A-T-C-T-C-A-T-A-G-C-T
Strand 2 : A-A-A-T-G-A-T-A-T-C-A-C-C-C-A
Strand 3 : T-A-G-T-G-C-C-T-G-G-T-C-T-T-T
Strand 4 : A-C-C-T-C-G-C-T-C-G-A-C-T-T-C

Choose the strand you transcribed and translated in the last lab and fill out the chart with the mutation

Strand #:	mRNA codon	tRNA anti-codon	AA (short)	AA (full name)

- Did you end up with the same chain of Amino Acids?

- If you did, why do you think it still worked? (do you remember some of the safeguards?)

Restriction Enzymes and Genetic Modification

We can also change strands of DNA by adding in sections. This is how viruses invade our cells and make us sick.

Biotechnical/Pharmaceutical companies have techniques to use **restriction enzymes** to insert sections of DNA into existing strands. When we add or take out genes from food, we call then G**enetically Modification Organisms (GMOs)**. There is a lot of debate about the use of GMOs and their safety.

Here are some websites that might be helpful in you deciding on your opinions about GMOs. Remember, one of our goals for this class is to make sure we are using the Scientific Method when we make decisions, so learning about the topic before we decide if we are on the pro or con side is important. Informed decisions are best! You may find that some of this information is contradictory, so make sure you look at a few sources.

World Health Organization
http://www.who.int/foodsafety/publications/biotech/20questions/en/

US Department of Energy
http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml

Wikipedia
http://en.wikipedia.org/wiki/Genetically_modified_food

Your instructor may include an activity about GMOs or how restriction enzymes work.

Epigenetics and Changes in Gene Expression

We just looked at why one allele might be more common in a population than another. But, there are also genes that we have that don't express at all. When we mapped the Human Genome, there were sections that appeared to do nothing. At first, those sections were labeled "junk DNA" and thought. There are different from section that we call non-coding sequences (which also don't seem to have a function), because some of these sequences are actually what we'd call **vestigial** or retain the function of the past. Some of our genes lie dormant for a long time and never get turned on. Some genes seem to get turned on due to environmental factors. Study how gene expression changes over time is a field called **Epigenetics**.

As we mentioned before, the old idea that it's a choice between gene expression and how you were raised is no longer as valid. It seems that how were raised, along with the lives of your ancestors, might affect your gene expression too!

You're instructor may have you watch a film, or complete an exercise about Epigenetics.
Here is some space to take some notes:

Summary Questions **name:**

1. **What is Natural Selection?**

2. **What are some examples in nature**

3. **What is a mutation?**

4. **What is the difference between a point mutation and a frameshift?**

5. **What is a GMO?**

6. **What is Epigenetics?**

The Diversity of Small Things

A microbe is a term we use to talk about small living things as a group. This lab will walk you through the smaller parts of our tree of life. Let's start with cells that don't have a nucleus.

Prokaryotes

Cell Type	Size (big/small)	Age (older/newer)	Nucleus (yes/no)	Other
Prokaryotic				
Eukaryotic				

Let's take a closer look at Prokaryotes

- Where do you think you would find prokaryotes?

Type of Cell	Where do they live?	How do they reproduce?	Who is older?
Bacteria			
Archaea			

Let's take a closer look at *Archaea*

- Do you think we can look at Archaea in the lab? Why or why not?

- Are there any Archaea around here?

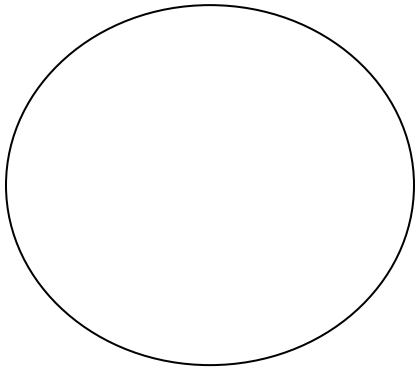
If we can't create the right lab environment to look at Archaea, we will focus on Bacteria instead.

Go to the poster of *Bacteria*

- Take a look at the different types on poster. Do you notice that there are three basic shapes? Be sure you separate the groups and look closely at the shapes

Shape of Bacteria	Fancy Science Name	Is it familiar?

Let's look at some slides: Find an example of each shape of bacteria. Be sure you really see the bacteria and not scratches on the slides.



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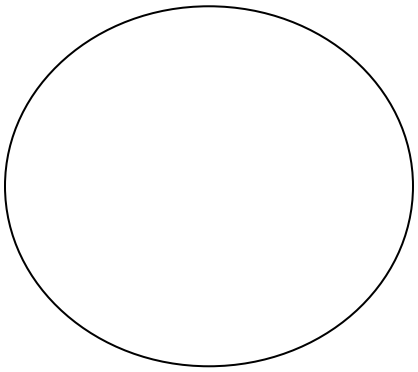

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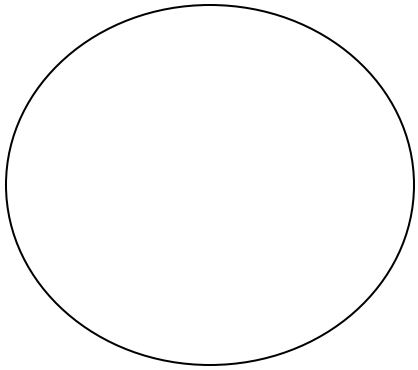

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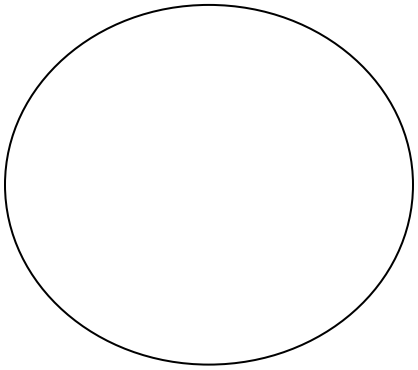

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Experiment with Microbes:

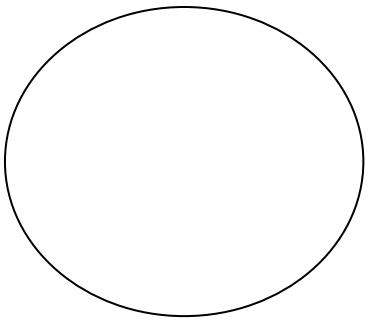
To take a closer look at the types of microbes we find in different places, we can grow colonies after sampling surfaces. We are going to take samples using agar gel plates to enhance the growth of whatever we sample.

Your instructor may have specific directions for this experiment, so make sure you pay attention. However, the basic steps of sampling are pretty standard. Here are the basic directions for using agar plates:

Steps for sampling:

- Take a gel plate from the front
- Keep the plate gel side up with the lid on until you are ready to sample.
- Take swabs that are sterile in a beaker at the materials table
- Get an Erlenmeyer flask of water to help get the sample
- Dip the swab in the flask, then rub the swab on surface you are sampling
- Open the plate, rub the swab on the agar (gel side) in zig-zag pattern (being sure not to puncture the gel)
- Quickly close the lid and keep plate gel side up
- Label the plate with your group name with masking tape, sealing the sides.

Draw on this circle how to swab the plate for practice



Given the directions from your instructor,

- What types of variables are you considering?

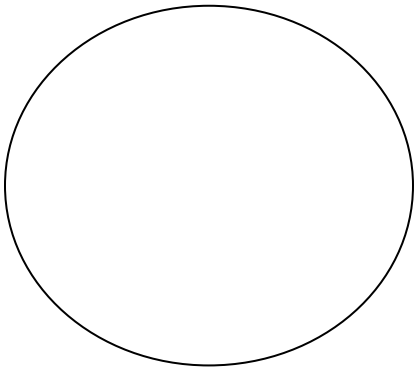
- What is your hypothesis? (Remember! This should be a statement)

Now that a week has passed, let's look at our plates!

- What types of microbes grew on your plate?

- What does that mean about your hypothesis?

What did your plate look like? Sketch your results below



✓ Do your results influence how or how often you will wash your hands?

Single Celled Eukaryotes

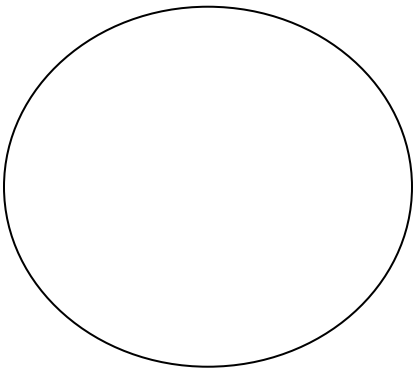
There are also single celled organisms that have nuclei. In general, they are classified by how they eat.

How do they eat?	Where do they live?

Let's start with eukaryotes that are photosynthetic –

Some photosynthetic organisms are eukaryotic and some are prokaryotic. There is a poster up that has examples of both. Go ahead and look at the poster, then look at slide examples:

Prokaryote:



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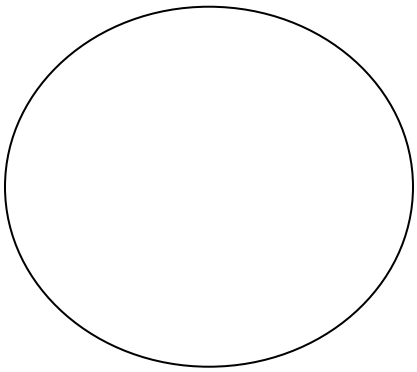
Eukaryote:



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- What do you think the Eukaryote has that the Prokaryote doesn't?

- What is another term for single-celled photosynthetic organisms?

Now, let's look at the animal-like single-celled organisms –

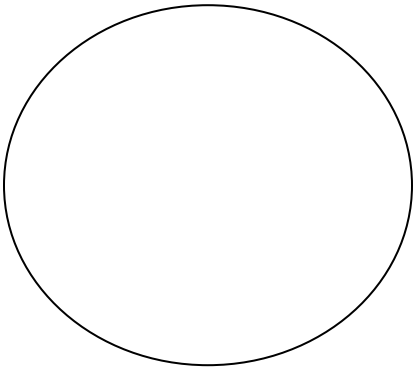
- If their feeding type is like ours, are they photosynthetic?

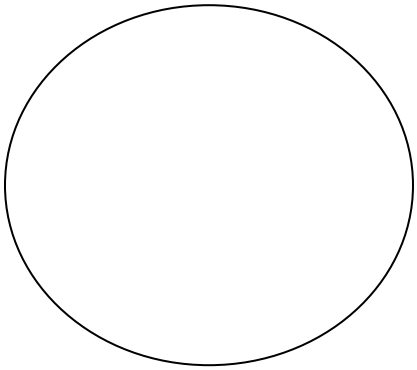
- If they are not, how do they get food?

- Do they have mouths?

- What is the term we used earlier to explain how we bring big things into cells?

There is a poster with examples of single-celled eukaryotes that eat like we do. Draw some from slides:





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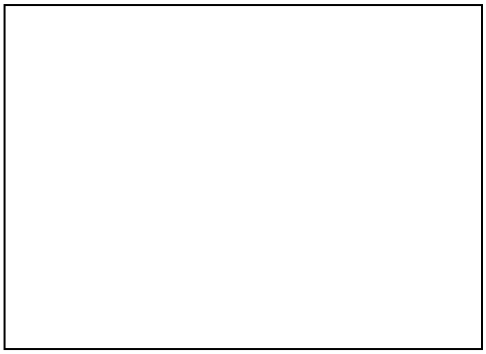
There is also a model of a Paramecium. Can you find them on the slides?

The last group of single-celled eukaryotes has a similar feeding style to Fungus.

- How do Fungi eat? (use the reference materials if you need to look it up)

Let's look at some examples of Fungus:

There are three groups of fungi. The groups are determined by what's called their fruiting body. Looking at the posters, can you see the different types? There are also jars out to look at. Label your drawing with the Fungus group.



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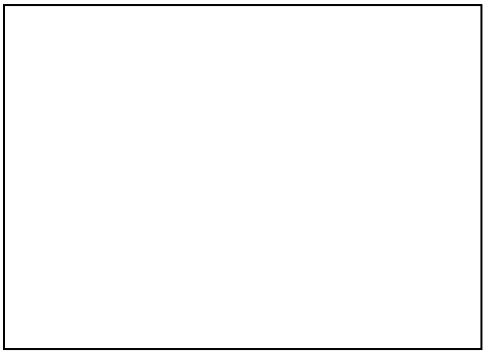

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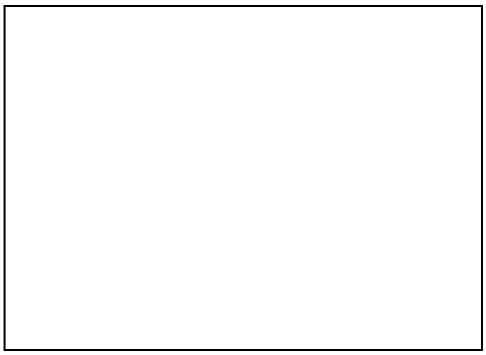
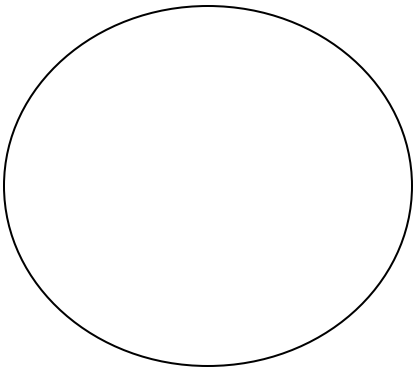


Name _____

Your instructor may ask you to make slides of different fungus.



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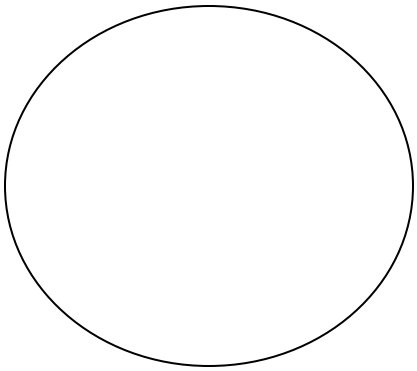

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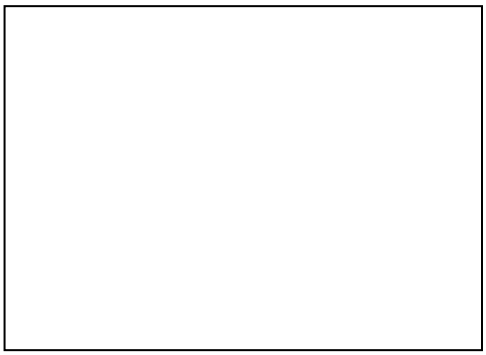
Two Organisms in One: Lichen

As you could tell from before, our photosynthetic single celled eukaryotes (or algae) live mainly in water. We also know that fungi absorb nutrients from the area around them (absorptive heterotrophs). Both need specific conditions to live, but together, they can live in some unique places. Together, they are called Lichen. These are Lichen with an 'i', not a 'y.' Those are werewolves but still two in one!

Let's look at some Lichen – using the textbook, find a good drawing of lichen:



Label the part that is photosynthetic

Label the part that is structural

Name _____

- Where can you find lichen?

Summary Questions **Name:** *

1. What is the main difference between Eukaryotes and Prokaryotes?

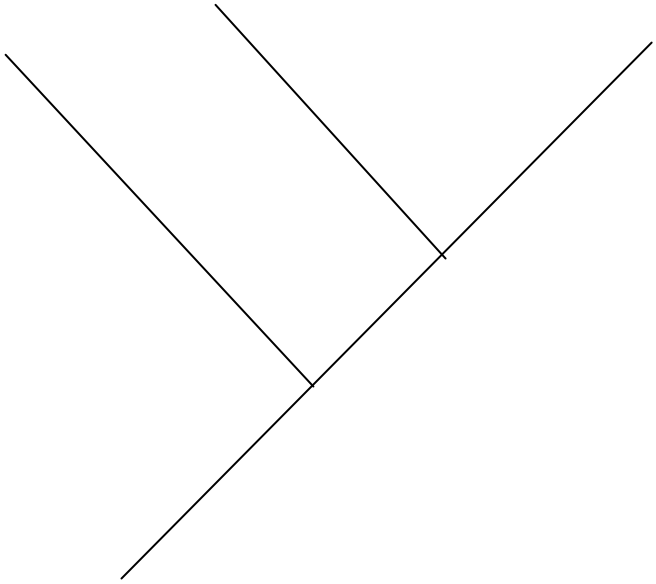
2. What are the three groups of bacteria?

3. What was your hypothesis for your gel plate experiment? How did it go?

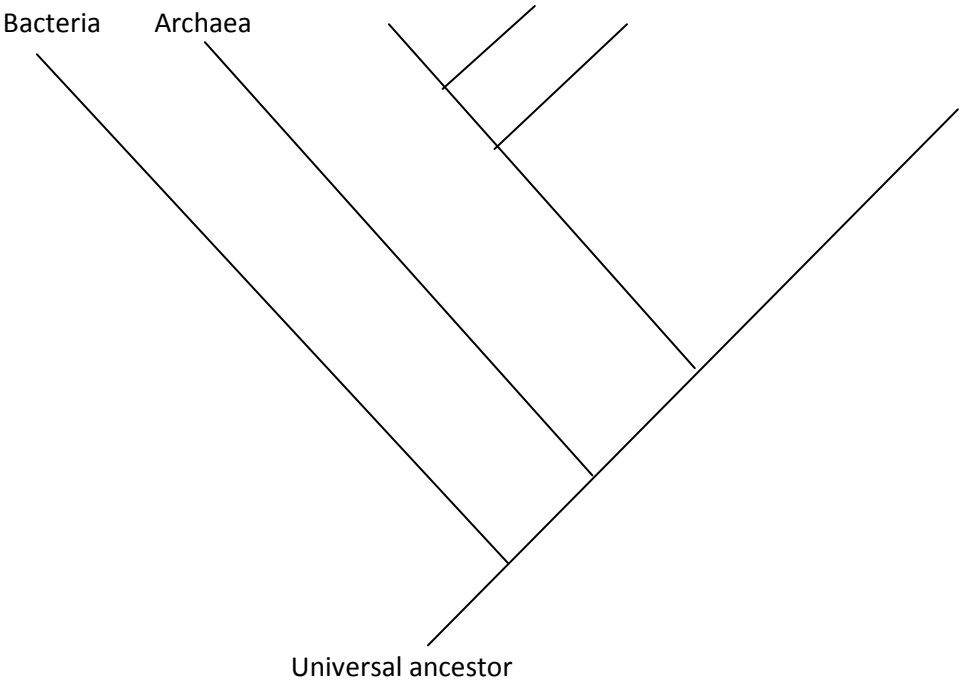
4. What are the three groups of single-celled Eukaryotes?

5. What are the three types of fungi we looked at? What are their characteristics?

Use the information from Question 5 to complete this phylogenetic tree of the different types of Fungus



Let's complete the tree with the life we have so far:



Evolution of Plants

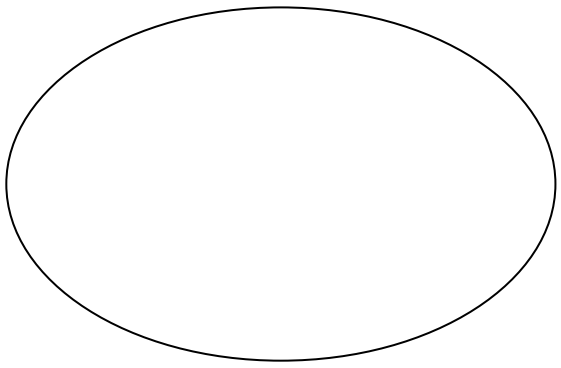
After walking through the single celled photosynthetic Eukaryotes including the photosynthetic Algae. Now, let's look at multi-cellular organisms starting with the photosynthetic Plants! There are four main evolutionary groups of plants. Much of what defines these groups has to do with how they deal with being on land and how they are different than algae. Here, we are going to walk through the groups and look at the reasons plants may have evolved the way they did. Your class may walk through campus to see real life examples too.

Movement onto Land: Algae to Plants

If you were algae, you wouldn't have the same restrictions for growth and reproduction that life on land has. What are some restrictions to life on land?

- What are some restriction to life on land

Algae also have a unique life cycle called the **Alternation of Generations**. This life cycle continues with plants. Draw out the life cycle here

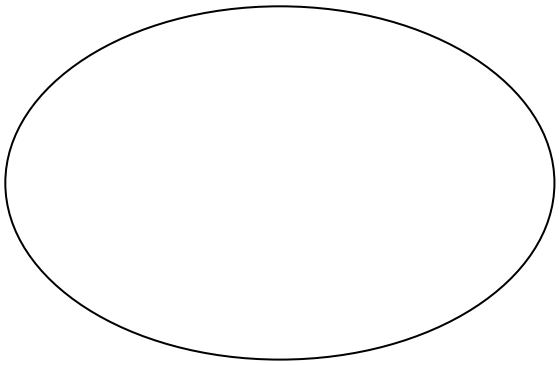


How weird is this! Algae spend some of their life haploid and some diploid. Note which parts are diploid and which parts of haploid on your diagram.

Terminology:

- What is a Gametophyte?
- What is a Sporophyte?
- Which makes gametes?
- Which makes spores?

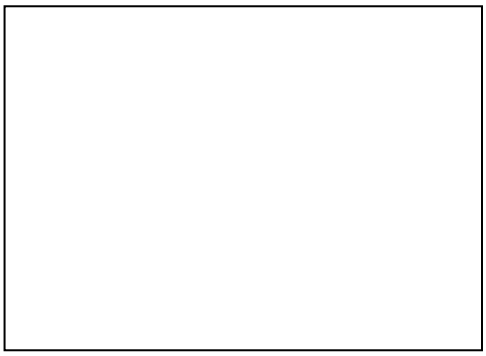
One way that plants are different has to do with how long they spend as a Gametophyte or Sporophyte. Moss are the first group to move onto land and are pretty close to algae. Draw out their life cycle using either the poster or the textbook.



- Given some of the factors that affect life on land, do you think moss would be very big if they are close to algae? Why or why not?
- What other things might restrict their reproduction?

Let's look at some examples of **Moss** –

There are a lot of jars out with examples of Moss. Draw three and label the parts



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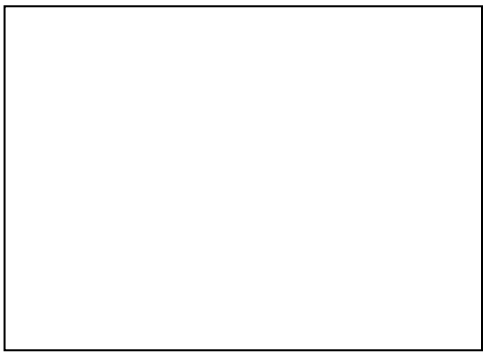

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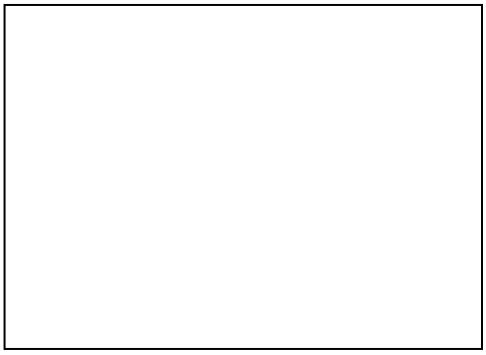

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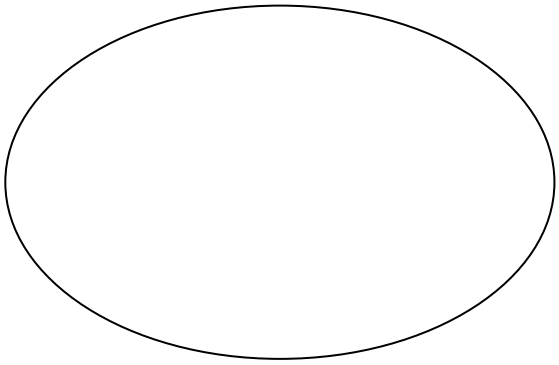
The next big step was being able to move water around

Ferns have the ability to move water around with the evolution of vascular tissue. This allowed them to get much bigger. Can you find the definition of vascular tissue as it relates to plants? Fill that in here:

- Vascular tissue:

Fill in the Alternation of Generations for Ferns highlighting the haploid/diploid parts.

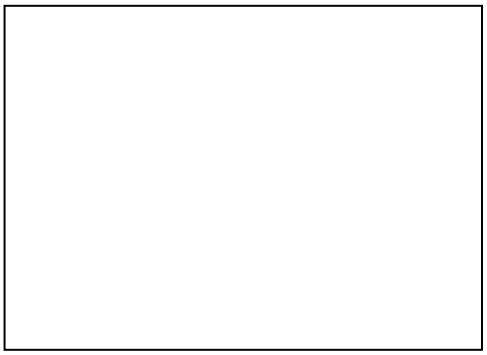


- Given that vascular tissue is a more complex structure, do you think it is likely to appear in the Gametophyte or Sporophyte structure? Think about if you think it's more likely to be in a haploid or diploid structure?

- Have Ferns solved the problem concerning water dependant reproduction?

Let's look at some examples of **Ferns** –

There are a lot of jars out with examples of Ferns. Draw three and label the parts. Use one box to draw the prothallum.



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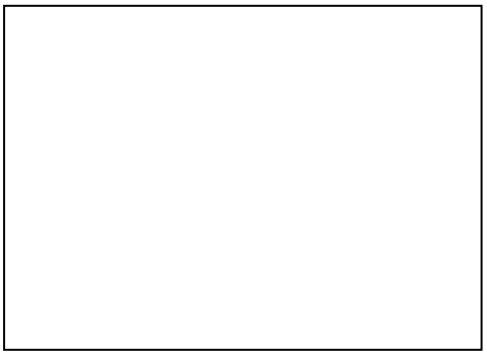

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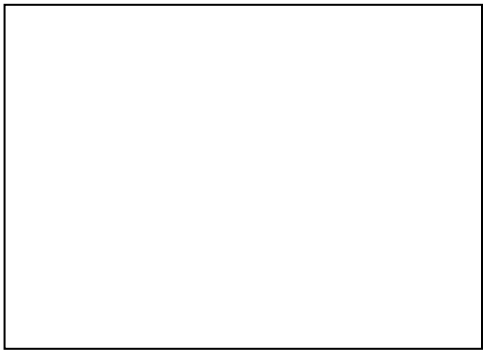


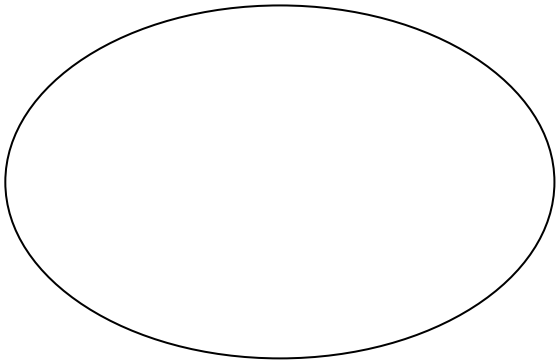
Name _____

The next big step was being able to move seeds around

Gymnosperms have the ability to move their gametes and seeds around. This allowed them to get exploit more areas of land. Keep in mind that before this there is no life on land away from the water's edge. Can you find the definition of Gymnosperms? Fill that in here:

- Gymnosperms

Fill in the Alternation of Generations for Gymnosperms highlighting the haploid/diploid parts.

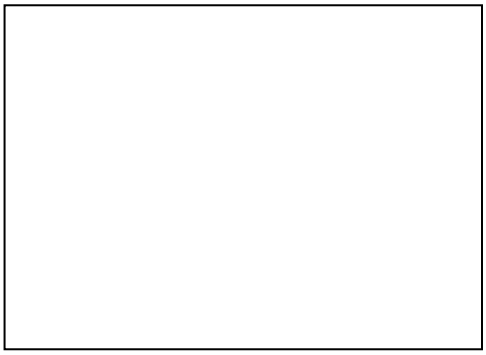


- Where is the Gametophyte in Gymnosperms? Do you see the spores like in Ferns?

- Have Gymnosperms solved the problem concerning water dependant reproduction? If so, how?

Let's look at some examples of **Gymnosperms** –

There are a lot of jars out with examples of Gymnosperms. Draw three and label the parts.



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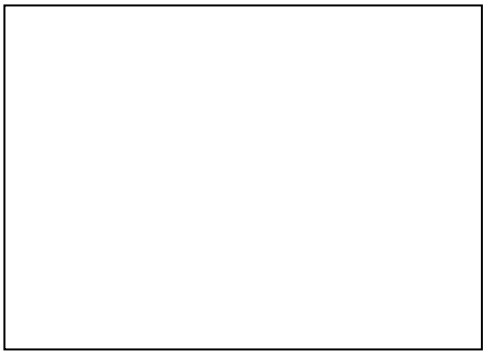

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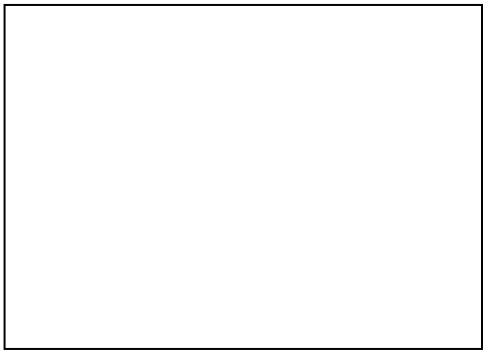


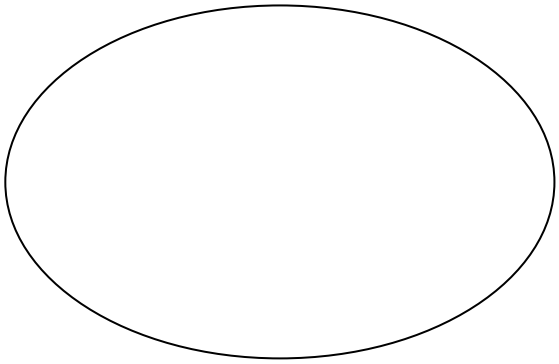
Name _____

The next big step was being able to attract pollinators

Angiosperms have the ability to attract pollinators with the evolution of flowers and fruit. This allowed them to get exploit more areas of land and outcompete Gymnosperms in some places. What are some of the ways flowers attract pollinators?

- Ways to attract pollinators

Fill in the Alternation of Generations for Angiosperms highlighting the haploid/diploid parts.

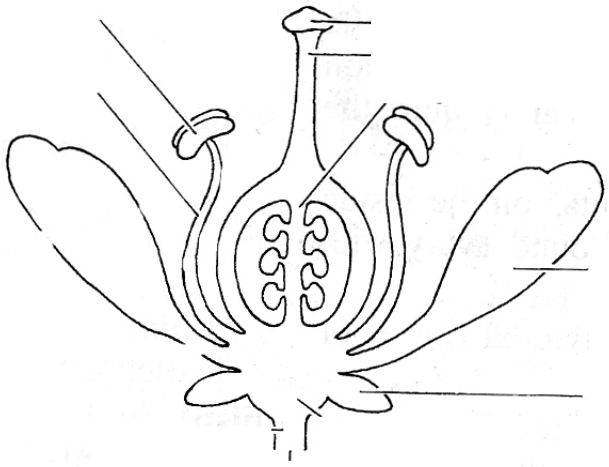


- Where is the Gametophyte in an Angiosperm?

- How does the fruit relate to the flower?

Let's look at some examples of **Angiosperms** –

There are a lot of jars out with examples of Angiosperms along with a model of a flower Draw three examples and label the parts of the model.



Name _____

Name _____

Name _____

Tree Rings

On the lab materials table, there is a cut piece of a tree. Notice that you can see rings on the flat, cut surface. Also notice that the rings are different widths, these rings are equal to the width of the plant cell during that years development. This size can correspond to the amount of rain that left during the development of the rings.

Quick Check:

What structure in plant cells might change the size of the cell?

What is the name of the type of tissue that allows water movement in plants? (hint: ferns had it first)

Plants need to move water up from the roots, then glucose down from the leaves. Their vascular tissues moves nutrients using Xylem and Phloem.

- Define these terms using the reference material:
  - Xylem
  - Phloem
- Looking at the posters of Roots and Stems, do you see a difference in the placement of the vascular tissue of trees? Why do you think they might be different?
- If the vascular tissue of a plant is on the outer section of the stems of plants, where do you think the youngest cells are in a tree trunk?
- What happens to the trees ability to movement nutrients around if someone carves their name into a tree?
- After a fire, sometimes you see the inside of the tree was destroyed, but the outer parts are still intact. Why do you think that might be?

Ways to determine the difference between the groups

Sometimes in Biology we use a **dichotomous key** to determine which group certain organisms belong to. We can come up characteristics of each group and use those to create a key. This will also help us complete our phylogenic tree for plants.

Let's list some of the characteristics of each of our plant groups:

Type of Plant	Structural Differences	Reproductive Differences
Moss		
Ferns		
Gymnosperms		
Angiosperms		

Now we can use these to create a dichotomous key. For instance:

1) Does the plant hugging the ground or can it branch up?
    a) hugging the ground – moss
    b) branching up – go to step 2
2) Does the plant have fronds?
    a) fronds – fern
    b) no fronds - angiosperms
3) Does the plant have cones?
    a) there are cones – gymnosperms
    b) no cones – go to step 1

Notice that the first step is reflective of the fact that ferns have vascular tissue, as do gymnosperms and angiosperms. So, we used a characteristic based on the structural difference between moss and the other plants to determine if it was a moss. Then, we had to ask more questions to determine the rest.

Here's another example for Angiosperms

1) Are you sure it's an Angiosperm?
    a. Yes – go to 2
    b. No – go back to your key
2) Can you see the plants reproductive parts?
    a. Yes – go to 3
    b. No – go to 5
3) Are the petals broad and wide?
    a. Yes – Mayapple
    b. No – go no 4
4) Are the petals narrow?
    a. Yes – Lily
    b. No – go to top
5) Is there fruit present?
    a. Yes – go to 6
    b. No – go to 3
6) Are the leaves round or pointy?
    a. Round – go to 7
    b. Pointy – go to 8
7) Is the fruit a round ball?
    a. Round – cherry
    b. Not round – go to 8
8) Does the fruit look tough or mushy?
    a. Tough – acorn
    b. Mushy - strawberry

Make a dichotomous key for the four groups of plants:

Try your key out with different jars that are set out. Quiz your group members reviewing the characteristics of plants along the way.

The Case

Frederick "Fat Freddy" Garbonzo, a local crime boss, was found shot dead in marsh area behind his restaurant. When the police detectives arrived, the victim was found on his back, hands placed over his abdomen in a position of repose, like a body in a casket. The lack of blood and the statements of witnesses who heard no gunshots suggest that the crime was committed elsewhere.

Several local business owners had keys to the service area because they sold supplies to the restaurant, and several also owed Fat Freddy large amounts of money. John Chapman runs a redwood tree farm and recently planted trees in the parking lot. Thomas Ato grows and supplies fresh fruit. Carl VonLinne runs a greenhouse/flower shop and supplies centerpieces.

A Crime Scene Investigator found parts of a few plants under the victim and in his clothing. Our forensics lab has been asked to examine and identify the flowers and to determine the likely location of his shooting death, in the hope that this information will implicate one of the suspects. We have samples of different plants that were found on the body in jars at the front of the room. We can use our dichotomous key for plants to determine narrow down our suspect list.

Plant Sample One: Determine the type of plant in jar using your key.

What type of plant did you determine was found: _____

- Does it make sense that this type of plant was found on the body?

- Does this plant indicate that the body was moved?

Plant Sample Two: Determine the type of plant in jar using your key.

What type of plant did you determine was found: _____

- Does it make sense that this type of plant was found on the body?

- Does this plant indicate that the body was moved?

If this narrows down the options to Angiosperms, use the key on the previous page to determine what type of Angiosperm you have.

Evidence from Crime Scene

Now, list the evidence you have acquired to determine which suspect you would you like to bring in for questioning about the murder. Be specific about how you came to this conclusion.

Summary Questions **Name:** *

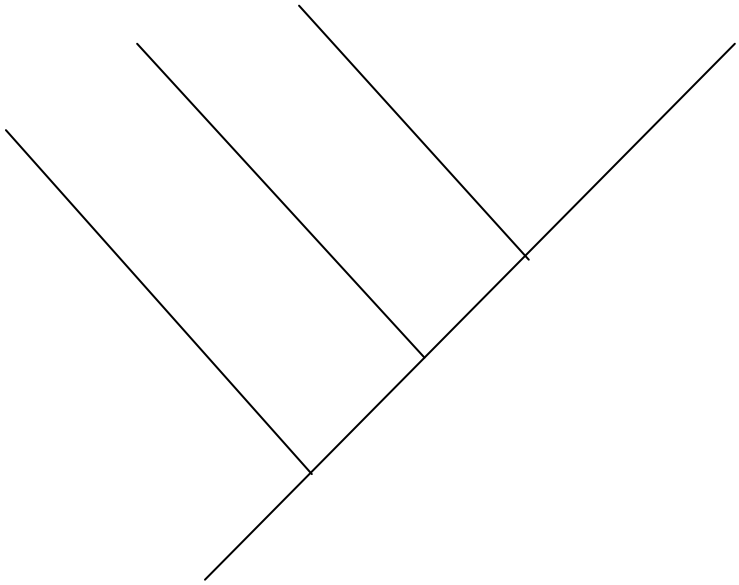
1. What are some restrictions to life on land?

2. What is the Alternation of Generations in Plants?

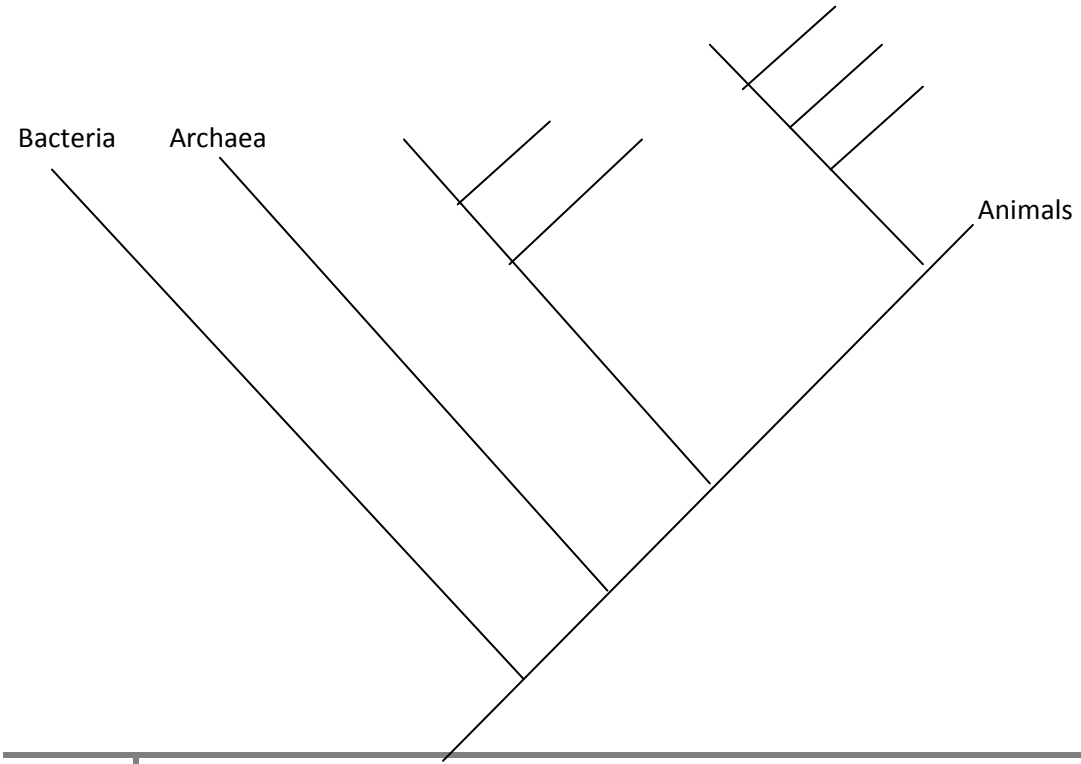
4. What are the four main groups of plants?

5. How do those groups deal with land-based restrictions differently? Be specific

Use the information from Question 5 to complete this phylogenetic tree of the different types of Plants



Let's complete the tree with the life we have so far:



Animal Phylogeny

As you have seen in lecture, there are a lot of different types of animals. There are a lot of different types of other organisms too, we just focus on our own Kingdom with a little more detail. In this lab we are going to look at the evolution steps in animal development that led to different Phyla, then work on our own Phyla – Chordata. Let's start in the ocean with our first variations since that's where Animals evolved first!

Starting for the top! Well, actually the bottom….Symmetry?

Looking at the first group of animals (either in the jars or the poster on the wall), you may notice that the sponges (***Porifera***) are very colorful, very oddly shaped and don't seem to have a pattern of growth. **Symmetry** is an evolution step in the variation of animals. This means that there is a pattern of growth that has balance. Some animals have a body plan that reflects **Radial Symmetry**, like pie pieces and some have **Bilateral Symmetry**, as in you can cut them in half and you'll see the same things on each side.

- Do you think these have symmetry?

- What brought you to that conclusion?

- Would it make sense that they don't have symmetry, given that they are the first things we are looking at?

There are a lot of jars of all the phyla. Find these and draw two.

Name _____

Name _____

Now, move to the next group might look familiar to you put you might not know there are so many different types. You are probably familiar with Jellys or Jellyfish (though they aren't fish) and maybe Sea Anemones from films or television.

- What is the scientific name for this Phylum?

- What type of symmetry do these organisms have?

- What brought you to that conclusion?

Body Tissues

Besides have symmetry, there is another characteristic of Cnidarians that makes them difference from sponges. Cnidarians have actual tissue types. Using the reference material, look up what we mean by **body tissues** and write out the definition here:

There are a lot of jars of all the phyla. Find these and draw two.

Name _____

Name _____

The next group of animals in our tree has a very long scientific name, but a very descriptive common name. They are called Flatworms. Take a look at some examples.

- What is the scientific name for this Phylum?

- What type of symmetry do these organisms have?

- What brought you to that conclusion?

There are a lot of jars of all the phyla. Find these and draw two.

Name _____

Name _____

Digestive Tracts

Another difference between these groups of organisms and the rest of the tree has to do with differences in their **digestive tracts**. Some animals have one entrance for food to go in, and use the same entrance for waste to go out. We call this type an **incomplete gut**. Other animals have what's called a **complete gut** which is more like a tube then the vase-like incomplete gut.

- Can you draw a basic plan for an incomplete gut?

- Which phyla that you've looked at so far have an incomplete gut?

- Do any have a complete gut?

Maybe not, but let's keep going and see if we find any.

Coelomates

Having a complete gut relates to these organisms having a true body cavity or a coelom. Write out the definition of a coelom here:

Our next group of organisms belongs to the **Phylum Nematoda**. Are they examples of true coelmate animals?

- If not, what are they?

There are a lot of jars of all the phyla. Find these and draw two.

Name _____

Name _____

Have you ever dug around in the dirt and came across our next group? Maybe you have a garden with compost and know how important Earthworms can be to the health of our soil.

- What is the scientific name for this Phylum?

- What type of symmetry do these organisms have?

- What type of digestive tract do they have?

- Why are these good for soil?

There are a lot of jars of all the phyla. Find these and draw two.

Name _____

Name _____

* Until now, the animals have looked quite different, is there anything that can help you distinguish between Annelids and Nematods?

More Diversity in the Water and on Land

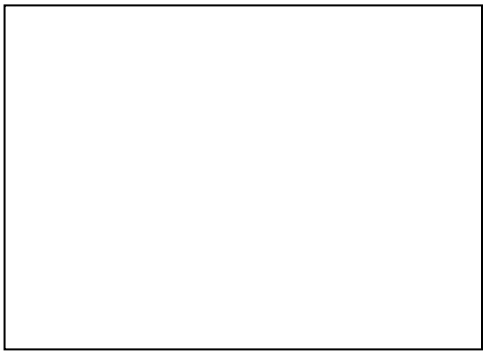
There are many Animals with complete guts and coeloms that are very different. Consider how long animals evolved in the ocean before moving onto land, can you see why that might lead to such vast diversity in the water as well as on land?

- What are your thoughts on this?

The next two groups have vast diversity both in the water and on land. There are cool things like **Molluscs**. Some are in the water and there are a few on land. Molluscs are divided into three main groups. List those groups here:

- Do any of these look familiar to you?

There are a lot of jars of all the phyla. Find examples of the three groups and one for fun.



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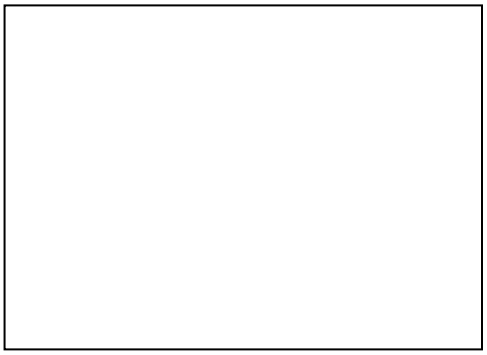

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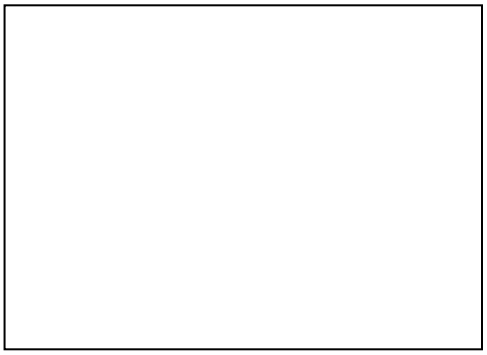

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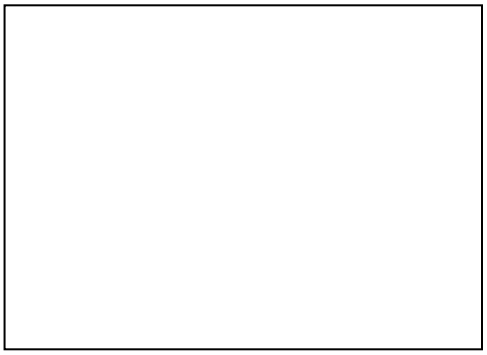


Name _____

Now we come to the most diverse, most abundant and biggest group of all them. If you think it's our group, that wouldn't be correct. These are the **Arthropods**.

- Do any look familiar to you?

Write out the three groups of Arthropods here:

There are a lot of jars of all the phyla. Find examples of the three groups and one for fun.

Name _____

Name _____

Name _____

Name _____

- Why do you think they are the most diverse and most abundant?

- How does this relate to them being the first on land?

Genetically speaking, the closest group or our group includes things like Sea Stars. This might seem weird (because it kind of is), but let's take a look at them.

- What is the scientific name for this Phylum?

- What type of symmetry do these organisms have in their embryonic stage?

- Do they have a coelom?

- What type of digestive tract do they have?

- Can you find anything in the text about the direction of growth of their digestive tract that might be similar to our group?

There are a lot of jars of all the phyla. Find two examples and draw them here.

Name _____

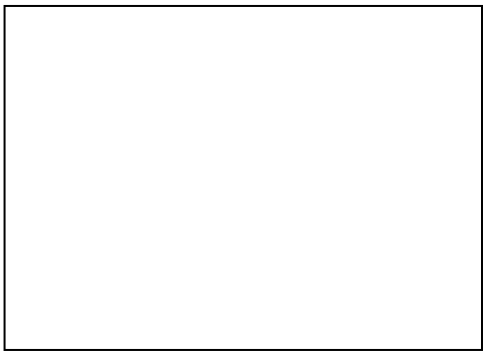
Name _____

And now, our group!

Let's look more closely at our Phylum, ***Chordata***.

- Find the definition and write it out here:

There are three sub-Phyla (or Superfamilies) of Chordata. Find those and draw examples here:



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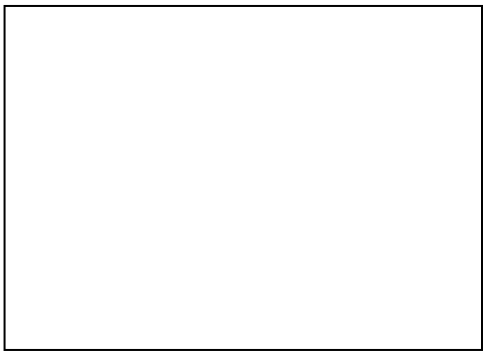

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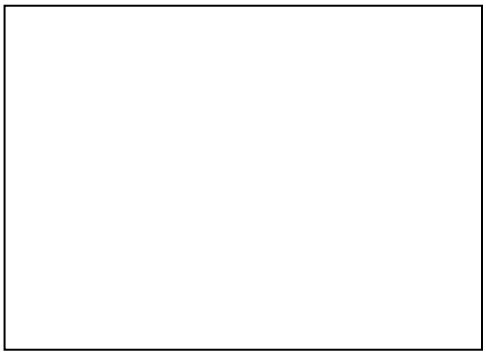


Name _____

Any notes about these groups?

- Looking the first two, do they look related to us?

- Where do they live? Water or land?

Let's look more closely at our group, ***Vertebrata*.** This group starts out in the water, and then slowly moved to land.

- Thinking back to the evolution of plants, what are some of the restrictions to life on land?

Let's look at how the vertebrates evolved and see if it parallels plants at all:

Development of a Skeleton and Jaw

One big evolutionary step in vertebrates is the development of a jaw and skeleton. Did the first two SubPhyla you looked at have a jaw? (On poster)

Two groups development skeletons, but one is cartilage and the other is boney like us (but in water). Find these water-based vertebrates with skeletons and draw examples here:

Name _____ Name _____

- Which one can make more refined movements?
  - Think about your fingers versus your arm

How are we going to get around on land?

Sure we have a boney skeleton if we are fish, but do they have limbs?

- Which is the first group to have limbs? Do we have an example in lab? (use the reference books if you need to)

What about breathing oxygen?

Now that we've moved onto land, how are we going to breathe out of the water? What do you have that lets you breathe in oxygen?

- Is that a similar problem for plants?

Quick Check: Do you remember why all these organisms need Oxygen?

One group development limbs and can breathe on land. These are called **Amphibians.** Find these land-based vertebrates limbs and potentially lungs examples here:

Name _____	Name _____

- Do these animals spend their entire life on land? Can they live away from water?

What about reproduction? (Think about Gymnosperms versus Ferns)

What types of changes occurred between Ferns and Gymnosperms to allow for life farther from the water?

Maybe we are on land, with limbs and lungs, but we are still tied to the water for two reasons:

1) Our eggs need water, if not a moist environment to survive

2) Our skin can't hand dry weather

Our next group evolved answers to both and allowed them to become the dominant Animal group on the Planet for a very long time.

- What group do you think that would be?

- How did Reptiles find answers to those two problems? Be specific about the reproductive evolutionary path.

- Are Birds Reptiles? How do they relate to the previous questions?

Draw examples of Reptiles

Name _____

Name _____

Name _____

Name _____

What about trying not to get eaten by dinosaurs?

Since Reptiles evolved tough skin and an amniotic egg, and since Gymnosperms had seeds and the away to sue wind to travel around, there were lots of places to live. But, how could you be something that wasn't a reptile and avoid being eaten?

- When would Dinosaurs been out and about (time of day)?
- So, if you didn't want to run into dinosaurs, when should you be out and about?
- If you were going to live at night, how could you stay warm? (Not fire, that takes awhile)
- If you were trying not to get eaten, is laying eggs the best plan?
- If not, what reproductive change occurs with **Mammals**?

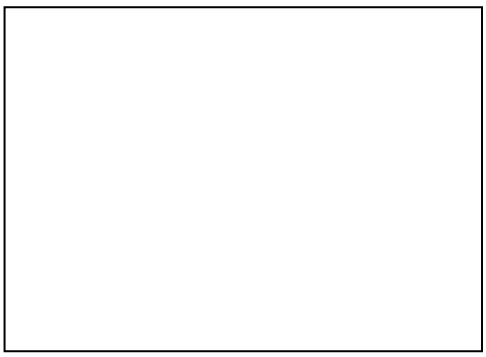
Look up the characteristics of Mammals and write it out here:

Let's look at Mammals more closely:

One big difference with mammals is carrying their young internally. Some offspring are more connected to their mothers then others, can you find the types of Mammals in the text?

- Write those out here:

Draw examples of Mammals



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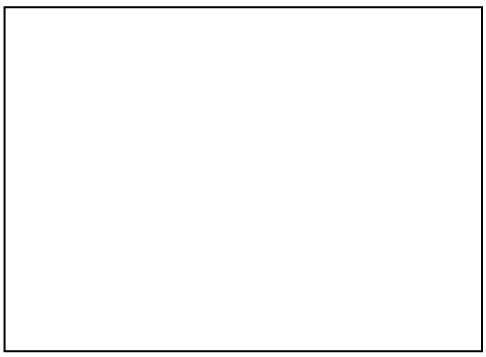

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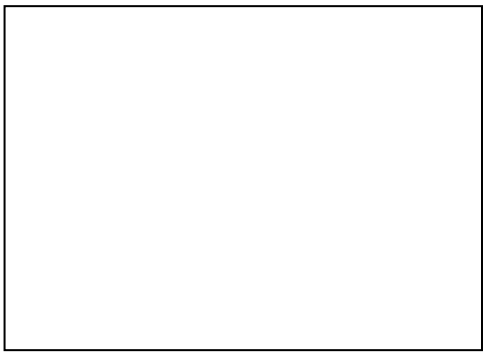

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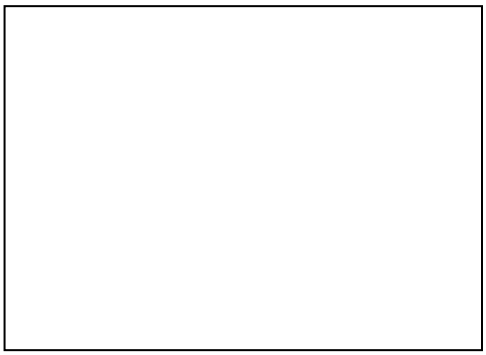


Name _____

- Why do you think Marsupials are so different from the other mammals?
  - Hint: think about the plates moving around

T**he Case: The Boneyard Mystery**

Scenario:

One spring, after enduring several long summers of record-breaking heat, a family decided to install a swimming pool in their backyard and to landscape the surrounding area. However, while digging in the yard, they unearthed several bones of different shapes and sizes. More bones appeared as the work continued, and the family wondered what kinds of bones these were, and why the bones were buried in the backyard. Had they stumbled onto an ancient burial ground? Were these the bones of prehistoric creatures?

Soon the swimming pool project turned into a job of carefully removing and cleaning the bones for closer examination and identification. The family felt that they needed some answers before they could continue their pool project.

There are a number of skeletons out to help you determine what type of animal these bones came from. Let's use our new knowledge of skeletons and jaws to try to figure out this mystery:

Data Analysis:

Six bones from the yard have been prepared for you to study. These bones are believed to be from six different organisms. Your task is to determine the organisms that these bones come from, to identify the specific bones, and to speculate about how they may have become buried in the yard.

Make some notes about what the bones look like here, then compare them to the skeletons that are on display.

Bone Piece	Distinguishing Characteristics	Organism
1		
2		
3		
4		
5		
6		

1) After identifying the animals found in the yard, can you infer anything about the past environmental conditions of the area?

2) On the basis of the information presented in the case and the data collected, can you determine which bones from the yard are the oldest? Explain why or why not.

3) What are some of the ways scientists determine the comparative ages of bones found at a dig?

4) Could the bones found at the dig site be considered fossils? Explain.

5) How do you think these bones got in the yard? Be sure to give a logical explanation and provide information to support your answer.

Summary Questions **Name** .

1) What are the main evolution changes that you see in animals before moving to land?

2) What is the difference between an incomplete and complete gut?

3) What is a coelom? Give examples of animals that have one, animals that don't and animals that just look like they should.

4) Which group is the most diverse and most abundant? Why might that be?

Big Phylogenic Tree for Animals – in the space provided, make a big tree for the Animal Kingdom. Make sure to notate the big changes that occurred between groups.

Now, make a tree for the Chordates – include changes here too

Human Evolution

Learning to compile data, extrapolate information from those data, and then develop a hypothesis is an important skill to learn for more than just Biology class. We can practice this skill by looking at evidence concerning human evolution and the discovery of human fossils. Here, we are going to look at Human Evolution and make some hypothesis based on multiple data sources.

Activity 1: Using Evidence to Extrapolate Information about Relationships

Scenario:

Five members of the Cross Country Running Team decided to have a rugged day of fun last Saturday. They drove out a long dirt road, and parked the car at a grove of trees that was 12 hours of hard hiking away from the freeway. All they had to do was to walk west and they were guaranteed to reach the Highway 8 Freeway, where they would meet a support vehicle.

Your task is to figure out the general paths that were taken by the individual people using the limited information below and to draw those paths on the map of "Trails of the Cross Country Hikers" provided in class. Make sure you read all the clues before you start.

Evidence:

1) The five hikers started out together, but divided into smaller groups, taking different paths as they went along.

2) The hikers' names are Bill, Hector, Julie, Tom and Maria

3) The hikers all began to walk at about 6:00 a.m. All of the hikers reached Highway 8 at around 6:00 p.m. but they did not necessarily arrive together.

a) Tom and Maria arrived at Highway 8 together

b) The last time Hector was with Julie was 5 hours before he reached the highway

c) The last time Julie was with Tom was 8 hours before she arrived at the highway

d) The last time Bill was with Hector, they were 10 hours away from the highway.

When drawing the map of the trails taken by these five hikers, remember that they all start together, so it should start as one line, then the individuals branch off at different times.

Movement of Cross Country Hikers

Bill
Julie
Hector
Tom
Maria

6am	8am	10am	12:00	2pm	4pm	6pm

Activity 2: Using Mitochondrial DNA to Determine Reproductive Isolation

We have an evolutionary clock made of human DNA that will tell us how many years it has been since any one group of humans has been separated from any other group of humans. When humans lived together, they mate, exchanging and blending their genes over many generations of time. This is how sexual reproduction creates common traits in human DNA. If one group splits into two separate groups that migrate far away from each other, and never get a chance to interbreed with each other again, they are no longer mixing genes (and DNA) and over time will begin to look different from each other.

What about Mitochondrial DNA?

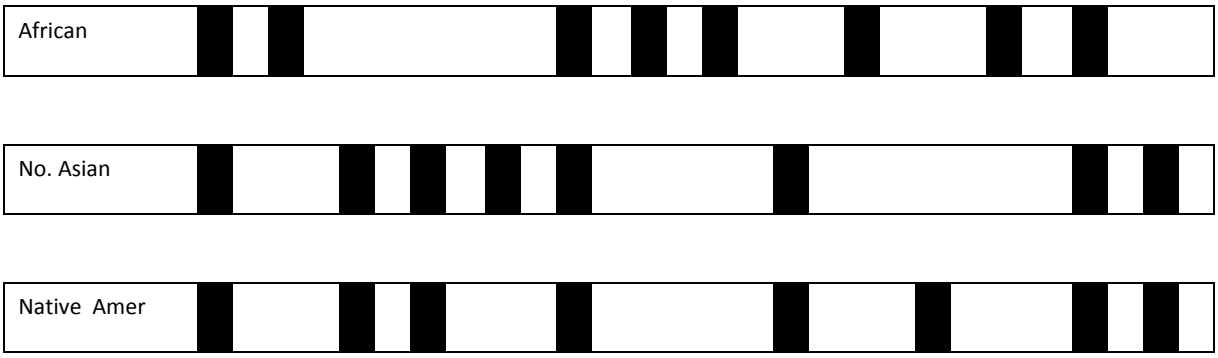
- Given what you learned before, does this DNA mix with the nuclear DNA in the cell?

- Why or why not?

So, mitochondrial DNA stays the same and cannot change except by "new" mutations. These mutations occur randomly as a natural process of living on this planet. By comparing DNA patterns, chemists can detect any new mutations that have been added to the small piece of original mitochondrial DNA that was passes on from mother to child through thousands of generations. If a group of humans splits off from a common ancestral group, then both groups will begin to accumulate different mutations from each other. Each group is genetically separated from the other group. This starts at the point where they no longer interbreed.

The easiest way to show that two groups have separated in the past is to count the number of new mutations found in the DNA of one group and not found in the DNA of the other group. The greater the number of different mutations, the longer is the amount of time that the two groups have been separated from each other.

Let's look at Mitochondrial DNA of different people:



Look at the lines; those are markers for different genes.

- Which two groups are the most similar?
- Which one of the three groups is the most different from the other two groups?
- Which group has been separated from the others the longest time?
- Which two groups haven't been separated from each other for very long?

Activity 3: Evolution of Modern Humans (*Homo sapiens*)

Estimating time of separation:

Biologists have studied many different species, including humans, and have estimated that it takes 500,000 years for 1% of the mitochondrial DNA to be changed by mutation. (This is an estimated mutation, and is currently being debated). Given that rate of mutation, we can estimate how long two groups have been reproductively separated by multiplying 500,000 years by the percentage of difference. (If the groups are 0.3% different: 500,000 x 0.3 = 150,000)

A representative sample of different human geographical/racial DNA has been collected and analyzed. When all of the different mutations were counted, scientists found that only 0.4% of the DNA of modern humans has been mutated.

- How many years have modern humans been on the planet?

Archeologists have found skeletal evidence of a modern-type human who lived on this planet about 100,000 years ago. There is a questions as to exactly how long modern humans have been here, and where they might have originated. You will investigate a partial answer to these questions.

Two important questions are:

1) Where did modern humans originate on this planet?

2) What is the trail that modern humans took when spreading out to the different continents on the planet?

Figuring out the answers to these questions is somewhat like doing the "Trails of the Cross Country Hikers" Problem. Here you will follow five geographical/racial groups instead of five hikers.

You must calculate when these groups separated from each other and related those times of separation to a world map. From that information you will be able to tell a story of modern human migration and origin.

Answer the following questions using what you learned about the Mitochondrial DNA clock.

Questions for Years since Separation:

1) When genetic researchers compare the DNA of Northern Asian population versus Native American populations, they find a 0.07% difference. The "Mitochondrial Clock" formula tells us that there has been about _____ years since the separation of these two groups.

2) When comparing the DNA of Northern Asians and European populations, they discovered a 0.1% difference3. The "Mitochondrial Clock" formula tells us that there has been about _____ years since the separation of these two groups.

3) When comparing the DNA of Indonesian peoples to either the European group or the Northern Asians, they find a 0.12% difference. The Mitochondrial Clock formula tells us that there has been about _____ years since the separation of these two groups.

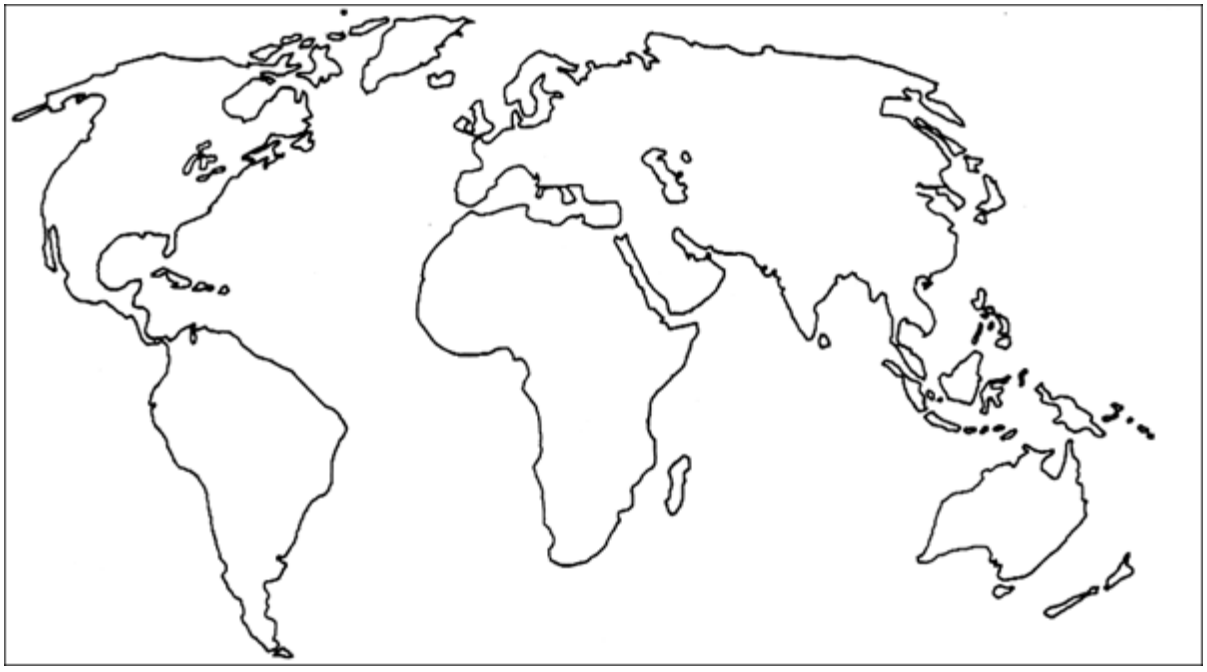
4) When researchers compare the DNA of African populations to any other group they find a 0.2% difference. The Mitochondrial Clock formula tells us that there has been about _____ years since the separation of Africans from other groups.

Using the “years since separation” information you just calculated, propose a pathway of human evolution similarly to map you made for the hikers. Show when each group split off of the original group. Then use the World Map to map out the trails taken by humans as they separated and spread out on this plant. Remember, there are no boats at this point in time, so they have to walk.

Mitochondrial DNA Map of Human Evolution

120,000	100,000	80,000	60,000	40,000	20,000	NOW

Map of the Movement of Modern Humans



Compare with Settlement Evidence

Below is a table of information about the general anthropological evidence of the earliest settlements of modern humans that have been excavated so far. Notice that these data represent settlement data, or the earliest evidence of human populations found in these regions.

Region	**Time of Earliest Settlements**
Americas	less than 35,000 years ago
Indonesia	50,000 years ago
Europe	35,000 years ago
Asia	60,000 years ago
North Africa	100,000 years ago

- How do these data compare to the Mitochondrial DNA data?

- What does that mean about when the groups separated reproductively and when they actually settled somewhere?

- Looking at the map, does that make sense? Mark these data on the map too!

Take a look at the skulls out on display

- Can you see the similarities and differences between the groups?

- There are a few non-human primates out too, how do they fit in?

Activity 4: Our Ancestry – not us but close!

Let's take a closer look at our ancestry and better understand those skulls.

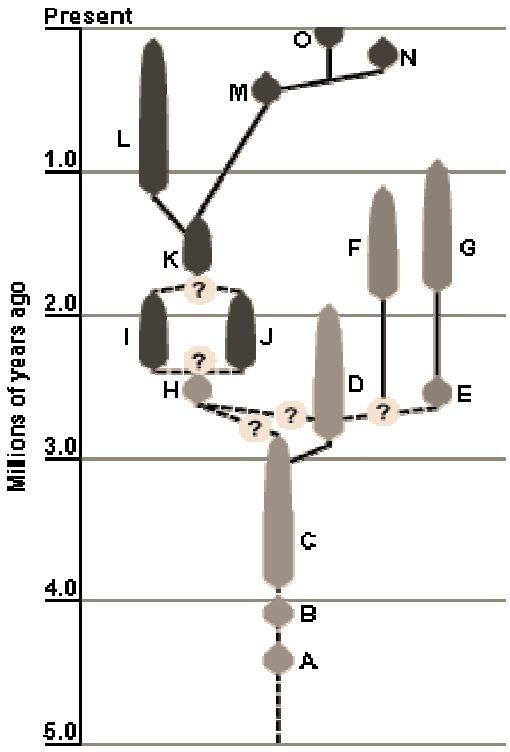
Define and describe the differences between

- *Australopithecus*

- *Homo habilis*

- *Homo erectus*

This is a potential phylogenetic tree created by anthropologists at UC Berkeley.



A-*Ardipithecus ramidus*
B-*Australopithecus anamensis*
C-*Australopithecus afarensis*
D-*Australopithecus africanus*
E-*Paranthropus aethiopicus*
F-*Paranthropus robustus*
G-*Paranthropus boisei*
H-*Australopithecus garhi*
I-*Homo rudolfensis*
J-*Homo habilus*
K-*Homo ergaster*
L-*Homo erectus*
M-*Homo heidelbergensis*
N-*Homo neanderthalensis*
O-*Homo sapiens*

- What kinds of evidence to you think anthropologists used to create this tree?

Fossils	Age of Fossils	Location
Ardipithecus ramidus	5.5 million years	Africa
Australopithecus anamensis	4.2 million years	Africa
Australopithecus afarensis	3.5 million years	Africa
Australopithecus africanus	3.5 million years	Africa
Homo habilis	2.5 million years	Africa
Homo erectus	1.8 million years	Africa
Homo erectus (Java)	1.5 million years	Southeast Asia
Homo erectus (Heidelberg)	900,000 years	Germany
Homo erectus (Peking)	500,000 years	China

Let's answer some questions about these data and try to map out our ancestors travels. Using a legend with different characters for each of the species listed (like stars or circles), then place the characters on the map.

After looking at all of the evidence,

1) Where did the various early hominids originate?

2) Which group migrated out of the continent of origin? How long ago?

3) How far did that group spread over the world?

4) Was there another group that later came out of the continent of origin (see Activity 3)

a. Which species was that group?

b. When did the migration of the new species happen?

Summary Questions **Name:** *

1) How do scientists use mitochondrial DNA to estimate reproductive isolation?

2) What did you find concerning the separation of modern humans?

3) What did you find about our ancestors?

4) Are we the first group to leave Africa?

5) Looking at the skulls, can you determine which is a direct ancestor and which is a 'cousin'?