LAB 1 – The Characteristics

(June 2014)

Section 1 - Observing Nature

[33] Welcome to the start of Lab 1. This Pat Farris again, and as you go through today's lab, I hope you'll enjoy taking a closer look at the qualities of living organisms. Remember if you need any help with the equipment or the lab material, let the lab instructor know. If you have your lab manual and a pencil, you're ready to get started.

[34] To start the lab, open up to page 1.1 and notice that we have listed the lab sections and the objectives on the first page of each lab. If you need to leave the lab before you've finished, it's a good idea to leave off at the end of one of these main sections so you can jump right back in when you return. Take a look through the objectives. We've got a lot of material to get through, so let's get started.

[35] We'll start by reviewing the topics from the Orientation, starting with qualitative and quantitative observations. Take a moment and copy the definitions of each of these observations into your lab book and click the forward button when you're done.

[36] Notice that we must have a number associated with any quantitative observation, whether it's the number of objects or a measurement made from an object. Just saying something is "large" or "fast" is not a quantity, so be careful that you indicate a number in your observation.

[37] Two other types of observation we did not discuss in the Orientation are direct and indirect observations. In some cases, a biologist must rely on data to determine how something is functioning or how something is put together. When a doctor looks at the levels of white blood cells in a blood test for example, they are often able to come up with a diagnosis and a course of treatment without ever looking directly at the disease-causing organism. This would be an example of an indirect observation.

[38] At this point, I'll let you try an indirect observation for yourself. Go up to the demo table and see if you can determine what is inside the two boxes which are labeled "A" and "B". Here are some possibilities of what might be in the boxes. Continue the program after you have made your guesses.

[39] Did you guess that container A contains a pencil and container B contains a nickel? Your indirect observations included the sound and weight of the objects as they moved inside the box.

Section 2 – Organizing and Analyzing Data

[40] Now we'll get to some direct observations of living objects. We went over the metric units in the Orientation lab, but take a moment now and review the chart shown in your lab book. After

reviewing the handy equivalents, I'll have you try a few practice questions on the next page of the program.

[41] What is the proper metric measurement of this flower? Continue when you have the correct answer.

[42] How about the size of this little berry in millimeters? Continue when you have the correct answer.

[43] Now that you've demonstrated your measurement skills, we'd also like you to be able to convert one unit into another. Try the four practice metric conversions shown in your lab book and return to the program when you have finished.

[44] How are you doing on the math? I hope you found these conversions pretty simple. Compare your answers to the ones shown here and copy the equations if you had any trouble. Now you're ready to collect some data of your own. Before we begin, however, let me explain about how data should be collected.

[45] We're going to examine a variety of leaves from a local tree. When you collect your own sample of leaves from the big box of leaves on the demo table, make sure you pick them randomly. What I mean by this is that you need to make sure you aren't making a conscious choice about picking leaves of a certain size. If you did, then you would be making a biased sample and it would not be a true representation of leaf sizes.

[46] After you have selected 20 random leaves at the demo table, you will measure them using the metric scale of the ruler hanging in your booth, then graph the leaf data on the histogram provided. Remember that histograms show *how many* of each thing we have. In this case, we will be showing how many leaves fall into each size category. The data will essentially pile up into each category until you have 20 squares shaded in.

[47] Next you will calculate the mean or average length of the 20 leaves and the range, which is a way to denote the largest and smallest values of a set of data. In other words, the range lets us know the extreme sizes of leaves.

[48] Now's the time to go to the demo table, collect your leaves and bring them back to your booth. Measure the leaves in centimeters, graph your data and do the calculations. Return to the program when you have finished recording the range.

[49] You may have noticed that your leaf sizes were widely scattered in size, and our histogram helps us quickly visualize these sizes. If you had continued picking leaves, let's say, hundreds and hundreds of them, you would probably notice that your histogram would take on a characteristic shape called a normal distribution shown here.

[50] A normal distribution is very common in biological organisms. In other words, the values for a set of data are often balanced on both small and large values. The really nice thing about normal distributions is that instead of doing an involved calculation to determine the mean, we can just look

at the central value of the distribution. But you need to collect a LOT of data to get this kind of distribution.

[51] In histogram example shown in your lab book, there are some mice with short tails and some with long tails, but most mouse tails are around 7.6 cm. This central tendency gives us a quick way to estimate the mean. Now estimate the average height of men from the graph shown in your lab book. After you have determined the mean and range from the histogram, return to the program when you are ready to begin Section 3.

Section 3 – Using the Compound Microscope

[52] One of the fun parts of taking a biology class is that you will get to see some wild stuff you've never seen before. Unless you've used a microscope in other classes, you've probably never seen real live cells up close and personal. Well in this class, we'll be examining all kinds of cells, either in prepared slides or microscope slides that you will prepare yourself. To do this we use a very powerful tool – the compound microscope.

[53] To start using the microscope, you'll need to learn the names of all the parts, so you'll know when to turn certain knobs and when to slow down and make careful adjustments. We're going to trust you to handle the scope carefully – they are very expensive and have to last us for years and years, so please follow the directions VERY carefully.

[54] Start by locating the parts shown in the diagram of your lab book. This type of scope is called a binocular compound microscope. "Binocular" means it has two ocular lenses at the top, just like a pair of binoculars you might use to watch a sporting event. "Compound" refers to the fact that there are three powerful objective lenses which give us a choice as to how much we want to zoom in on a specimen.

[55] At this point I'll let you take your time and get acquainted with the microscope parts and how they function. Read the instructions carefully because when you reach the end of the exercise, you'll have to ask the lab instructor to come over to your booth and check your set up. After the instructor has signed the signature box, complete the last part of the exercise using the high power lens and then return to the program to begin Section 4.

Section 4 – Qualities of Magnified Images

[56] I hope you got through your letter i exercise without too much drama, because we'll be using the microscope all semester and it does take some practice. If you struggled to find your letter i on the slide then let me go over a few hints to help you in the future:

[57] Whenever you use the microscope, make sure you're using both eyes, opened and relaxed. There's no squinting required, even if you wear glasses or contacts. Also make sure you use the lenses in the correct order – always use scanning first to find the object, center it in the field of view, then rotate the low power into place, using only fine focus from then on. If you have trouble finding the object on scanning, move the stage all the way up, center the coverslip over the light, then look

through the scope while slowly moving the stage down. Just to make sure you're getting all this, let's try some questions:
[58] For this question, drag the labels so they point to the correct lenses on the photograph. Click the "Score this page" button when you think you have them all right. Continue when you get 100%.

[59] Ok, now try labeling the other parts of the microscope. Click the "Score this Page" button and make sure you get 100% before you continue.

[60] And one more question...

[61] Good! Now let's find out what we're really seeing when we look through the scope. I hope you noticed how the scope seemed to do the opposite of what you thought it would – in other words, when you put the slide on right-side up, the specimen appeared up-side down, and when you thought you were moving the slide away from you, the slide appeared to go towards you. This optical property is called inversion. Answer the questions at the beginning of Section 4, then return to the program.

[62] Next we'll examine just how much magnifying power we have in these scopes. How much magnification depends on which objective lens is in place. We can calculate the total magnification if we remember that we are always looking through the 10 power ocular lenses, as well as the selected objective lens. For example, if the scanning is in position as we look through the scope, then we have the scanning power (4 times) multiplied by the ocular power (10 times) for a total magnification of 40 times. So when the scanning lens is in place, what we see is magnified 40 times.

[63] Look at each objective lens to determine the power. It is printed in large numbers on the lens. Complete the calculations for the other two lenses and fill them in your lab book.

[64] I hope you found the total magnifications to be as shown on the screen. You can see that the microscope is a very powerful optical device. Later in the semester we'll even be able to see some bacteria without too much trouble.

[65] The next thing we'd like to know about our view through the scope is how much of a slide we're able to see. The drawing in your lab book of the microscope slide shows a typical presentation – the large glass slide with the square coverslip attached, just like in the letter i slide you examined earlier. On the drawing you can see black circles which represent the "field of view" or "field diameter" of each lens.

[66] Now you can see why we start with the scanning lens when we're searching for something. It gives us the most real estate to search to find our little critter or cell or whatever we're looking for. Once we've zoomed in on high power, we'll be seeing a very large image, but a very small portion of the slide.

[67] Go ahead and complete Section 4 by calculating the size of these fields - first by measuring the drawing in your book with your ruler, then by calculating the actual values. You will obviously be using centimeters or millimeters when you use the ruler, but when you get to the actual calculation, we'll be converting those units to micrometers. Since this is the first time we've used the

micrometer units, here's a hint on the calculation: there are one thousand micrometers in each millimeter. Return to the program when you have completed the calculations at the end of Section 4.

[68] Did you get the correct values in micrometers? Check your answers here. Remember, whenever we're using the microscope, all our measurements will be in micrometers.

Section 5 – Measuring Objects through the Microscope

[69] Every measurement you do through the scope will be in the micrometer unit, also known as the micron. The smallest thing you can see with your naked eye is about one hundred micrometers in diameter, or about one-tenth of a millimeter.

[70] To do these measurements, we clearly can't go smashing a ruler under the objective lens. Instead we will use a very precise scale called the micrometer scale that is already part of your microscope. You may have noticed the scale already when you used the scope before. If not, turn on your microscope light and look through both oculars as you normally would. You should see the scale is a large arrow with numbers on it.

[71] As you look through the scope, rotate the right ocular gently and notice that this will rotate the scale. That's why it's important you use both eyes and don't squint as you use this type of microscope.

[72] This scale might appear to be sort of a ruler, but it is not for a very important reason – you will be changing objective lenses as you look at objects. There is only one micrometer scale, so we need to know what the number scale represents at each power. Examine the conversions shown on the micrometer scale at the beginning of Section 5 and study the sample problems. Continue the program when you are ready to try a question.

[73] What is the size of this object? Remember to use the correct conversion for the scanning lens mentioned. Continue when you have your answer.

[74] I hope you noticed how the micrometer scale shows a *relative* distance, not actual units in micrometers. Now you're ready to complete your measurement of the dot on the letter i using the microscope. Take your time with this exercise and make sure you understand it before you go on because we will be measuring microscopic objects all semester. When you have completed Section 5, take your lab book up to the lab instructor to be checked.

[75] I know that using the microscope is a bit complicated at first, but take your time and you will get the hang of it. This is probably a good time to point out the two appendices in the back of your lab book. Take a look at Appendix 1, which reviews parts of the scope in case you forget the names, and Appendix 2, which reviews the calculations we just did. Now let's get back to some living things…

Section 6 – Characteristics of Life - Organization

[76] The first characteristic of life that we will examine is organization. Even if we've never seen a particular organism before, we can usually guess if an object is living or was once living if we see some sort of structural pattern. A quality we see in almost every life form is called symmetry, or the balance of structures, shown here in these beautiful diatoms.

[77] Here is an extremely old fossil impression. The person who recognized its significance was a 15 year old boy in England who enjoyed looking for fossils near his home. Because he noticed the organization, he guessed it was the impression of a living thing. This creature lived more than 500 million years ago and turns out to be one of the oldest multicellular fossils ever found. The fossil is called *Charnia masoni*, after its discoverer, Roger Mason.

[78] Here you can see the extreme degree of organization found in a bee's eye. Where does this organization come from? Well, we know that every organism that has ever existed on earth is composed of cells, and cells are sometimes referred to as the "unit of life". The organization of cells allows the entire organism to function and grow efficiently.

[79] To observe this characteristic of life in a little more detail, we'll dive into the cellular structure of a little plant with the scientific name of "*Ranunculus*". The common name of this plant is Buttercup, named for the shiny bright yellow flowers. Now that you know how to use the microscope, you can observe the organization found in the root cells of this plant.

[80] Find the slide labeled "*Ranunculus*" in your blue slide box. Before placing the slide on the microscope stage, notice the little root slices under the coverslip. Make sure your scanning objective is in place and the stage is as high up as it will go, using the coarse adjustment. As you place the slide on the scope, place one of the root slices over the circle of light on the stage.

[81] Inside the root cross section you will see specific cell types stained to show up as distinct groupings, and we'll examine each of these cells in more detail in just a moment. But for now, complete the measurement of the root diameter and answer the questions to complete Section 6, then continue the program.

[82] Did you remember to multiply by the correct conversion factor and express your answer in micrometers? Great! Let's go on. You'll be using the same *Ranunculus* slide in the next exercise, so keep it on the scope for now.

Section 7 - Characteristics of Life - Metabolism

[83] The next characteristic that all living things share is the ability to use energy, which we refer to as metabolism. Please record the definition of metabolism in your lab book. Metabolism is a very general term which includes all the chemical reactions in a living thing, since all reactions require energy.

[84] Although we can't view energy easily, we can look at some cells that are directly involved in storing energy for a plant. In plant roots, this layer of cells is called the **cortex** and these cells store a

critical molecule called starch. Starch is the compact form of hundreds of sugar molecules. Examine the root cross section shown on the screen to orient yourself to the various cells.

[85] Now examine the same *Ranunculus* slide and find some typical cortex cells with some nice fat starch grains inside. Carefully zoom in on high power and complete Section 7. Draw just one or two cortex cells and label the starch grains inside the cells. Continue with the program when you are done with the drawing, but leave the *Ranunculus* slide on the scope if you are continuing on to the next section of the lab.

Section 8 – Characteristics of Life - Homeostasis

[86] In addition to starch, the stored form of sugar, another critical molecule for plants is water. Water can only be absorbed by the roots, so all plants need specialized cells to conduct water throughout the rest of the plant. You can't just go sloshing water around though, water is a molecule that must be regulated, and this brings us to our next characteristic of life – homeostasis.

[87] Review the definition of homeostasis – it is the maintenance of a constant internal environment, despite changes in the organism's external environment. Let's think about our little *Ranunculus* on a hot day. Throughout the day, the plant is taking in as much water as it can through the roots, but water is also being lost through the leaves by evaporation. A plant has to balance this water loss and gain to maintain its shape. In other words, it has to maintain a constant internal environment no matter how hot or cold it gets during the day.

[88] When you looked at the whole root cross section of *Ranunculus*, you undoubtedly noticed the bright red cells in the center of the root. These specialized cells are called xylem cells and they are critical for the homeostasis of almost all plants on earth.

[89] Examine your *Ranunculus* slide again and complete your drawing of five xylem cells. This time you will also determine their sizes and don't forget to convert the units to micrometers. When you have finished your calculations, you are done with that slide and can put it back in your blue slide box. Continue the program when you are ready to begin Section 9.

Section 9 – Characteristics of Life - Responsiveness

[90] Our next characteristic of life is responsiveness, the ability to respond to stimuli. To observe this characteristic, you will observe some very small organisms that are found in our campus pond. They are invisible to the naked eye, but will be quite obvious through the microscope.

[91] Your blue slide box contains a plain glass slide and small square coverslip. Now you'll prepare your own microscope slide by placing a single drop of pond water onto the central area of the slide and gently lowering the coverslip onto the drop. Once you have your sample, look around the slide on scanning to find some moving organisms. You may have to turn your light down to see these delicate creatures.

[92] Did you find any creatures? Please observe them for a few minutes and watch how they react to stimuli. Do they bump off of objects in their path or move through them? Do they react to other creatures? Can you observe them feeding? Record a few of your observations in the space provided and return to the program when you are ready to begin Section 10.

Section 10 – Characteristics of Life - Reproduction

[93] The next characteristic of life is reproduction, the production of new individuals of the species. One method of reproduction you may not have thought about is called asexual reproduction, which does not involve sex cells. Here's a little animal called a *Hydra* which is producing a new individual by a process called "budding". Weird, huh? Please record the definition of asexual reproduction in the table of your lab book before continuing.

[94] The more common method of reproduction that is more familiar to you is, of course, sexual reproduction. This method requires the production of some very specialized cells called gametes. You probably know gametes from their more common name, eggs and sperm. Please record the definition of sexual reproduction on the table before continuing.

[95] Here are some gametes in action. Only one of the sperm will actually fertilize the egg, causing exactly the right number of chromosomes to come together in the resulting cell called a zygote. The chromosomes contain all the genetic information needed to produce an adult organism. Have you ever thought of yourself as a single cell? Well, you were once, and because of some very fancy chemistry, you're now a college student sitting in a booth listening to my voice.

[96] We'll spend several labs discussing how this fancy chemistry works, but I think you already know it involves DNA, an exquisite little molecule that is something all life on earth has in common. But as I said, we'll get to that molecule later in the semester. But for now, let's finish Lab 1 with the last section of the lab, Section 11.

Section 11 – Characteristics of Life - Adaptation

[97] Okay, home stretch for the lab work – you'll be outta here soon! But we've left one the most important biological concepts for the end, so I need you to pay close attention. Please record the definition of adaptation – a characteristic of a species that allows survival.

[98] That little definition probably doesn't sound like too big a deal, but it is the cornerstone of how biologists think about everything they study. Let's start with some examples that will illustrate this concept. We'll look at some desert organisms that demonstrate some extreme adaptations. I'll give you a summary table to copy at the end of this audio section, but for now, let me explain the three types before you start writing.

[99] Here's a classic desert animal – the camel. It is certainly the largest animal you would find in any desert, and it lives in one of the harshest deserts on earth, the Sahara Desert of Africa. Being such a large animal is not easy. There are very few trees for shade and something the size of a camel certainly can't dig a burrow to hide in, so how can such a large animal survive the heat?

[100] The first major type of adaptation is called physical, and these are the adaptations that you can see on the animal. Now think about the sand the camel is walking on. It's hot. Way hot. The sand temperature is close to 130º F. If you've ever tried walking across a hot parking lot barefoot at the beach, you know that humans don't have the adaptation necessary to do what this camel can do all day long. A camel's foot has a thick leathery surface that is like wearing permanent pair of boots. Their feet also flare out to keep them from sinking too far into the sand. These are both examples of physical adaptations.

[101] Another physical adaptation that everyone knows camels have is the hump, but you may have seen too many cartoons and think that there is water in the hump. That's not true at all, because a camel's hump actually contains fat. This big fatty lump on their back acts as insulation against the sun's rays.

[102] Another type of adaptation is one that we can't see and this is called a physiological adaptation. Physiology is the study of internal body function and chemistry, and when studies of camel physiology were done, it was found that the camel's hump was able to store excess body heat, so the camel's overall body temperature didn't go up to dangerous levels even on the hottest days.

[103] So that's enough about camels, let's look at another organism for our third type of adaptation called behavioral adaptation. This little African bird is called a weaver. It builds elaborate nests that hangs high in the trees to keep its chicks safe from snakes and other predators. This is not something this bird had to learn, this is a behavior he was born with. Birds that are skilled at making nests will have more offspring than birds that build their nests poorly or in the wrong place.

[104] So the three types of adaptation are summarized for you here, and it's time to record them in your lab book.

[105] Now I don't want you to think adaptations are only found in animals, because desert plants would have some remarkable adaptations as well, such as very long roots, thick leaves for storing water, bending their leaves away from the sun, being a light color to reflect the sun, and on and on. Boy, I could go on and on, couldn't I? But I bet you'd like me to wrap it up, huh?

[106] So let's finish up Lab 1 with a few more questions, just to show me you've been paying close attention. Review these characteristics of life for a moment, and continue when you feel ready to answer a couple of questions.

[107] Which characteristic of life is this an example of?

[108] What type of adaptation would this be an example of?

[109] Okay, that's enough for today! You have completed your first laboratory. Keep the objectives on the first lab page in mind when you review this lab. If you feel up to it, this is a good time to try the self-test questions on the next page, but I'll understand if you're just too exhausted to go on and want to try the questions later at home. Please be sure that your booth is cleaned up and that your microscope light is turned off. Click on the main menu button for the next student, and don't forget to log off on the lobby log-in computer. See you next week!