>> It's February 9th and it's 2015, can you believe it? It is! And tonight and every Monday and Wednesday at this time we're going to be dealing with human physiology. Like it or not the human body is basically a molecular machine and so obviously we have to deal with chemistry because molecules make up cells, don't they? Cells make up tissues. Tissues make up organs. Organs make up systems. Systems make up, well, you. So in this unit we call it Unit 1, is basically an exercise in cellular and molecular physiology and tonight we're going to take you backwards maybe into your chemical experience, your knowledge of chemistry, and just review and introduce maybe some important ideas that I hope are familiar. So to begin everything that we can see and touch and occupies space is called matter and you know that matter is made of atoms, right? What's an atom? By definition an atom is the smallest unit of matter that has and maintains a unique chemical behavior, unique chemical properties, and so we talk of what? Helium atoms, hydrogen atoms, carbon atoms and so forth and what makes one atom different from another is its subatomic makeup as you probably know. So here's the typical portrayal of an atom and I trust you recall that the center of an atom is called a nucleus and herein reside what? What do we find there? Protons and neutrons. A proton has what electric charge? And a neutron you can guess has no electric charge. These atomic or subatomic particles make up and are confined to the nucleus. Spinning around in orbits or clouds or so called shells are electrons and so these revolve at great speed around the nucleus and electrons have what charge? Negative. And are distanced from the nucleus in select orbits as you know from chemistry. Also from chemistry you know that the number of electrons typically equals the number of protons and [inaudible] have a negative charge and although protons have a positive charge the atom itself normally has a neutral charge, at least that's typical scenario. So beyond atoms we know the next level of organization [inaudible] molecule, so what's a molecule? Two or more atoms bonded together. Simple to say and certainly we can speak of molecules that are familiar, water, sugar, others that we'll get to later today, but we can't just brush over this term bond. What are bonds? What are chemical bonds? What are the ones that we care about and that we deal with in human physiology? First we have something called a covalent bond. A covalent bond you might remember is basically a bond which is created by the sharing of electrons between the atoms. So what's sharing? Some of you may share a textbook or a car or even a child with somebody. Sharing means they spend part of the time with you and part of the time with somebody else, right? That's the idea. So what are some important atoms that create covalent bonds? Here are four. In fact these four make up 90% of the atoms in your body and you know the lingo. What's H? O? Oxygen. N? And of course C is carbon. These little hatch marks here are not typos or accidents. These are indicative of how many covalent bonds each of these atoms can actually form, the maximum number so with that said how many covalent bonds can a hydrogen form with another atom? How many covalent bonds can an oxygen form? Two. Nitrogen apparently and carbon can form up to four which is part of the reason that carbon containing molecules are so complex and form the basis of life as we know it. So covalent bonds are the results of sharing electrons and these bonds are strong, that is not easily broken, but don't get me wrong they're not rigid. Can something be [inaudible] and not rigid? Of course. What about a rope, is a rope strong? But is it right? No. So these bonds are quite flexible, quite capable of bending and a little bit of twisting but nevertheless they are strong. Now that doesn't mean they're indestructible. We'll certainly see that they can be broken but they're not easily broken. They remain intact for instance in water. And speaking of water what is this molecular doodle over here on the side? It might not be clear but I'll give you a clue, this larger atom there in the center of those Mickey Mouse ears that is oxygen and you might recognize these others are hydrogen. So how many hydrogens appear to be here and with one water we know we're illustrating or attempting to show water, $H_2O$. A typical example then of a covalently bonded molecule. Now covalent bonds are strong, not rigid, but they can be polar or nonpolar so there's a topic that may not be clear instantly. Remember the electron has what charge? And if the electron is spinning back and forth remember what is being shared between these atoms are electrons. So let's imagine this laser light is an electron, okay? That's cool. So the electron's going around and around in a figure eight pattern spending part of its time around the--? And part of its time around the oxygen. If it spends an equal amount of time at both locations then that charge is equally spread or shared between those two sites and that creates a nonpolar covalent bond. But what if the electron spends more time in one location than another? Would that render one part more negative than another? And when that happens it's said to be a polar bond. A polar bond is the result of equal sharing of electrons whereas a nonpolar must be the equal sharing of electrons, and this might not seem to matter at this point but very soon we'll explain the importance of that concept. So before leaving this category what are some examples of covalently bonded molecules? $H_2O$, what's that? $CO_2$, carbon dioxide. $NH_3$? Ammonia. And $C_6H_{12}O_6$ is sugar but specifically its glucose, a molecule we'll mention virtually every lecture in this course. So all of these are held together by covalent bonds and those bonds as we had said might be polar or nonpolar depending upon the sharing of those electrons. All right the second kind of bond that's prevalent in the human body and throughout this planet, ionic bonds. Now here the electrons are not being shared, what's the word, key word here? And that means one atom actually dumps an electron and the other atom receives so it's

not a sharing it's a permanent transfer of electrons from one atom to another. So in this example we see a sodium atom. A typical sodium atom has 11 electrons and next to it here is a chlorine atom. It has 17. Now remember what's the ratio of electrons to protons that [inaudible] electrons to protons usually what? Equal. But what if the sodium atom gave up an electron? What if any atom gave up an electron? How would its charge change if it gave up an electron? It'd become positive. And if something picked up that electron then that atom would become? Right. So there you go. That's exactly what happens in this case. Sodium gives up an electron and chlorine picks it up. Therefore sodium now is positive, chlorine is now what? And what do you know about the behavior of opposite charges? If something's positive, something's negative, they're actually what? Attracted. Opposites attract. So now because of this transfer the sodium ion is positive, the chlorine is negative and they attract each other. Form what bond? What kind of bond? It's an ionic bond. They're held [inaudible] attraction. Now this kind of bond is relatively weak at least compared to covalent. So weak in fact that if you drop this molecule which we now know is sodium chloride, what's the common name for sodium chloride? So if you take a granule of salt and put it into water it disappears but on a molecular level it's doing something else, here's the word, it's dissociating, it's actually ionizing because the water will split or otherwise allow these charged atoms to move apart, that is in water an ionically bonded molecule will dissociate into ions. An ion is a charged atom. So just to recapitulate this molecule here is called what? Sodium chloride. Held together by? In water it dissociates into two things called ions. The sodium ion which is positive and the chloride ion which is negative. So these ionic bonds are weaker especially easily broken in an aqueous solution. Examples? Well examples include NaCl what's that? Sodium chloride and what's KCl? Potassium chloride. And they maybe NaOH, you played with that in chemistry I suppose, that must be sodium hydroxide. These are held together by ionic bonds. Good to go? Good to go. Next and final bond that we'll have anything to say about tonight, so called hydrogen bonds and a bit of a misnomer because hydrogen bonds actually are not bonds at all at least in the sense that we've been talking about because the electrons are not shared or not transferred so what's going on here and why are they even called bonds? Basically hydrogen bonds are very close range meaning only present when atoms are very close together, close range, very weak electrostatic attractions typically between hydrogen in one polar molecule and oxygen in another polar molecule or part of the same molecule. Now I know that's awfully wordy but hopefully it'll make sense in a moment. So hydrogen bonds can form between molecules or they can also form within the same molecule, typically between hydrogen and oxygen. Now what's the importance of hydrogen bonds? Basically they help determine the physical properties of the molecule especially for instance whether it's soluble or insoluble in water. Also determine the inner activity, even the reactivity of the molecule, and also the physical shape of the molecule. So certainly in chemical books or on Google or on TV you see molecules portrayed sometimes with a stick and ball kind of graphic and the shape is really dictated usually by the number, the arrangement of hydrogen bonds. Examples of molecules that feature or otherwise depend on hydrogen bonds. Between water, now that's a key word there, not within water but what? Between water. That means between one water molecule and another. And also within this ubiquitous iconic molecule, what's this one here? Instantly when you hear the initials DNA you have this double helix graphic in your head don't you? And that double helix is no accident, it's the result of hydrogen bonding within the molecule. The same can be said for RNA, the same can be said for proteins. All proteins have a pretzel-like shape which is really made and maintained by the hydrogen bonds. So hydrogen bonds have a lot of importance in that they determine the physical properties and the actual shape of the molecule itself. All right so let's back up. What are the three bonds we just covered? Covalent, ionic, and hydrogen. Which are the strongest, hardest to break? Weakest? Hydrogen bonds. Which actually form ions, charged atoms especially when in water, ionic, okay? Good enough. So let's move on to water which familiar enough, certainly fundamental for life. If we go out there to Mars or other planets what's the first thing we want to find there before we get too excited? Water. If we don't find water we're out of there. We know that water as we know it is the basis of life so clearly you can't overestimate the importance of water. Oh and I know if you blinked you missed that graphic, oh cool. So this is water ladies and gentleman and this O stands for? And those H stand for? Now If you look closely on the graphic you see the H has a little plus sign, right? And the O has a little negative sign and that at first might be odd because didn't we say that molecules and atoms are overall neutral? Well maybe so but what does this imply? Remember how is the hydrogen attached to that oxygen? What kind of bond is actually represented by this line right there? Covalent. And thus the electrons are not transferred, they're what? And based on this graphic does the electron spend more time around the oxygen or more time around the hydrogen? How do you know? Well the oxygen is negative. So, that's a water molecule held together by what kind of bond? And are those covalent bonds polar or nonpolar? Ahh, how do you know they're polar? Because there's not an equal sharing. So water is a classic example of a molecule held by covalent bonds. It's a classic polarized molecule. How many water molecules on the page so far? One, kind of lonely. So a single water molecule is created by hydrogen bonded to oxygen and the name of the bond is a covalent bond. Is it polar or nonpolar? It's very what? Polar. Rendering the hydrogen positive, rendering the oxygen negative. Okay, so what? Well if we toss in another water molecule will there be any predictable [inaudible] between these added water molecules? The answer is yes, eww, and in case you missed that I have to play it again so, eww. I'll do it again, this is so much fun. Now why did it do that? I know it was programmed to do that but--, why did this oxygen kiss up to that hydrogen, was it just accident or is there some explanation. Yeah. The oxygen has what net charge? And the hydrogen has what net charge? So that is not only predictable but it is obligatory meaning it's going to happen every time. And is that a bond? Yes it is. What kind of bond? A hydrogen bond. Which goes back to this statement, we have hydrogen bonds but not in the water, not in water but what's the key word, between water molecules. So that's a hydrogen bond. Eww. That's neat. And there's another one and okay these are what? Hydrogen bonds. And we can keep doing this but it's kind of boring. So remember hydrogen bonds are not sharing or even transfer of electrons but rather just a close range attraction as the definition says, an attraction between what? Hydrogen in one polar molecule and oxygen in a different or even the same molecule. So, oh, we're going to do it once again, okay great. Hydrogen bonds form with other water molecules, great, so what. Essentially the creation of these hydrogen bonds brings water molecules pretty tightly together, that is it causes them to huddle, huddle together, and therefore permits and maintains water as a liquid at what? Now this goes back to physical states of matter but you know that matter can exist as solids, right? Then liquids and then a gas. And the difference is not the chemistry but rather the density or spacing of the molecules. In other words if these water molecules were able to move apart we'd still have water but it wouldn't be a liquid, it would now be a gas. So the hydrogen bonds have this benefit shall we say. They permit water to be what? A liquid, at relatively high temperatures. Is your body a relatively high temperature organism? Yeah. So thankfully we have these hydrogen bonds otherwise water wouldn't be a liquid it would be a gas and we'd be different. So water is of course a molecule which is held together by hydrogen bonds and even though we sometimes dismiss water it's just water, it's just there like the air that we breathe. Water can be the medium in which things happen, that is it can be the solution that is the solvent or in many cases it's actually a participant, that means a reactant. It can change. So I suppose it's tempting to think of water as just a bystander, just a molecule that's there and doesn't get involved and that is sometimes the case, but water can also be a reactant as we'll see and so we don't want to think of it is inert, we want to think of it as having no reactivity, unable to change. It's certainly able to change. So let's go on and talk about water in a different light. Just a second ago we threw out the word solution I think. What's a solution? I don't mean an answer to a question but what's a solution? A solution is a fluid mixture of two or more substances, right? So whether it's Gatorade or a margarita it's still a what? A mixture of two or more substances, sometimes lots of substances. I'm always blown away when I look at the label for Mountain Dew. I mean they almost have to have you know pages devoted to it because there's so much stuff in there, but fundamentally is Mountain Dew a solution? That is is it a fluid mixture of a lot of stuff? Sure. And these things are either solutes or solvent. Solvent is typically the liquid and therefore in most contexts it's usually especially H2O so the solvent is the [inaudible] which solutes are dissolved so referring again to Mountain Dew what is the primary solvent? And what are just a few of the solutes you think are in there? Yep that's right on the list, actually technically not sure but high fructose corn syrup but okay. And what else is in there that qualifies as a solute? Caffeine. It's way up on the charts in fact that's why we buy it really. I mean if it didn't have caffeine its sales would plummet but okay. Does it have a lot of dyes and colorants and preservatives and actually wood rosin? Yeah it has all that stuff, very tasty stuff, and I'm not trying to be cute but are there lots of solutes in a solution of that nature? Sure. Are there lots of solutes in cytoplasm? A concept that certainly is familiar. Is water the basis of the cytoplasm in cells and are there hundreds, thousands of different solutes? Okay. So all of that is nothing new really but when we say that solutes are dissolved in solvent what does that actually mean? What does it mean to dissolve? It's not just disappearing from out sight. There must be something going on. When something dissolves it actually mingles, that is the solute is able to mingle in a crowd of water molecules. And so what dictates whether something will or will not dissolve is the simple relationship here. Something will be soluble if the molecules are polar in nature or ionized and able to establish what? Able to establish hydrogen bonds with water. And so if they can they will and if they will they're now soluble. And if they can't they won't. So in this graphic we see sodium chloride which we know is salt and it's common knowledge that it dissolves in water because in water the sodium chloride molecule ionizes and the sodium and chloride ions can establish what sort of bonds? Hydrogen bonds with water. So that's basically it. A molecule which is insoluble basically cannot and does not establish any hydrogen bonds so it remains to itself and when a molecule remains to itself it's going to float on the water. It's going to be distanced from water. And what's something in your household experience that you know doesn't dissolve in water? Oil. Classic statement oil and water don't mix because oil is a nonpolar or neutral molecule. Therefore it can't establish what? Therefore it will not, cannot dissolve in water. So it's a simple idea. So if I say I have a molecule here and I want to know whether it's soluble in water. What's the question you have to have answered before you can know? All right it's polar. Then what? It'll dissolve in water. Oh it's nonpolar. It won't. Simple rule, simple idea. Those molecules which are polar or otherwise have a lot of ionized groups will establish hydrogen bonds and therefore be soluble. Those that do not, those that are nonpolar will not and therefore are said to be, there's the word, insoluble. Now tomorrow and certainly throughout the course we'll be dealing with this idea which is related to solutions. The concentration of something and that's a term we all know and use but what does it really mean on a chemical level? The concentration is not the amount. The amount is just a number. Concentration is the number of what? Do you know what? So concentration is the amount per a given volume so for instance we can speak of the number of people in this room. We could count them up. Could we also speak of the concentration? That would be the number per what? So if we had a big room that number would produce a low concentration. If we were all in a phone booth--, do you know what those are?

[ Laughter ]

I've got to update my analogies. Years ago there were these aluminum structures, actually before that they were wood, and you would go in there, they were very small, and there was actually a telephone on the wall there and you'd put coins in there and you'd actually talk to somebody. These things were called phone booths. All right, so, back to that, if we were all in a phone booth that would be a high concentration. If we were all in the Super Bowl that would be a low concentration. Okay you've got it. So anyway when it comes to solutions we can talk about the concentration of a solution, again the number of solutes in a given volume of solvent, and there are lots of terms or units of expression. One that makes intuitive sense is percentage so if we say 10% sugar what does that mean? It means 10% is sugar and the rest is water. Okay. So percentage is simply a weight in grams per volume. In biology weight is usually in grams and volume is usually in liters so in this example we have 100 grams of something and this is a liter, it's a thousand what? Milliliters. So let's reduce that fraction. How can you reduce that fraction? Well you know how to do it you get rid of that zero and get rid of that so that comes out to what? One tenth which is otherwise 0.1 which is otherwise equal to 10% so it's not a complicated or difficult concept but percentage is one way to express concentration. Also you're all graduates of chemistry so you've heard the term, you've struggled with molarity. Molarity is the number of moles that is the molecular weight in grams per liter, so we could say a one molar, a two molar, a 0.5 molar and so both of these are in common use but they both involve what? Solutes per volume of solvent and so we have to review and accept these methods of expression. All right so looking back under Roman numeral four we spoke of solutions which consists of solutes and solvent. Solutes will be soluble in solvent if they have what property? Solutes will be soluble in water if they're polar and if they're not polar they will be insoluble. If they are soluble they will form some level of concentration expressed either as percentage of molarity. So where are we going from here? Let's talk about this very important solution. We gave a name. We gave the name cytoplasm. It's also called cytosol, in other words it's the interior soup that all cells contain. Don't get me wrong cytoplasm varies from cell to cell but is water a part of all cytoplasm? Sure. So water's the primary solute or solvent? Solvent. Are there lots of solutes? Yeah. And they include let's assume various ions and that is charged atoms and because these atoms are charged they form what are called, you've heard this term, they form what? Electrolytes. What are some electrolytes that come to mind or that are certainly family, Na is? Sodium. K is what? Cl and Ca, calcium. The charges are indicated here. Some of these are anions, some of these are cations. They're all the E word, what's that? And that means or at least tells us that they help in the conduction of electricity, that is electricity can pass or otherwise be carried through solutions which contain electrolytes. Some ions also determine the pH of the solution. You know about pH from chemistry and so we have HCl, NaOH, as you know HCl is commonly known as what? Hydrochloric acid and NaOH is sodium hydroxide. Do these shift or influence the pH of a solution? Naturally so. So influencing the acidity and alkalinity are such ionically bonded molecules as HCL and NaOH. Apart from the ions though the important or certainly uniquely biological molecules are so called organic molecules. Now the word organic today is so malign, you know we say "oh those bananas are organic", whoop-di-do! Any banana is organic, but what does that mean? Well that means you pay more because they're not sprayed with pesticides and okay that's great. If you want your organic bananas--, I just had a choice of that moments ago, I was at the store. They had regular bananas and they had organic bananas. The organic bananas are twice the amount of--, I went for the nonorganic. Anyway, I digress. Literally the word organic has nothing to do with pesticides. Organic is a simple notion. It means anything that contains carbon. Any molecule which is a carbon-based molecule is an organic molecule and very often as we said carbon bonds with other prevalent atoms such as hydrogen, oxygen, what's N? Or S? Sulfur actually. So organic molecules by definition must contain carbon in combination with other atoms such as hydrogen, oxygen, nitrogen, even sulfur, phosphorous and so forth. Organic molecules can be simple, that means relatively uncomplex, relatively small molecular weights, or they can be complex. Now the dividing line here is arbitrary and certainly not a law of any kind but tonight we're going to call the simple organic molecules, those that are smaller in structure and include primarily carbohydrates and fats. And then the big guys, the gargantuan or complex organic molecules include proteins and nucleic acids. Now don't get me wrong I'm not saying complex are better and simple or dumb, it's just an arbitrary designation. So tonight in the time we have left we're going to consider carbohydrates and fats and then at the beginning of Wednesday we'll look at the two so-called complex organic molecules namely proteins and nucleic acids. So turning the page and under the heading of simple organic molecules we have carbohydrates. Now isn't that word really two words put together? What are the two words that are put together there? Carbon and hydrogen or at least something like that. Carbohydrates are basically hydrated chains of carbons and so this expression, this abbreviation really is the definition of a carbohydrate. Do carbohydrates have carbon? Yes. Do they have hydrogen? Yes. Do they have oxygen? Yes. And what's the ratio of these atoms? For every carbon you will always have what? Twice as many hydrogens and the same number of oxygen, hence these are literally what? Hydrated carbon chains. Hydrated meaning containing water. Now the word chain is accurate but misleading because we think of a chain like you know you might have on an, I don't know, piece of valuable property. Now chains can be linear but what can happen to a chain if you connect the two ends? What was linear is now a circle. So even though we use the word chain here carbohydrates are not always linear but are often looped up into chains. From chemistry, form biology, from high school, from junior high school you've been introduced to this. So what are the simplest of the sugars? They're called monosaccharides. Mono means what? One. Saccharide means sugar so one sugar and the ubiquitous, the most common, the most fundamental of the monosaccharides is this guy here which we introduced a moment ago, glucose. Hardly a chain but a ring really, but if we were to tell you that it has six carbons, and it does, then how many hydrogen does it have? And how many oxygen does it have? Therefore the formula for glucose must be CHO--, there you are and yeah you can count them up. They're all there. So if glucose follows this rule associated with carbohydrates and if there are six carbons there must be 12 hydrogen and 6 oxygen and that's true. So this is the formula or the representative diagram for glucose and don't panic we're not going to ask you to memorize that or draw it on an exam. This is not chemistry this is physiology, but if we flash that on the screen for a millisecond would you recognize it as glucose? Yeah it's glucose. So recognizing it is all we really want and this molecule here is curiously similar, indeed has the same formula but instead it's called what? Galactose. Because the molecular arrangement of these hydroxyl groups is slightly different but still both of these are what? Both of these are monosaccharides and thus simple sugars, simple sugars. Can we take two monosaccharides and hook them together and if so what would we have? Well let's do that. Here's what? It says it's glucose and here's fructose. Okay. Both of these by themselves are what? Monosaccharides. And if you bond them together, if you create a covalent bond between [inaudible] and fructose [inaudible] H2O [inaudible] will come out of this reaction but you won't have a monosaccharide an more, hmm, what would you think you'd call something that's made of two sugars? Disaccharide. And this one is the familiar sucrose better known as table sugar or cane sugar or brown sugar or white sugar or whatever, it's all the same. So a disaccharide is nothing more than two monosaccharides covalently bonded together. And could we put another monosaccharide and we have a trisaccharide wouldn't we? And we could keep doing this endlessly. We could always tack on more glucose or more monosaccharides. At some point it gets pretty wieldy, pretty heavy and so when we get to this level of 1000 or more what? 1000 or more monosaccharides, then we've got something that we call a polysaccharide. Polysaccharides are known in general conversation as complex carbs, sometimes called starch, sometimes called glycogen. Fundamentally most polysaccharides are made of glucose, just bonded together again by covalent bonds, and so this representation here is indeed a polysaccharide, one that's very common in your liver, stored there as this compound called glycogen. So in an analogy of course glycogen is like a $100 bill which can be broken down like any $100 bill into what? Single dollars. Actually it's not a $100 bill it's a $1000 bill. I'm sorry I missed that point but it started out as a good analogy. What are some of the cell functions that we associate with carbs? And we don't have to be you know too exact because it's common knowledge? What do carbohydrates provide for your body or your--? Energy, okay. Would you say energy now, energy later, or both? All right, so are there carbs that provide immediate energy for your cellular machinery? Are there carbs that are stored and used more for periods of starvation or long distance running let's say? So cell function, certainly energy. Energy now, energy later, immediate or stored energy. And that is pretty much the whole story. In other words carbohydrates have a pretty exclusive but yet undeniably important function. They provide energy, that is energy for cellular activities either in an immediate way or in a more prolonged way which really is the same as a dollar bill. What is a dollar bill? You can provide--, you can buy now or store it, use it later, you know, payment schedule. What about water solubility? We said before what would you have to know, what question would you have to have answered? All right. So okay, glucose is very polar. It has a lot of these hydroxyl groups. So if glucose is polar then you know automatically it is? Water soluble. And isn't that common knowledge? And so what about a disaccharide? Well if a disaccharide is nothing more than two monosaccharides then you would assume that it would still be soluble and that's true, and you would assume the same thing for a polysaccharide because actually isn't just a polysaccharide a bunch of glucose? So if each glucose itself is soluble then you'd assume that something like glycogen would also be soluble but, no. Why is that? Because each of these glucose molecules is by itself polar and therefore soluble but when you get these into this pattern like this these polar molecules tend to interact with themselves and therefore as a unit this whole thing is not soluble because it is not polar it is? Neutral. So if we say, and it's true, that glycogen is neutral then therefore glycogen unlike glucose or fructose and others, glycogen is definitely what? Not, not soluble in water, just a fact. So in summary most carbohydrates are very soluble by virtue of their polarity but there is one exception and that's polysaccharides. Why are they not soluble in water? Because they're not polar, they're neutral. And why aren't they polar? Even though the individual subunits are polar the whole molecule is neutral as a result of the inner activity of those subunits. All right so a simple review of at least a simple survey of carbs. Next and last for tonight, lipids. What's the common name for a lipid? The F word, yes, that. And these are described or defined as hydrocarbon chains, not hydrated. What is it? Hydrocarbon. Again the word chain is featured here but what did we say previously about chains? Even though chains are typically thought of as linear they sometimes can link up forming a necklace, forming a ring, forming something circular and that's certainly true. Now in the lipid category there are three important subtypes, the most abundant of which are TG's. TG is an acronym for triglyceride, also known as triacylglycerol, okay? Also known as neutral fat. What's the word neutral emphasize or refer to? Not charged. So with that said what do we already know about neutral fats in terms of their solubility in water? Not soluble. Triglycerides, second category so-called phospholipids which we'll learn in a moment are basically like a triglyceride, that is they're made of glycerol, two fatty acids but replace one of the three fatty acids with a phosphate group. So before going further let's look at this a little more exactly. This molecule here is labeled for you as glycerol. You can see it on your page. And glycerol is actually a sugar having how many carbons? Three. Okay, fine. And these molecules over here are obviously organic. There's a bunch of carbon. And they're said to be fatty acids. Fatty acids are just that, they have a hydroxyl, excuse me, a carboxyl group on one end which is COOH and they can go on in quite length chains. Now take a look at these two. One is labeled saturated, the other is labeled polyunsaturated. Terms that I think you've heard. Haven't you heard the expression that this oil is saturated fat and that one is unsaturated fat? And if you have, saturated fats are associated with what sort of organisms on this planet? Saturated fat associated with animals. Unsaturated fat associated with plants. And just thinking of nutrition and health what's best for you? A saturated fat or an unsaturated fat? Because the simple truth is saturated fat is very insoluble in water and tends to coat the inside of your arteries leading to that undesirable condition called atherosclerosis. All right so I digressed. But what's it even mean to be saturated? What did we say previously in this lecture about a carbon atom? How many bonds maximum can a single carbon atom form? Four. All right. That was maximum. Can it form less than four? Yes. So look at this, these carbons are forming less than four, these--, excuse me these are forming four which is the maximum and these are forming less than four. So the word saturated means whether the full number of bonds possible are created. So what does that all mean? Essentially as we've already said saturated fats are very insoluble in water whereas unsaturated fats are more soluble in water, therefore tend to be more healthy in the long run in terms of diet but I just had to give you that background. That's almost unimportant for what we're about to say because whether a fatty acid is saturated or not it can still bond with a glycerol and to get back to our focus if we have three fatty acids bonded to a glycerol, what do you call that when three fatty acids are bonded to a single glycerol? It's called a triglyceride. And if you've ever had your blood test and you know certainly a chemical panel they might do a triglyceride analysis which is just that, measuring the level of triglyceride in your blood. Okay, fine. Now what's different about this molecule? You've got them side by side. Do each of these have a glycerol? Yeah. Does this one have three fatty acids? Yep. How many fatty acids over here? Two. And the third position is replaced not by a fatty acid but [inaudible] did you see the P. Then the oxygen, oxygen, oxygen, oxygen. When you have that group as such and to repeat it's P surrounded by what? Oxygen, oxygen, oxygen, oxygen. That's called a phosphate group and so now what was a TG--, what's a TG? Is now a what? Phospholipid. All right so what? Well the difference is very important. A TG as we already said is entirely neutral, in fact the other name of a TG is [inaudible]. Therefore in water a TG is totally and completely insoluble, but when you take away one fatty acid and plug in a phosphate group then what was a TG is now called? A phospholipid. So what? The phosphate group confers a level of polarity, electric change, and now this TG which was neutral is now partly charged and therefore partly what? Ah, partly soluble. In other words it has some ability to dissolve in water. And so stealing the thunder of I guess Wednesday's lecture we're going to find that the cell membrane is made primarily of phospholipids and connecting to ideas you learned in biology again a phosophlipid has some solubility and some insolubility. The words hydrophilic and hydrophobic might even come into mind. So anyway phospholipids very different and important as we'll learn and emphasize important in cell membranes. And finally for tonight the third kind of fat is a steroid. Now steroids have what sort of reputation? If you say he's on steroids is that a compliment? Not usually. Well I guess it could be in some circles. But I do want to eradicate that stereotype because steroids are not bad. We'd all be D-E-A-D without steroids, but okay what are steroids? It says' they're hydrocarbon rings, okay. So unlike phospholipids and triglycerides these feature a basic central so called steroid ring made of carbon and hydrogen and again you don't have to memorize this but this is the steroid complex that all steroids have. All right so when you see that, oh a steroid. But what makes one steroid different from another is not this but the attachments, that is the associated atoms connected to that steroid nucleus. So here's a familiar steroid or at least one that you've heard by name. What is it? So cholesterol is a steroid. What's some other steroids that you know by name? I know you know some. So okay I'll say testicles and you say? I guess you don't say. Testosterone, right? Is testosterone a steroid? Is estrogen a steroid? Is progesterone a steroid? Is cortisol a steroid? Yeah I could go on and on, but anyway so do you know some steroids? Yeah. What do they have in common? They all have this basic steroid ring. Beyond that though are they soluble or not? So what question needs to be asked and answered? They're not. They're not what? They're not polar. Therefore you say not soluble in water. Okay. And therein lies the negative connotation we have about cholesterol. What's the negative connotation? Why do we fear cholesterol? Because is it soluble in water? Nope. So does it sometimes streak or otherwise clog arteries? And can that kill people? Okay. So is your cholesterol level in your blood worth knowing or monitoring or keeping tabs on? Sure. But don't get me wrong is cholesterol evil or good? Well it's actually good because it's part of cell membranes. It's like anything else too much not so welcome. And certainly testosterone and estrogen are other examples of steroids, all useful, but returning to the theme. What have we said about all steroids in terms of their polarity? They're not polar. And if they're not polar they're not soluble. And as an aside that allows for an interesting means of delivery. Can you take testosterone and put it on your skin and rub it in and will it go through your skin? Because it's not water soluble it's a fat so fat soluble compounds can be delivered in patches or creams which is just a tidbit of information. So let's finish this off. What are some cell functions for this whole category? What are some of the functions that come to mind for lipids? Energy. Energy now or energy later? Energy later, right? The whole deal with fat, you can eat a ton of fat, you know a half gallon of Haagen-Daz or whatever and it's not really going to provide any immediate energy. It's going to go straight to the adipose cells and hang out until you're starving some day. Some week, some month, some year. All right. So anyway what was the question? Are fats used for energy? Yes. Now or later? Later. So they're a savings plan if you want some analogy. Anything else? Fats, well--, people always want to say padding so I'll throw it out there. Fats for padding. Yeah, okay, but really pretty low on the functional importance [laughing] and if you want to go there fats can also provide insulation from heat loss but really all of that is secondary. What's the primary function of TG's? We've already said it energy storage. Now what about phospholipids? We touched on that and they're not used for energy. Phospholipids make up and are essential for the creation of? Cell membranes. Without phospholipids game over, that is life as we know it impossiblay, that's Spanish for not possible. All right so what have we got so far [laughing]? Yeah I'm really semi nonfluent in Spanish but I like to throw that out. You say muy bien, all right, I say gracias, that's about as far as I can go [laughing]. All right, I'm sorry, cell functions. Energy now or energy later? All right. And cell membranes, got that? What else? What did we say about steroids? We gave you some examples. What were some names, some actual examples of steroids? One's up on there. Cholesterol. Important in cell membranes. Testosterone, estrogen, what's their big deal. It's the H word. Hormones, right? All right so I'm being coy and delaying the inevitable here but cell functions include energy storage, cell mem, that's an abbreviation for membrane, and of course hormones. Now don't get me wrong are all hormones steroids? No. Are some hormones steroids? Yes. So it's just a clarification. And finally what about water solubility? You should know. Are some of these soluble in water? Are any of these soluble in water? Partly. Which one is partly soluble? And why or what's the explanation for this partial water solubility? Well that's what it forms but why is a phospholipid partly soluble in water? Because it has a? Phosphate group and the phosphate group gives that molecule some level of C word, charge, and therefore creates the partial solubility. The rest of these lipids are not charged, definitely neutral. So as a rule, as a statement, as a general statement lipids are insoluble except, except for what? Phospholipids. And they are not fully soluble but partly soluble and their role as you know and as we said is to help create what? Cell membranes. If phospholipids were fully soluble in water what would happen? Well cell membrane would disappear and game over again. All right, so we want them to be and indeed they are slightly soluble by virtue of that phosphate group. So we're done. Tonight we talked about organic molecules. What were the two? The two simple ones were carbohydrates and lipids. What are we going to do Wednesday. The complex which include proteins and nucleic acids. Have a great evening. Drive safe. See you tomorrow.