Lab 6 – Ecology

(April 2014)

Section 1 - Levels of Ecological Organization

[2] Hi this is Lyn Koller. This week we will be looking at a few aspects of ecology. In order to understand what we'll be studying, let's break down the word ecology; "eco" or "oiko", the Greek root, translates to "house" and as you all know "ology" translates to "study of". So when studying ecology, we are looking at where we live.

[3] The first thing we need to do is define a few terms. You will remember from the first lab that living things are organized from subatomic particles through atoms, molecules, organelles, cells, tissues, organs, and systems.

[4] Above the level of the organism, living things are also organized into several additional levels. We will look at these levels over the next few program pages. You should fill in the correct term for the definition of each level in Section 1 as we go along. By the way, the definitions are not listed in order in the laboratory manual, so be sure to find the correct definition.

[5] While not one of the levels of organization, the definition of a species is important in working with ecological concepts. There can be many different ways to look at a species, but the easiest is to simply say that a species is composed of similar organisms which are capable of interbreeding to produce fertile offspring – that is the "kids" can reproduce.

[6] Organisms which cannot interbreed to produce fertile offspring are separate species even though they might be able to produce offspring. An example of this is the mule; it is a sterile hybrid produced when a female horse mates with a male donkey.

[7] Now to the levels of organization. The first level above the individual organism is the population. You can see several examples of populations here as well as the definition.

[8] When you think of populations, no doubt you are imagining human populations. We define our populations by lines on a map. For example, we can talk about the human population of California or Nevada. Non-human populations usually occur in areas defined by the environment. For instance, Lake Tahoe in north central California has a population of rainbow trout. The fish are able to swim anywhere in the lake. Look at the map shown here, you can see that Lake Tahoe occurs in both California and Nevada; the border goes right through the lake! Do you think the fish care whether they are on the California or Nevada side?

[9] The second level is the community. Again you can see an example of a community and the definition. Since the community includes all populations, it includes all of the living organisms found in the area.

[10] The next level is the ecosystem. This is a broader category that not only includes the living things in an area, but also includes the non-living things with which they interact. Here you can see the plants which make-up part of the living component and the dirt and rocks which make up part of the non-living component of this environment.

[11] If you compare similar ecosystems around the world you are describing a biome. For instance there are many different desert communities, but you can speak in general of a desert biome.

[12] Finally if you consider all of the biomes on earth, you are looking at the biosphere. Any place an organism can live is included – land, water, and atmosphere.

[13] At this point you should have filled in all of the definitions in section one. If not, do so now and then try to place the terms in the correct order from lowest to highest level of organization. When you have gotten them in the correct order return to the program so we can continue.

Section 2 - Abiotic Factors

[14] In Section 1 I mentioned living and non-living things. Living things are considered "biotic" factors while non-living things are considered "abiotic" factors. Abiotic factors include things such as temperature, wind, and rain. These abiotic factors determine the types of communities that will be in found in an area. Write the definition of "abiotic" in your lab manual and then we'll continue.

[15] Let's start our study of abiotic factors with temperature, one of the most obvious. The temperature of any location on earth is determined by the amount of solar radiation or sunshine the area receives.

[16] The angle with which the sunlight strikes the earth is called the angle of incidence. The greater the angle, the greater the heating. This is why it's cooler in the morning and evening and warmer during the middle of the day.

[17] As you know it's hotter at the equator and colder at the poles of the earth. The angle of incidence gets smaller as you travel from the equator to the poles. This results in the same amount of solar radiation being spread over a larger area and thus cooler temperatures. To see this, complete the exercise on "solar radiation and temperature" in your lab manual. Be sure to use the metric system when measuring and then return to the program.

[18] I hope you saw that the same amount of sunlight covered a greater distance at the pole and thus there was less heating per unit of surface area at the poles than at the equator.

[19] Another obvious abiotic factor is wind. We all know about Santa Ana winds here in Southern California, but what is the general effect of wind in the environment? Wind not only moves things like dust and sand around, it also moves moisture. Here you can see a simplified diagram of global wind patterns. As you can see, air masses circulate vertically, and they also move over the earth's surface horizontally.

[20] Take a look at a local example of these wind patterns. Here is a west to east profile of California – somewhere near the middle of the state. Because of global patterns of air circulation, wind generally approaches our coast from the west. As the air sweeps across the Pacific Ocean, it picks up moisture which is deposited as rain when the air mass moves inland.

[21] The first hurdle the air hits is the Coast Range. These small mountains are only 3-4,000 feet in elevation. On the windward side of the mountains, the air rises up and over the mountains. This causes the air to cool and the moisture in the air to condense into clouds which produces rainfall.

[22] After passing over the Coast Range, the air descends into the Central Valley. You guessed it! As the air goes down it heats up and the moisture evaporates leaving the Central Valley fairly dry. This dry region on the leeward side of a mountain range is called a rain shadow.

[23] Of course the wind doesn't stop here it continues across the state, but now it reaches the Sierra Nevada Mountains. The elevation of these mountains reaches over 14,000 feet. That means that the air cools off even more than it did over the Coast Ranges. More cooling equals more condensation. In fact, the most rainfall occurs at around 8,000 feet on the windward side of the Sierra Nevadas.

[24] Once again after passing over the Sierra Nevada Mountains, the air descends into the Owens Valley and what do we find there? That's right, a rain shadow. If fact much of Owens Valley is like a desert. So

now you should be able to complete the exercise on "Wind and Rain Shadows" in Section 2. Return to the program when you have finished.

[25] Let's see if you understand this concept by dragging the labels to their proper locations on the transect. When you have them correct, continue with the program.

Section 3 - Food Chains and Webs

[26] Now that you have an idea about abiotic factors, we'll focus on biotic factors. The first we'll look at is trophic levels. A trophic or feeding strategy is simply how an organism obtains energy. Plants start the whole feeding relationship by obtaining energy from sunlight during photosynthesis. Plants are considered producers and are autotrophs or self feeders. Copy this definition of autotroph in your lab manual.

[27] Organisms that are not able to make their own food are considered heterotrophs. Copy this definition as well.

[28] Heterotrophs can be divided into categories as well. The first, consumers and can be herbivores, carnivores, or omnivores as you see here. Again copy these definitions.

[29] The second, decomposers, are consumers that feed on nonliving organic materials. Copy this last definition into your laboratory manual and then we'll continue.

[30] If we put these different types of organisms into a linear representation of who eats whom, we get a food chain. Look at the food chain here and in your laboratory manual. It is a simple food chain with the arrows showing the direction of energy flow. Energy flows from the sun to the grass which undergoes photosynthesis. The grasshopper then eats the grass and obtains its energy and so on down the line.

[31] When energy passes through a food chain, not all of the energy is incorporated into the next level. For instance, the grasshopper has to hop around to find its food, it has to eat and process the food, and it has to stay away from predators. All of these activities require energy and to make matters worse, every time energy is transferred, some is dispersed as heat! The end result is that only about 10% of the energy makes it into the grasshopper's growth and is available to the next trophic level.

[32] See if you can follow this example and choose the correct amount of energy for the last organism in the food chain. If you do this successfully, you are ready to complete the exercise on energy transfer in a food chain in your laboratory manual. Return to the program when you have all the kilocalories recorded and decided if there are more grasshoppers or hawks.

[33] Did you say more grasshoppers? Great! Let's continue.

[34] As you can imagine, nothing in nature is as simple as a linear food chain. Food chains are interconnected into more complex food webs as you can see here. The more complex or the more links a food web has the more stable it is. Notice again the arrows point in the direction of energy flow.

[35] The last part of Section 3 shows you a food web with the arrows missing. The information here and the next program page will tell you who eats whom. As you draw in arrows to show energy flow, remember the arrows always point in the direction that energy flows from one organism to the next. Start placing your arrows with this information and then continue.

[36] Here is the second part of the food web information. Finish placing the arrows and then continue.

[37] Now that you have all of the arrows completed you can place an "H", "C", or "O" in the box next to each organism to show whether each is an herbivore, carnivore, or omnivore. When you have completed the food web have the lab instructor check and sign off your work and then return to the program.

Section 4 - Stem Structure

[38] Since plants are the producers at the base of most food chains and webs, they deserve a closer look. For this closer look, we will first consider tissues of the stem. Plants need to get their leaves up and into the sunshine and have a water source in order to carry on photosynthesis. The plant stem provides support for the leaves and transports water up to the leaves. It will also transport photosynthetic products back down through the plant.

[39] Obtain a slide of a stem cross section and focus it under the scanning lens. Notice that it has a regular pattern of vascular bundles around the stem. Change to low power and focus on a small portion of the stem containing a few vascular bundles. Once you have these in focus, switch to high power. Now you can fill in the missing cells in the outline of the stem in your lab manual. Sketch the cells in the regions you see labeled here. Notice you are only going to fill in one quarter of the stem. We'll get to the functions after you have finished sketching and labeling.

[40] Now that you have sketched the cells of the regions and tissues of the stem let's find out what they do. The plant stem has several regions and tissues that you see in the table of Section 4. Copy the function of each before proceeding to the next page in the program. The first tissue is the epidermis. You can see its function and structure here.

[41] The cortex is a region made up of parenchyma cells and found interior to the epidermis. Here is its structure and function.

[42] The pith is found in the interior of the stem and is also made up of parenchyma cells. Once again, here is the function and structure.

[43] The vascular bundle is made up of two tissues, xylem and phloem. While they are both involved in transport, as you can see here they transport different things. Be sure you have the functions of all of these structures and regions copied into your lab manual and then return to the program.

Section 5 - Flower Structure

[44] Section 5 examines flower structure. Flowers are actually modified leaves and are important in plant reproduction. In this diagram you can see the important parts of a flower. Copy the names of these structures into the table in your lab manual and then return to the program.

[45] As I talk about the various structures, be sure to copy the functions into the table. First are the petals of the flower. Often these are quite colorful and showy. As we will see in the next section, they can be important in attracting pollinators.

[46] Structures b, d, f, and e comprise the female portion of the flower. Their functions are listed here for you to copy into the table.

[47] The anther, supported by the filament is the male portion of the flower. Copy the function of the anther into the table.

[48] The sepals are green most of the time, but in flowers like tulips, they look the same as the petals. Regardless of their color, they form the outside of the flower bud and protect the flower before it blooms.

[49] Take a look at the cross section of this flower. Can you identify the different structures in an actual flower? Be sure you have all the information on the flower structures copied into the table and then you can continue.

[50] Did you get all of that? See if you can drag each label to the correct structure. Once you have them correct, continue with the program.

Section 6 - Flower Reproductive Strategies

[51] Plant reproduction relies on the sperm cells enclosed in the pollen grains getting to the ovules in the ovary. Pollen from one plant can get to another plant in a variety of different ways. In grasses and pine trees for instance, wind will blow the pollen. Of course this is pretty hit or miss, so other more efficient methods of pollen transfer have evolved.

[52] Before we go on, take a moment to prepare a slide of some pollen grains. In the first part of Section 6, sketch and measure one or two of the pollen grains and then return to the program.

[53] The next few program pages will look at organisms that transfer pollen from one flower to another. Flower scent, color, and shape all play a part in attracting pollinators. After the scent attracts them, the nectar is a food reward. A flower's structure is adapted to the pollinator so it can obtain the nectar.

[54] As we go through the following pollinators I will only show the most common types of flowers they use to make it easier for you. Many insects pollinate flowers, but one of the most well known is the honeybee. Here you see the type of flowers they typically visit.

[55] Another insect pollinator is the butterfly. Here is the type of flower they like.

[56] Birds are also pollinators and the humming bird is quite adept at obtaining nectar and thus pollen from this type of flower.

[57] Lastly, there are different mammals that pollinate flowers as well. Here you see a bat with one of its favorite flowers. Since bats are active at night, white or pale colored flowers are more visible.

[58] OK, let's see how well you can match the flower with the pollinator. When you have matched them up correctly, continue with the program.

[59] Pollination and fertilization of the ovule has been successful and now the resulting seed needs to be dispersed away from the parent plant. By moving away from the parent plant the seedling will have more room to grow and it won't be competing with the parent plant for nutrients and sunshine. The dispersal can be by physical or biological means. The mechanism that disperses the seed is called a vector – thus physical or biological vectors disperse seeds.

[60] First let's look physical ways in which seeds can be dispersed. Many seeds have structures that catch the wind and can be blown to new areas like dandelion seeds. With tumble weeds the whole plant blows around and as it tumbles, seeds are scattered.

[61] Gravity will cause seeds to roll downhill and in some cases this will move the seed far enough. However, water can help the process. If you have only seen coconuts in the grocery store, you don't

know what it looks like when it falls off the tree. They have a fibrous husk and float very well. This is how coconuts are dispersed among islands. The coconut falls off the tree, rolls down the beach and is carried by ocean currents to another island.

[62] The second means of seed dispersal is biological. Animals that store seeds for later use are a common means of dispersal because the animal doesn't go back and dig up all of the seeds it stored. This squirrel is a good example.

[63] Other animals eat fruit that contains seeds. They simply digest the fruit around the seed and pass the seed itself through the digestive system to be deposited at a different location.

[64] A lot of seeds can stick to an animal and be transported. Seeds can get tangled in the fur of an animal to be scratched, chewed, or pulled off at a later time in a different place.

[65] Some seeds produce sticky substances that adhere to an animal. Mistletoe is an example of this type of dispersal. The seeds stick to the feet of birds and are transported to new branches.

[66] Take a look at these seeds. See if you can match the dispersal mechanism to the seed. When you have matched them up correctly, finish Section 6 by finding the seeds on display and filling in the table. Return to the program when you have completed the table and had the instructor check the table.

Section 7 – Symbiosis

[67] Another interesting interaction between organisms is a symbiotic relationship. In your laboratory manual you can see that this is a relationship where there is some direct physical contact between the organisms. The contact can be for the lifetime of the organisms, or for a shorter period of time. There are three different types of symbiotic relationships based on the type of interaction between the organisms.

[68] As we look at these symbiotic relationships fill in the table in Section 7. You can also find examples on demonstration in the lab. Mutualism is a relationship where both organisms derive benefit from one another. This is sometimes described as a "+" "+" relationship. You can see a plant and animal example here.

[69] Commensalism is a relationship where one organism benefits and the other member of the relationship is neither benefited nor harmed. This is sometimes described as a "+" "0" relationship. Again here is a plant and animal example.

[70] Parasitism is a relationship where one organism benefits at the other organism's expense. This is sometimes described as a "+" "-" relationship. Parasites are some of the most fascinating organisms because of their adaptations. Parasites can be external or internal. Take a look at these parasites. Be sure you have completed the table before you continue.

Section 8 - Plant Adaptations to the Environment

[71] Plants, unlike animals, are stuck where they start to grow so they must be adapted to their environment. In Section 8 you will see a table that lists a few of the communities found in California. For each community copy the habitat characteristics in your laboratory manual. Before you go on, can you remember the correct definition of a community?

[72] Coastal Sage Scrub is a community growing in the Coast Ranges. The ocean has a moderating effect which produces a mild climate. While the rainfall is low, only 10-20 inches of rain per year, the proximity of the ocean keeps the area moister and cooler.

[73] Chaparral occurs inland. It tends to be hotter during the summer and less humid than in the Coastal Sage Scrub so the plants here are more drought adapted. If you have ever driven out of the San Fernando Valley, you have passed through Chaparral or Coastal Sage Scrub.

[74] Grasslands, as the name suggests, contain mostly grasses. This community is found in hot inland and central valleys as well as valleys within the coastal ranges of California. In most areas the native grasses have been replaced by non-native species or agriculture. During years with heavier winter rains, wildflower displays can be spectacular.

[75] Coniferous Forests are dominated by what we commonly refer to as pine trees. This community occurs at higher elevations (although along the northern California coast it may occur at sea level). The mountain coniferous forests have warm summers and cold winters with snow and thus a much higher annual rainfall then the previous communities.

[76] Alpine habitats occur above tree growth limit. Permanently frozen soil or permafrost exists here and only the surface layer of soil thaws out in the spring and summer. Extreme winds also occur, making it even tougher on plants.

[77] Hopefully you remember the rain shadows you identified in Section 2 so you know where dry areas can occur. In California, deserts are typically found in rain shadows. Be sure you have these characteristics listed and then continue with the program.

[78] Now that you know some of the physical characteristics of the communities, we'll look at how plants are adapted to them. Here you see some adaptations that are common in alpine plants. The plants tend to be small and low growing. This helps them avoid drying winds. Their leaves may have waxy cuticles to prevent evaporation. Their flowers often droop, facing the ground to capture the heat radiated from the soil.

[79] The Coastal Sage Scrub has plants that are adapted to dry climates. The leaves may be light in color to reflect the heat. They might also be small in size or covered in hairs to reduce evaporation. Here are some examples.

[80] The Chaparral also has plants adapted to a dry climate, but here it is hotter than in the Coastal Sage Scrub. Many chaparral plants have waxy cuticles to retain water. The leaves can be thick and leathery which protects against the heat as well. Small leaves once again reduce evaporation. Some plants have leaves in fascicles where they protect each other from sun and drying breezes.

[81] Grasses are also drought tolerant. They grow close to the ground thus exposed to less drying winds. Also, their leaves can roll up so less surface area is exposed to the environment.

[82] Conifers have small, needle-like leaves with a small surface area and a waxy coating to reduce evaporation. They survive cold winters by preventing their cells from freezing.   Plants growing beneath the conifers are adapted to growing in acidic soils.

[83] Desert plants have some of each of the adaptations we have already talked about, plus a few others. Since rainfall is not only low, but unpredictable some plants have a very rapid life cycle. They grow and bloom very quickly and are consequently very small. Other plants like the Palo Verde tree loses its leaves when it's dry and the green bark takes over photosynthesis. Without leaves, the plant loses less water. Spines are also common on desert plants. They provide shade and a windbreak which will both reduce water loss. Pleated stems on cacti allow the plant to take up and store lots of water when it does rain.

[84] Now that you have seen some adaptations complete Section 8 by looking at the plants on demonstration and describing their adaptations. The alpine plant has been done for you as an example. Pick out a plant for each of the other communities; list its name, and one of its adaptations and how that adaptation functions. Return to the program when you have finished.

Section 9 - Human Impact: Population

[85] In Section 9 we will start by looking at how fast the human population is growing. Find the computer in lab that has the population time clock running. Record the time and the population size – I know you have to be quick because it changes so quickly – so just get close. When you have finished looking at some population growth curves I'm going to have you return and once again record the time and population. Return to the program after getting your first population number.

[86] Organisms are adapted to have excess biotic potential. That is they are capable of producing more offspring during their reproductive life than those needed to replace themselves. For example rabbits reproduce – well like rabbits. They have multiple births each reproductive season which ensures that there will be survivors to continue the species even though the death rate is high.

[87] But what if there isn't a high death rate? What if all offspring survive to old age? If this happens, there would be exponential growth of the population – it would grow more and more quickly. The growth curve would look like a "J" and is thus called a J-shaped curve which you see pictured here. Draw a curve like this in your laboratory manual on the exponential growth graph.

[88] When you look around the environment, you don't see lots and lots of every kind of plant and animal. This is because not all offspring survive to an old age. Some get sick and die, others get eaten. There isn't enough space or resources for all organisms to survive.

[89] When you look at this graph, notice that there is a line called the carrying capacity. This is the maximum number of individuals of the species the environment can support. The carrying capacity will cause the population number to level off. Draw the carrying capacity and logistic growth curve in your laboratory manual.

[90] I've shown you just two possible population growth scenarios but there can be others. At this time go back and get your second human population reading and complete Section 9. Return to the program when you are ready to continue.

[91] Did you predict that the human population growth follows the exponential growth curve? If so, you are correct. You can see the human population growth curve here. If you want to know where the carrying capacity is for humans, you will get different answers from different sources.

Section 10 - Human Impact: Ecological Footprint

[92] In this last section, you will calculate your ecological footprint. An ecological footprint takes into account the earth's ability to recycle and regenerate the resources used by humans. As you will see, sometimes the human demand for resources is greater than the earth's capacity.

[93] For each of the seven tables in Section 10, you will need to look at each activity and decide which is closest to your lifestyle. Place the points in the "my points" column and total each table as you go along. At the end you will need to transfer all of the table totals to the "Ecological Footprint Summary" where you will total the points for your lifestyle and see how many acres it takes.

[94] I hope I haven't worn you out with all of the calculations! Let's see how your footprint compares to some other average footprints. While there is not complete agreement and numbers will change over time, here is a typical average world footprint. How does this compare to your footprint? Do you use more acres or fewer acres?

[95] If everyone on earth used the same number of acres as you do, how many worlds would be needed? As an example, the calculation of worlds needed is shown for the average world footprint. Use the formula below this to determine the number of worlds needed if everyone had the same footprint as you calculated for yourself.

[96] Industrialized countries usually have larger footprints. How does your footprint compare to that of the United States? Notice that the United States does not have enough acres available to support this average footprint.

[97] Take a look at the footprints of some other countries. As you can see some are very large while others are small. Thinking about your own footprint, do you have a large or small impact on the environment?

[98] Now go back over your activities. Are there any you could change to lessen your impact? For example, could you recycle more? Maybe change regular light bulbs to compact fluorescent bulbs. How about turning off the water while brushing your teeth? See if you can find some simple changes you can make.

[99] Making changes can be inconvenient or in some cases difficult. Thinking about your answers to the last question, how would these changes impact your lifestyle. Changing light bulbs would probably not have a great impact. Getting a more fuel-efficient car is more problematic due cost considerations. If you already have a small footprint you are obviously doing your part to take care of the environment. If not, think about some changes!

Section 11 – Article Review

[100] Now that you have answered the questions at the end of section 10 you are almost done! To complete Section 11 choose one the articles from the demo table that you find interesting. After reading the article, summarize it in a few sentences and then write a few sentences about what you found most interesting about the article or how you might use the information in the article in your daily life. Once you have completed the article review you are ready to go. We'll see you next week.