Lab 5 Immunity and Nutrition

(June 2014)

Section 1 - Bacteria

[2] For today's lab, we'll go through some of the basics of human health – a few of the common disease-causing agents, immunity and nutrition. I can pretty much sum up the lab by saying "wash your hands and eat more vegetables", but that's not really enough knowledge for a college-educated person like yourself, so let's get to some of the details, starting with bacteria.

[3] The first thing you should appreciate about bacteria is that they are everywhere. You can find bacteria in every temperature from Arctic ice to the hottest boiling hot pool, in every level of pH, and every oxygen condition. Each species has evolved a complex chemistry suited to each of those environments.

[4] We looked at the basic cell structure of bacteria last week and you saw that bacteria are pretty simple in construction, but you should realize that they are extremely efficient at growing and dividing. When an organism is that small, it doesn't take much in the way of nutrients and oxygen to keep them going, and as long as they have food, they can reproduce asexually perhaps as often as every 20 minutes.

[5] Some bacteria require oxygen to grow, just like we do, and these are called "aerobic" bacteria. Some bacteria, however, don't need oxygen at all because they use a different chemical system for respiration that allows them to live in oxygen-free environments. These types of bacteria are called "anaerobic". Record the two types of bacteria in your lab book.

[6] An example of an anaerobic species is *Clostridium botulinum.* Because this species doesn't need oxygen, it can live inside a sealed can of food. These bacteria can release a deadly toxin and could kill someone who unknowingly ate that food. You may have heard of this toxin in another context, when it is used in very small doses to paralyze facial muscles, which cosmetically reduces the appearance of wrinkles. In this form the toxin is called "botox".

[7] Another way we can classify bacteria is by their shapes. Record the three different bacterial shapes by drawing the cocci, bacilli and spirals in your lab book.

[8] Although bacteria have a reputation for causing diseases, very few actually do. If they do cause disease, they are called "pathogens" a term which comes from the Greek roots "to give birth to" and "suffering". Here is a listing of some bacterial diseases you may have heard of. Please record at least four of these diseases in your lab book and record the definition of pathogen before we go on.

[9] Almost all the other bacteria found on earth are completely harmless. In fact, humans generally carry quite a few around on a regular basis, and these are called our "normal flora" or sometimes our "microbiota". It's a good thing we do carry around so many kinds of bacteria, because the more regular, harmless bacteria we have along for the ride, the less chance a pathogenic species will be able

to gain a foothold. Take a minute and describe the difference between normal flora and pathogens before we continue.

[10] There are roughly 1000 species of bacteria that live on the outside of humans, shown here. These are in addition to the almost 200 kinds of bacteria in your intestine we talked about last week. Record the total number of species in your lab book. As long as these skin bacteria stay on the outside there's no harm to us.

[11] It is perfectly normal to have these friendly bacteria on our skin because they are keeping the bad ones at bay. What you ***don't*** want, however, are these normal skin bacteria getting into your bloodstream, where they might become pathogenic in that new environment. That's why it's so very important to wash cuts and scratches and keep wounds covered to keep the skin bacteria where they belong - on the outside.

[12] We can look at some "normal flora" by growing bacteria on small plates called petri dishes. Petri dishes have a clear, gelatinous substance called agar that contains an additional nutrient broth. To speed up their growth, the plates can be placed in a warm incubator for a few days. Record the process of how bacteria are grown in a laboratory before you continue.

[13] Last week we asked a few student volunteers to touch a petri plate with their fingertips to see some examples of normal flora. Observe the "student plates" at the demo table and estimate how many different species are growing on a particular plate. You may choose any of the plates for your estimate, but please! Don't open any of the plates!

[14] Another way bacteria can get into our bodies is through our food. Our stomach acid, with a pH of 2 or less, can generally kill most bacteria, but there are a few food-borne pathogens that can get by even the stomach acid. So clean that cutting board and kitchen counter, wash your hands after handling raw meat and cook food thoroughly. Remember, bacteria are very small and there are lots of them. Everywhere.

[15] If a pathogen does get past your defenses, you're probably thinking, no problem, we've got antibiotics to get rid of them. Well, that used to be the case, but recently we're finding that bacteria are changing a little faster than we can develop drugs to fight them. Record the definition of an antibiotic before we go on.

[16] We can test to see if an antibiotic is effective or not with a special petri plate called a Kirby-Bauer plate. Each petri plate has just one species of bacteria - one plate has *E. coli*, and the other has *Staphylococcus aureus*, commonly called *Staph*. Instead of little colonies of bacteria as we saw on the "student plates", in this case the bacteria were applied in a continuous coating, and will appear as a pale material on top of the agar. The little white discs that you see on the plate have been soaked in different antibiotics.

[17] If you see a clear area around the disk, this means the antibiotic has effectively stopped the growth of its small area of bacteria. But if you see the bacteria growing all the way up to the disk, then the antibiotic is unable to stop the growth of that species and we say that that bacterial species is resistant to that particular antibiotic.

[18] Now you can go to the demo table and find the Kirby-Bauer plates with the two species of bacteria. Determine which would be the most effective antibiotic in stopping the growth of each species and fill in the table of Section 1. And again! **Please don't** try to open the plates! Return to the program after you have filled in the table, answered the questions and had the table checked by the lab instructor.

[19] Whenever a doctor prescribes an antibiotic for you, it is VERY important that you take the medication as instructed. Each species of bacteria occurs in varieties or strains, and some varieties are a little tougher to kill than others. If you stop taking a course of antibiotics too early, you are leaving the toughest bacteria behind, creating a very dangerous variety that is a hazard to you and the rest of us.

[20] The very best defense against pathogenic bacteria is clean living, and by that I mean washing your hands. Your normal flora will do their best to keep invading bacteria away, but look at the effect of hand washing at the demo table. Compare the plates cultured from unwashed hands and washed hands and record your observations in your lab book.

[21] Now you may have heard that using a hand-sanitizing gel is just as effective as hand washing, but studies have shown that the alcohol in the gel must be more than 60% to have any effect, and the gels can't get through dirt and grime. So if you don't have access to soap and water, you can use the gels as an alternative, but a thorough scrubbing of soap and water is much more effective. Now make sure you've answered all the questions in Section 1, and continue when you're ready for some questions.

[22] Now let's see how much you've learned about bacteria.

[23] Which of these antibiotics would be most effective against the bacterium shown here?

Section 2 - Viruses

[24] Now let's discuss another potential pathogen, the viruses. Viruses are non-living infectious agents. They are considered non-living because they can't use energy or reproduce on their own – they must invade other cells to make more viruses. Record the definition of a virus.

[25] The living cell that a virus invades is called the host cell, and there is a virus that infects just about every living thing on earth. Even bacteria can catch viral diseases. Here are some viral diseases you may have heard of.   Record at least three of these viral diseases in your lab book.

[26] The word "virus" comes from the Latin word for "poison" and there are over 5000 named viruses. Their names are not regular scientific names like *Homo sapiens*, however. Virus names are often just numbers and letters, like H1N1, that describe the proteins that make up the outside layer. The inside of the virus contains just a few genes of either RNA or DNA.   Complete the labels on the virus shown in your lab book.

[27] This animation shows a single virus using a host cell to reproduce. The virus leaves its protein coat on the outside of the host cell, and inserts its genes into the host. The host cell uses the foreign DNA to unknowingly make more viruses, eventually killing the host cell when the new viruses burst out. Continue on the next page of the program and I'll have you copy a labeled diagram of this sequence.

[28] Complete the labels showing the life cycle of viruses in your lab book.

[29] Some viruses have an extra sneaky trick. These viruses actually grab a piece of the host cell's membrane on their way out of the host cell, thereby disguising themselves in the host cell's clothes, essentially. These viruses are called enveloped viruses and the ones which cause HIV/AIDS and influenza are examples of enveloped viruses. Record these examples in your lab book and answer the next few questions as we go along.

[30] Viruses can't be killed in the traditional sense, since they aren't living things. An antibiotic that you can take to get rid of a bacterial infection would have absolutely no effect on a virus - the chemistry and life cycles are totally different. There are a few antiviral drugs you may have heard of, such as Tamiflu or Relenza, and they work by inhibiting the function of the viral structures.

[31] If viruses can't reproduce on their own, then how do we grow them for study? It's not easy – there's no little agar petri plate for viruses. Instead, viruses are cultured inside other living cells such as chicken eggs or in special cells grown in the lab.

[32] The best way to prevent the spread of viruses is – you guessed it – washing your hands. Viruses can be picked up anywhere, and keeping your hands clean is the best way to keep them at bay. But humans also have a fairly reliable system for fighting both invading bacteria and viruses, the cells of our immune system, which we will cover next.

Section 3 - Blood Cells and Immune System Basics

[33] Before we get to how the immune system works, you need to know the components of blood. You may think of blood as simply a bunch of red blood cells, but remember that it is actually a very complex type of connective tissue, made up of four components.

[34] The components of blood are red blood cells, white blood cells, platelets and plasma. These components are shown here by how much of the blood volume they take up. The white blood cells seem pretty rare, but you will see in a moment they are critical to keeping you healthy. Let's go through each of these components one at a time.

[35] The plasma is mostly water, but it also contains some hormones, salts, vitamins, clotting proteins and antibodies. It provides the fluid medium to allow blood cells to flow efficiently around the body.

[36] Platelets are spiky particles that are critical in blood clotting when you have an internal injury.

[37] The red blood cells, also known as RBCs, are very odd little cells. They only have one job - carry oxygen to the body's tissues, then take away the waste carbon dioxide. To do this single job, they don't need to grow, divide or produce any molecular products, so they don't contain any special organelles like mitochondria or ribosomes, and they don't even have nuclei. 95% of a red blood cell is hemoglobin, a protein that carries oxygen and carbon dioxide.

[38] The white blood cells, the WBCs, are what keep us healthy. They are our internal defense system as well as the clean-up crew when our cells are worn out. There are five types of white blood cells with fully functional organelles including nuclei. Identify the blood components shown in your lab book before we go on.

[39] Examine the human blood slide in your slide box in your booth and locate the very numerous red blood cells compared to the rarer white blood cells. Look for a WBC that resembles the one shown in your lab book, then continue after you have answered the question about blood cells.

[40] Remember that one of the jobs of white blood cells is to engulf worn out cells in a process called phagocytosis. Record the definition of phagocytosis and then let's see if you can answer this question: What organelle would be numerous inside a white blood cell? (mitochondria, lysosomes, ER or ribosomes?)

[41] That's it - lysosomes. After the white blood cell surrounds a foreign cell, the lysosomes go to work breaking it down and digesting the cell. This is just one of the ways your immune system keeps you healthy. Take a minute and make sure you've answered all the questions about blood before we go on to how the immune system works.

[42] Now let's see how blood is involved with fighting pathogens. You remember that all cells have proteins incorporated into their membranes, yes? Well these proteins act as identifiers, sort of like a name-tag. The viruses have proteins on the outside as well, so your immune system can identify them too. These identifying proteins are called antigens. Antigens don't have to be parts of cells, they can be any protein that causes an immune response. Record the definition of antigen in the table of Section 3.

[43] The molecules in plasma we're interested in are Y-shaped proteins called antibodies. Antibodies are able to stick to specific sites on a foreign cell's proteins, much like a key made for a particular lock. Record the definition of antibody in the table.

[44] Antibodies are produced by specialized white blood cells when they first encounter foreign proteins, and are an important component of blood plasma. Whenever a WBC detects antibodies attached to a cell, it indicates that the cell is foreign and the WBC will destroy it. Record this interaction in your book.

[45] On our first exposure to a foreign protein, let's say it's the outside of a cold virus, our WBCs will produce antibodies. However, it takes time to generate enough antibodies to mount an effective defense and label all those invaders. The infection may last several days to more than a week before the immune system has effectively quelled the invader and you start feeling better.

[46] The good news though, is that once you've been exposed to a virus, you now have immunity to that virus forevermore. What happens is that the exposure initiated the production of antibodies, so when your body comes in contact with that virus again, your immune system will mount an effective defense in just a few hours, not enough time for the virus to get another foothold. Answer the question about exposure to viruses before you go on.

[47] We can make use of this immunity mechanism to make vaccines. A vaccine is often a disabled version of a virus, with the identifying protein ID name-tags intact. Some vaccines just have the antigen that would still stimulate the immune system, and we'd react the same way as if the vaccine were an actual infection. Record how a vaccine works in your lab book before you continue.

[48] Here are some diseases for which effective vaccines are available. Record three of these in your lab book. I should mention though, that although the influenza vaccine is on this list, it's a bit trickier than the other diseases.

[49] The virus that causes the flu, or even the common cold for that matter, is just too flexible for scientists to develop the perfect vaccine. Every year, millions of people get colds and flu because those viruses are constantly mutating. A mutation is just a slight variation in their proteins that confuses our antibodies. It's like they switch name-tags every year, so scientists are chasing a moving target.

[50] But one thing all flu viruses have in common is that they can spread through a population very quickly, so wash your hands frequently when it's flu season and if you do get the flu, please, people, STAY HOME!

Section 4 - Health Decisions - Smoking

[51] Okay, you've all seen enough stop smoking ads in your lifetime, so you're already very aware of lung diseases such as emphysema and lung cancer. But even without these two deadly diseases, maybe you'd like to see what all the fuss is about?

[52] Examine the slide showing lung tissue damage and compare the tissue with the healthy lung tissue shown here. Record your observations in your lab book. As you look at your slide, please appreciate what a very tiny piece of lung you're actually observing through the microscope and how very dirty it is.

[53] It's not just the accumulated dirt that's the problem. Inhaled smoke contains free radicals, which are molecules or ions with unpaired electrons. As these molecules seek out electrons to complete their energy shells, they damage the stable molecules around them, such as those that make up cell membranes or the DNA of your chromosomes. Record the definition of free radicals and the damage they cause.

[54] Smoke can also wreak havoc on your skin. Years of damage to DNA and membranes results in less blood flow to the skin, starving the skin of nutrients and oxygen. Smoking also increases an enzyme which breaks down collagen, a molecule which keeps your skin smooth and flexible. Collagen naturally decreases as we age, so smoking in essence speeds up the aging process, resulting in a wrinkly, gray "Smoker's Face". Record the cellular damage done to skin by smoking in your lab book.

[55] Here's a list of diseases in which smoking has some role. Now you can see why one of the first questions a doctor asks you is if you smoke. Record at least three of these diseases in your lab book.

Section 5 - Health Decisions - Sleep

[56] For this health topic, I'd like to make you aware of what your brain is up to while we sleep. The brain is not resting like the rest of your body. New research has revealed that the brain is actively making connections of our life's experiences while we sleep.

[57] When researchers tested the ability of subjects to retrieve facts and figure out puzzles, in every case, if the subjects were allowed to sleep on it, their performance improved.

[58] Just like computer memory, there are areas of the brain that store information for the short-term, like the day's events. What makes an experience a long-term memory is when it is stored in the brain's hard drive - the neocortex, that wrinkly outer layer of the brain. Sleep is required to shuttle new memories into the neocortex and to link the new events with the information already stored in the brain.

[59] In addition to sleep enabling the brain to store information long-term, it also helps you make new, novel connections. There are many tales from science history where a scientist has woken up with a brilliant new idea. Dmitri Mendeleev awakened from a dream that gave him the idea for the periodic table of elements – an idea that revolutionized the study of chemistry.

[60] A recent study tested how brains make connections during sleep. The experimental subjects were asked to complete some calculation puzzles in which the seventh calculation was the answer to the puzzle. Some subjects were allowed to sleep between puzzle solving and they showed some improvement over subjects that did not sleep, as expected. But the important result was that the players that slept were often able to discover the hidden shortcut in the game - that the second calculation was always the same as the seventh.

[61] Sleep affects other aspects of your physiology as well. Researchers studied the body chemistry of subjects which had their sleep repeatedly interrupted. They found that poor sleep patterns resulted in an increase in a key molecule that causes inflammation in the body. Inflammation is implicated in cardiovascular disease, arthritis, diabetes, certain cancers, and obesity. List three of these before you go onto Section 6.

[62] So if you want to be healthy, slim and smart, get regular sleep. But not right now - it's time to introduce Professor Koller for the rest of today's lab.

Section 6 - Health Decisions - Energy Needs

[63] Thank you Professor Farris. This next portion of the lab deals with nutrition. I'm sure you have all heard the old saying, "You are what you eat." Since you are all familiar with the organic molecules we studied in Lab 3, you can probably figure out that the molecules that make up your body come from the food you eat.

[64] Well, how many molecules do you need in a healthy body? If you ever listen to the news you have heard about the epidemic of obesity facing the country. How do you know if you are or aren't a healthy weight?

[65] One simple way of determining where you stand health wise with your weight is to calculate your BMI or body mass index. There are several ways to determine this, but we will use a simple calculation that uses your height and weight. At this time I am going to ask you to calculate your BMI in the first part of Section 6. If you don't want to use your actual numbers in the lab manual it's OK, but you should know your true BMI for your own information so calculate it for yourself. Once you have calculated your BMI come right back to the program.

[66] Now that you have a number for your BMI, compare it to those shown here. Within which category does your BMI fall? Record this in your lab manual below your calculation. Because this calculation does not tell you about your percent of body fat it may not always be a definitive picture of your health.

[67] You might be thinking -"OK, so what if I am a little overweight?" As you learned in the first part of this lab, there are many causes of diseases, and being overweight is always a factor. Here you can see just a few of the problems carrying too much weight can cause. Also, you can see the increase of obesity in the United States from these maps. This is a definite health care concern.

[68] Time to get up and take a stretch! Go over to the demonstration table and look at the fat model there. How much do you think that fat blob weighs? Take a guess, record it in your lab manual and then come back to the program

[69] Now that you know where you stand in the weight category, what do you do with that information? If you are a healthy weight, you probably want to stay there. If you are in the overweight or obese category you may want to lose weight. Back to the food you eat. Aside from being part of your body, molecules from food also provide energy to run your body's activities.

[70] Energy is measured in a unit called a kilocalorie or Kcal. The technical definition of a kilocalorie is show here, but you don't need to memorize it. To determine the number of kilocalories in food it is burned in an apparatus that measures the heat given off. OK, I know, too technical, back to the useful real life stuff.

[71] You may not have seen Kcal used too many times because we are used to the more common Calorie with a capital "C". One Calorie is the same as one kilocalorie. Let's translate this into the food you eat.

[72] Exactly how much food do you need to eat to provide building materials and energy without getting too much of a good thing? As you can see here and in your lab manual you can lose weight by eating fewer calories than you expend. You can gain weight by eating more calories than you expend. If you match your calorie intake with your energy expenditure you should remain the same weight.

[73] The next exercise you will complete in Section 6 determines the number of calories you expend in a 24 hour period. This will only be an approximation, but if you are realistic in your estimates, you should get a fairly reasonable number. Let's look at some of the activities you might choose.

[74] Resting – this should be pretty obvious. You don't need a lot of calories while you are sleeping. And don't use the two hours of sleep you get on a night when you are up cramming for an exam – which you know won't help your memory or your exam score!

[75] Very Light Activity – this basically involves sitting and not doing much else – the proverbial couch potato in front of the TV or studying which always seems like hard work, but doesn't use that many calories.

[76] Light Activity – this one is a little tricky because walking can be a stroll or a fast walk. Light activity would be a stroll. Household chores can include dusting, vacuuming, or other onerous chores.

[77] Moderate Activity – this would include very fast pace walking, as well as bicycling and jogging.

[78] Heavy Activity – be realistic with this one. While you may engage in these activities for a short time each day, you probably don't spend hours at them. OK, calculate the total calories you expend in a typical day and then return to the program.

[79] Remember that chemistry? The nutrients that you get from your food come from three of the biologically important molecules – proteins, fats from the lipid group, and carbohydrates. A balanced diet should have a certain percent of each. Write these percents in your lab manual.

[80] Just knowing these three nutrients don't tell the whole nutrition story. We also need to look at a few more things about food. Record these figures in your lab manual as we go along. You know that fats can be saturated or unsaturated. A healthy diet restricts the intake of saturated fat calories.

[81] The muscles in your intestines need exercise like all muscles. Dietary fiber provides this exercise. Fiber can also be useful in lowering cholesterol and regulating blood sugar levels. With this in mind, record the grams of fiber you need in your diet.

[82] Cholesterol has a bad reputation, but your body does need cholesterol to make many important molecules. The idea is to limit dietary cholesterol because your body can make the cholesterol it needs. Record the cholesterol intake before you continue.

[83] The last item to list is sodium intake. High sodium intake can increase blood pressure and increase the risk of heart disease and stroke. Record the recommended daily consumption. To put this in perspective, one teaspoon of salt (that's sodium chloride) contains 2,400 milligrams of sodium.

[84] Got that calculator handy? To complete Section 6, I am now going to have you calculate what you need in your daily diet. Take the total kilocalories expended daily that you calculated previously, and put it in each of the left hand blanks with the star. Carry out the calculations in each line to get your daily amounts. You can see here the line for calculating the grams of protein you need. When you have completed the calculations, return to the program.

[85] You might have noticed that there were no percents or calculations for trans fats. This is because you should eat as little as possible of these fats. They both raise bad cholesterol or LDL and lower good cholesterol or HDL, thus increasing the risk of heart disease.
Lastly, be aware that dietary guidelines change over time and as new information surfaces, recommended intake of various food categories will change.

Section 7 - Health Decisions – Menu Choices

[86] In Section 7 I'm going to have you look at nutritional information from a restaurant. These days almost every eating establishment has nutritional information available online. There are several different restaurant nutrition lists in lab, but if you rather find a different one online, you may do so. Either way let me give you some additional information.

[87] First take your total Calories expended per day – that's the figure with the star – and place it in the gray shaded box under the "Recommended" amounts. There will be a star in this box too. Now in the same column, place the amounts of protein, fats, saturated fats, carbohydrates, and fiber you just calculated. These are the figures with the plus signs. For example, your grams of protein would go in the pink shaded box and so on down the column. Two other nutrient amounts are already listed.

[88] When you find a restaurant you would like to use, list the name in the space provided at the bottom of the table. Next, pick a "meal" you might want to eat. There are six spaces for menu items, but you don't need to fill all of them in if your meal contains fewer items. Also, if the nutritional information sheet doesn't all of the figures, just fill in those that are listed.

[89] Once you have completed the table and have calculated the percent of daily requirements, look at each nutrient to see if it is more or less than 33%. We'll use 33% assuming this is one meal of three during the day. With this information you can answer the questions following the table.

Section 8 - Health Decisions – Food Labels

[90] Hopefully the last exercise gave you an insight into eating out. We are now going to look at food labels and the information you can get from them. Knowing what is in food products can help you make wise food choices.

[91] Look at the first part of Section 8. Here you can see the types of information you can get from food labels. One thing is the ingredients in the product. The ingredients are listed by the amount in the product from high to low.

[92] Food additives are also listed and are added to food products for a variety of reasons. They can improve texture, flavor, nutrient content or be a preservative.

[93] The manufacturer or distributor is also listed somewhere on the label.

[94] Nutrition information is now on most food products. This can be somewhat confusing at times because the information is usually based on a 2,000 Calorie diet. Did your daily Calorie intake turn out to be exactly 2,000 Calories? Probably not.

[95] What about that serving size? If you have a product that is a single serving it's pretty clear cut if your daily Calories match the 2,000 Calorie standard. However, what if you have a box of cereal? How easy is it to determine a serving size? Do you use a measuring cup? How big is your bowl – is this the way you determine a serving size?

[96] Now go and choose a label or select one from home and fill in the table in Section 8. Once again, every label doesn't have all of the information in the table, so fill in whatever is available. When you have finished, return to the program.

[97] OK, one more little math exercise. First be sure you know the daily Calorie diet the label is using. How does this compare to your daily Calorie needs? More? Less?

[98] Look at the last part of Section 8 and determine your serving size for your food product. To do this you will need your daily Calorie requirement you calculated in Section 6, the figure with the star. Multiply your daily Calories by the serving size from the package and then divide this by the product daily Calorie diet given on the package.

[99] Assuming your serving size is different, what are your thoughts on the label information? Do you think it was useful? Will you look at food products in a different way now?

Section 9 - Case Studies

[100] To finish up your lab, choose one of the Case Studies from the demonstration table and summarize the article in a few sentences. When you have completed a case study you are done for the week! See you next time.